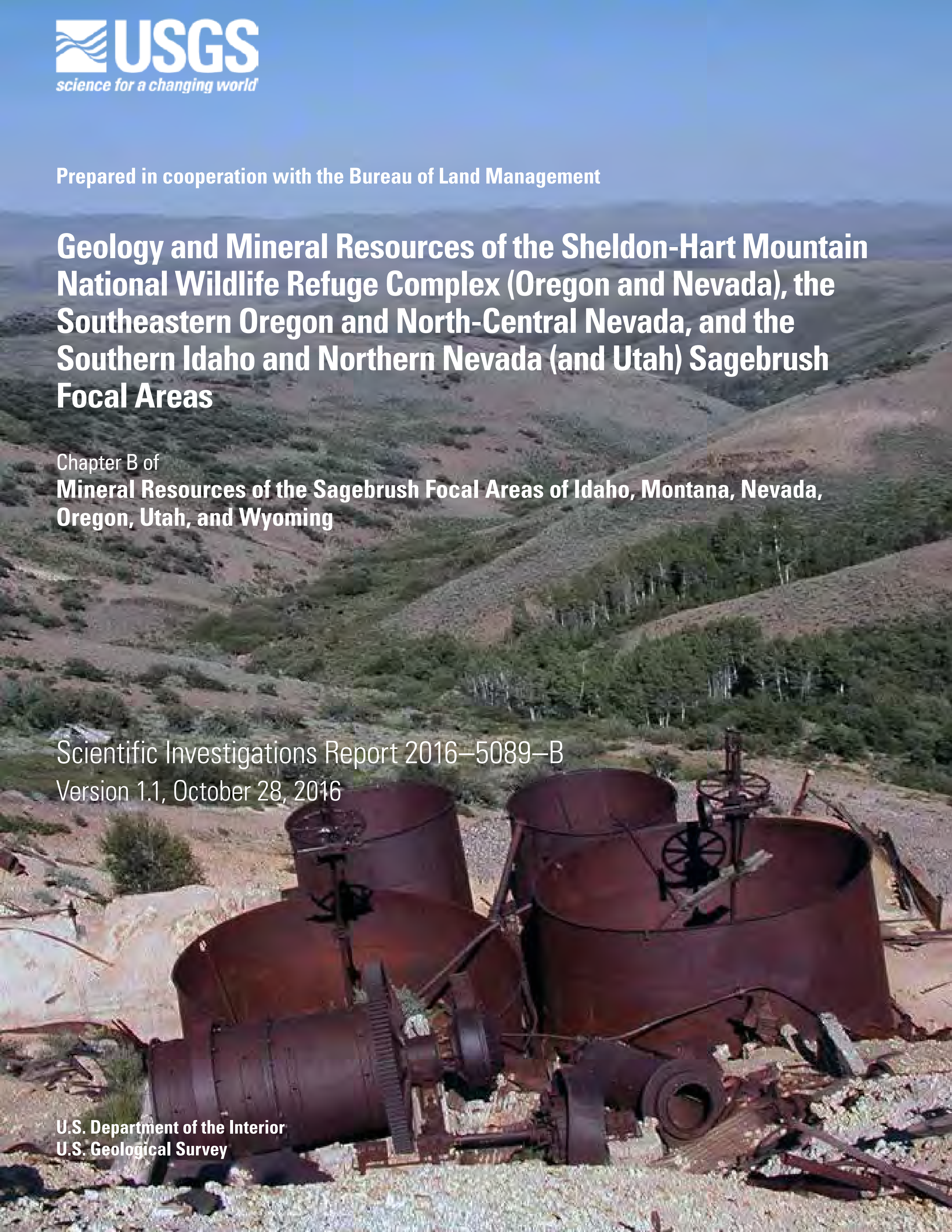

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Geology and Mineral Resources of the Sheldon-Hart Mountain National Wildlife Refuge Complex (Oregon and Nevada), the Southeastern Oregon and North-Central Nevada, and the Southern Idaho and Northern Nevada (and Utah) Sagebrush Focal Areas

Chapter B of
Mineral Resources of the Sagebrush Focal Areas of Idaho, Montana, Nevada, Oregon, Utah, and Wyoming

Scientific Investigations Report 2016–5089–B
Version 1.1, October 28, 2016

U.S. Department of the Interior
U.S. Geological Survey

COVER. Photograph of remains of cyanide mill, National District, Nevada (U.S. Geological Survey photograph by Peter G. Vikre).

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U.S. Department of the Interior
SALLY JEWELL, Secretary

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Author Responsibilities

Peter G. Vikre—Introductory text, conjunctive text, summarizing text, and editing for all sections; contributions to exploration and mining activity, tract descriptions, and locatable mineral commodities not assessed

Mary Ellen Benson—Tract delineation, rating, and description for phosphate occurrences and diatomite deposits; figure construction

Donald I. Bleiwas—Market analyses of assessed locatable mineral commodities

Joseph P. Colgan—Geology; figure construction

Pamela M. Cossette—GIS; figure construction

Jacob DeAngelo—Geothermal occurrences; figure construction

Connie L. Dicken—GIS; land use statistics

Ronald M. Drake II—Oil and gas; figure construction

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Gregory L. Fernette—Exploration and mining activity

Jonathan M.G. Glen—Geothermal occurrences; figure construction

Jon E. Haacke—Coal occurrences; figure construction

Susan M. Hall—Tract delineation, rating, and description for hydroallogenic uranium deposits; locatable mineral commodities not assessed

Albert H. Hofstra—Tract delineation, rating, and description for orogenic gold, epithermal gold and silver, volcanogenic massive sulfide copper, Carlin-type gold, black shale vanadium, sedimentary exhalative zinc-lead-silver-gold, Mississippi Valley-type lead and zinc, and bedded barite deposits

David A. John—Tract delineation, rating, and description for epithermal gold, silver, and mercury deposits

Stephen Ludington—GIS; tract delineation, rating, and description for epithermal gold and silver, and intrusion-related deposits

Mark J. Mihalasky—GIS; tract delineation and rating for numerous deposit types; salable minerals sections; locatable mineral commodities not assessed

James J. Rytuba—Tract delineation, rating, and description for epithermal gold, silver, mercury, and gallium, volcanogenic uranium, gemstones, hectorite (lithium-rich clay), specialty clay, and zeolite deposits

Brian N. Shaffer—Coal occurrences; figure construction

Lisa L. Stillings—Salable minerals sections; locatable mineral commodities not assessed

John C. Wallis—Figure construction

Colin F. Williams—Geothermal occurrences; figure construction

Douglas B. Yager—Potash occurrences

Lukas Zürcher—Tract delineation, rating, and description for intrusion-related deposits

Contents

Figures

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Conversion Factors

[U.S. customary units to International System of Units]

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
yard (yd)	0.9144	meter (m)
	Area	
acre	4,047	square meter (m^2)
acre	0.4047	hectare (ha)
acre	0.4047	square hectometer (hm^2)
acre	0.004047	square kilometer (km^2)
square foot (ft^2)	929.0	square centimeter (cm^2)
square foot (ft^2)	0.09290	square meter (m^2)
square inch (in^2)	6.452	square centimeter (cm^2)
square mile (mi^2)	259.0	hectare (ha)
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
barrel (bbl; petroleum, 1 barrel=42 gal)	0.1590	cubic meter (m^3)
	Mass	
ounce, troy (oz)	31.103	gram (g)
pound, avoirdupois (lb)	0.4536	kilogram (kg)
ton, short (2,000 lb)	0.9072	metric ton (t)
ton, long (2,240 lb)	1.016	metric ton (t)

[International System of Units to U.S. customary units]

Multiply	By	To obtain
	Length	
centimeter (cm)	0.3937	inch (in.)
millimeter (mm)	0.03937	inch (in.)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
kilometer (km)	0.5400	mile, nautical (nmi)
meter (m)	1.094	yard (yd)
	Area	
square meter (m^2)	0.0002471	acre
square kilometer (km^2)	247.1	acre
square centimeter (cm^2)	0.001076	square foot (ft^2)
square meter (m^2)	10.76	square foot (ft^2)
square centimeter (cm^2)	0.1550	square inch (ft^2)
square kilometer (km^2)	0.3861	square mile (mi^2)
	Volume	
cubic meter (m^3)	6.290	barrel (petroleum, 1 barrel = 42 gal)
cubic meter (m^3)	264.2	gallon (gal)
cubic meter (m^3)	0.0002642	million gallons (Mgal)
cubic centimeter (cm^3)	0.06102	cubic inch (in^3)

Multiply	By	To obtain
cubic meter (m^3)	35.31	cubic foot (ft^3)
cubic meter (m^3)	1.308	cubic yard (yd^3)
cubic kilometer (km^3)	0.2399	cubic mile (mi^3)
cubic meter (m^3)	0.0008107	acre-foot (acre-ft)
	Mass	
gram (g)	0.032	ounce, troy (oz)
gram (g)	0.03527	ounce, avoirdupois (oz)
kilogram (kg)	2.205	pound avoirdupois (lb)
metric ton (t)	1.102	ton, short [2,000 lb]
metric ton (t)	0.9842	ton, long [2,240 lb]
	Density	
kilogram per cubic meter (kg/m^3)	0.06242	pound per cubic foot (lb/ft^3)
gram per cubic centimeter (g/cm^3)	62.4220	pound per cubic foot (lb/ft^3)

Supplemental Information

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as °F = (1.8 × °C) + 32.

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as °C = (°F – 32) / 1.8.

Datum

Vertical coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Altitude, as used in this report, refers to distance above the vertical datum.

Abbreviations

Ad	andradite (iron-rich garnet)
AMIS	Automated Minerals Information System
AOC	Assessment Oversight Committee
API	American Petroleum Institute
AR	“as received”
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
ASTM	American Society for Testing and Materials
AU	assessment unit (oil and gas)
BCF, BCFG	billion cubic feet (of gas)
BHT	bottom-hole temperature
BLM	Bureau of Land Management
BRW	Bear River Watershed (Sagebrush Focal Area)
BV	“best value”
CAGR	compound annual growth rate
CAI	color alteration index
CFR	Code of Federal Regulations
CIGS	copper-indium-gallium selenide
CSA	Canadian Standards Association
CSM	clay-sulfate-mica
CSAMT	controlled-source audiofrequency magnetotellurics
DLA	Defense Logistics Agency
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOI	U.S. Department of the Interior
EGS	enhanced geothermal system
EIS	Environmental Impact Statement
ETM+	Landsat 7 Enhanced Thematic Mapper Plus
FLPMA	Federal Land Policy and Management Act of 1976
f.o.b.	free on board
FWS	U.S. Fish and Wildlife Service
g/t	gram per metric ton
Ga	giga-annum or billions of years ago
GFTZ	Great Falls Tectonic Zone

GHC	Geo-Heat Center
GIS	geographic information system
HSSR	Hydrogeochemical and Stream Sediment Reconnaissance
IDW	inverse distance weighted
LEDs	light-emitting diodes
LLD	lower limit(s) of determination
m.y.	millions of years
Ma	mega-annum or millions of years ago
MAS	Minerals Availability System
MCF	thousand cubic feet of gas
MILS	Mineral Industry Location System
MMBO	million barrels of oil
MMBNGL	million barrels of natural gas liquids
MOP	muriate of potash
Moz	million troy ounces
MRDS	Mineral Resources Data System
Mt	million metric tons
MTU	metric ton unit
MVT	Mississippi-Valley-type
MW	megawatt
MWe	megawatt electricity
NASGLP	North American Soils Geochemical Landscape Project
NBMG	Nevada Bureau of Mines and Geology
NDS	National Defense Stockpile
NEPA	National Environmental Policy Act of 1989
NGDB	National Geochemical Database
NGL	natural gas liquids
NGS	National Geochemical Survey
NMIC	USGS National Minerals Information Center
NOAA	National Oceanic and Atmospheric Administration
NOGA	USGS National Oil and Gas Assessment
NURE	National Uranium Resource Evaluation
NWR	National Wildlife Refuge
opt	troy ounce per short ton
oz	troy ounce

PGE	platinum-group element
PGM	platinum-group metal
PLSS	Public Land Survey System
ppm	parts per million
REE	rare earth element
REOE	rare earth oxide equivalent(s)
RMOTC	Rocky Mountain Oilfield Testing Center
ROD	Record of Decision
RTP	reduction-to-the-pole
SaMiRA	Sagebrush Mineral-Resource Assessment
SEDAR	Canadian System for Electronic Document Analysis and Retrieval
SEDEX	sedimentary exhalative
SFA	Sagebrush Focal Area
SG	specific gravity
SI	structural index
SOP	sulfate of potash
SWIR	shortwave-infrared (region of the electromagnetic spectrum)
t	metric ton
TCM	Tax Court Memorandum
Th/K	thorium/potassium ratio
TMI	total magnetic intensity
TOMS	Topographically Occurring Mine Symbols
TPS	total petroleum system
UMOS	Utah Mineral Occurrence System
USBM	former U.S. Bureau of Mines
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
USMIN	USGS Mineral Deposit Database
VMS	volcanogenic massive sulfide
wt.%	weight percent
WYO	Southwestern and South-Central Wyoming (Sagebrush Focal Area)

Chemical Symbols and Formulas Used

Ag	silver	Gd	gadolinium
Al	aluminum	Ge	germanium
Al_2O_3	aluminum oxide	H	hydrogen
Ar	argon	H_2S	hydrogen sulfide
As	arsenic	Hf	hafnium
Au	gold	Hg	mercury
B	boron	Ho	holmium
Ba	barium	In	indium
$BaSO_4$	barium sulfate	Ir	iridium
Be	beryllium	K	potassium
Bi	bismuth	K_2O	potassium oxide
Br	bromine	La	lanthanum
C	carbon	Li	lithium
C_{org}	organic carbon	Lu	lutetium
CO	carbon monoxide	Mg	magnesium
CO_2	carbon dioxide	MgO	magnesium oxide
Ca	calcium	Mn	manganese
CaO	calcium oxide	Mo	molybdenum
Cd	cadmium	N	nitrogen
Ce	cerium	NH_3	ammonia
CH_4	methane	Na	sodium
Cl	chlorine	NaCl	sodium chloride
Co	cobalt	Na_2O	sodium oxide
Cr	chromium	Nb	niobium
Cs	cesium	Nd	neodymium
Cu	copper	Ni	nickel
Dy	dysprosium	O	oxygen
Er	erbium	Os	osmium
Eu	europium	P	phosphorous
F	fluorine	P_4	elemental (white) phosphorus
Fe	iron	PO_4	phosphate
Fe_2O_3	ferric iron oxide	P_2O_5	phosphorous pentoxide
Ga	gallium	Pb	lead
GaAs	gallium arsenide	Pd	palladium
GaN	gallium nitride	Pr	praseodymium

Pt	platinum	Te	tellurium
Rb	rubidium	Th	thorium
Re	rhenium	Ti	titanium
Rh	rhodium	TiO_2	titanium dioxide
Ru	ruthenium	Tm	thulium
S	sulfur	Tl	thallium
Sb	antimony	U	uranium
Sc	scandium	U_3O_8	triuranium octaoxide (yellowcake)
Se	selenium	V	vanadium
Si	silicon	V_2O_5	vanadium pentoxide
SiO_2	silicon dioxide (silica)	W	tungsten
Sm	samarium	WO_3	tungsten trioxide
Sn	tin	Y	yttrium
Sr	strontium	Yb	ytterbium
Ta	tantalum	Zn	zinc
Tb	terbium	Zr	zirconium

Mineral Formulas Used

adularia	$KAlSi_3O_8$
alunite	$KAl_3(SO_4)_2(OH)_6$
andradite (garnet)	$Ca_3Fe^{3+}{}_2(SiO_4)_3$
ankerite	$Ca(Fe,Mg,Mn)(CO_3)_2$
argentite	Ag_2S
arsenopyrite	FeAsS
barite	$BaSO_4$
bornite	Cu_5FeS_4
cassiterite	SnO_2
chalcocite	Cu_2S
chalcopyrite	$CuFeS_2$
cinnabar	HgS
clinoptilolite (zeolite)	$(Ca,Na,K)_{2\text{-}3}Al_3(Al,Si)_2Si_{13}O_{36}\cdot 12(H_2O)$
coffinite	$U[SiO_4,(OH)_4]$
corderoite	$Hg_3S_2Cl_2$
dolomite	$CaMg(CO_3)_2$
erionite (zeolite)	$(Ca,Na,K)_{10}[Al_{10}Si_{26}O_{72}]\cdot{\sim}30H_2O$

fluorite	CaF_2
galena	PbS
hectorite (smectite clay)	$Na_3(Mg,Li)_3Si_4O_{10}(F,OH)_2$
hematite	Fe_2O_3
ilmenite	$FeTiO_3$
kaolinite	$Al_2Si_2O_5(OH)_4$
leucite	$K(AlSi_2O_6)$
magnetite	Fe_3O_4
molybdenite	MoS_2
molybdite	MoO_3
monazite	$(Ce,La,Th,Nd)PO_4$
montmorillonite	$(Na,Ca)_{0.33}(Al,Mg)_2(Si_4O_{10})(OH)_2 \cdot nH_2O$
nepheline	$Na_3KAl_4Si_4O_{16}$
opal	$SiO_2 \cdot nH_2O$
phillipsite (zeolite)	$(Ca,Na,K)_{4\text{-}7}[Al_{4\text{-}7}Si_{2\text{-}9}O_{32}] \cdot 12H_2O$
powellite	$CaMoO_4$
pyrite	FeS_2
quartz	SiO_2
rutile	TiO_2
scheelite	$CaWO_4$
siderite	$FeCO_3$
sillimanite	Al_2SiO_5
sylvite	KCl
sylvinite	$KCl+NaCl$
sphalerite	$(Zn,Fe)S$
staurolite	$Fe_2Al_9Si_4O_{23}(OH)$
stilpnomelane	$(K,Ca,Na)(Fe^{2+},Mg,Fe^{3+})_8(Si,Al)_{12}(O,OH)_{27} \cdot nH_2O$
tetrahedrite	$(Cu,Fe,Ag,Zn)_{12}Sb_4S_{13}$
uraninite	UO_2
xenotime	YPO_4
zircon	$ZrSiO_4$

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Executive Summary

Purpose and Scope

The U.S. Department of the Interior has proposed to withdraw approximately 10 million acres of Federal lands from mineral entry (subject to valid existing rights) from 12 million acres of lands defined as Sagebrush Focal Areas (SFAs) in Idaho, Montana, Nevada, Oregon, Utah, and Wyoming (for further discussion on the lands involved see Day and others, 2016). The purpose of the proposed action is to protect the greater sage-grouse (*Centrocercus urophasianus*) and its habitat from adverse effects of locatable mineral exploration and mining, subject to valid existing rights. This report addresses the mineral-resource potential of a subset of lands proposed for withdrawal. It summarizes the current status of locatable, leasable, and salable mineral commodities and assesses the potential of selected locatable minerals in lands proposed for withdrawal that span the Nevada, Oregon, Idaho, and Utah borders.

In this report, the four study areas evaluated by the U.S. Geological Survey (USGS) for the Sagebrush Mineral-Resource Assessment are (1) the Sheldon-Hart Mountain National Wildlife Refuge Complex Sagebrush Focal Area (943,866 acres [~3,820 square kilometers, km^2; 1,475 square miles, mi^2]) in Washoe County, Nevada, and Harney and Lake Counties, Oregon; (2) the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area (1,382,477 acres [~5,595 km^2; 2,160 mi^2]) in Humboldt County, Nevada, and Harney and Malheur Counties, Oregon; (3) the Southern Idaho and Northern Nevada Sagebrush Focal Area (3,734,263 acres [~15,112 km^2; 5,835 mi^2]) in Cassia, Owyhee, and Twin Falls Counties, Idaho, Elko County, Nevada, and Box Elder County, Utah; and (4) the Nevada additions (394,289 acres [~1,596 km^2; ~616 mi^2]) in Humboldt and Elko Counties, Nevada. Hereafter, we refer to these as the four USGS study areas. The charge to the USGS was to evaluate the proposed withdrawal areas, which are a subset of lands contained within the entire Sagebrush Focal Area. Because the detailed outline of the withdrawal areas are complicated and discontinuous, we chose to define the extent of our "study area" to the outer Public Land Survey System (PLSS) township boundary containing a given section of land within the withdrawal area. For a more detailed discussion see Day and others (2016).

Geologic Framework

The four study areas encompass the northern part of the Basin and Range physiographic province, a large, arid region of alternating north-trending rugged mountain ranges and low-relief intermontane basins. Parts of the study areas also cover the high lava plateaus of southern Idaho and the Nevada-California-Oregon border region. The Columbia Plateau physiographic province is characterized by subdued topography underlain by widespread, thick deposits of stratified volcanic rocks and isolated volcanic cinder cones. The study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area includes the southwestern part of the Snake River Plain, a broad northeast-trending basin floored by basaltic lavas. The study areas drain largely to the north and then west via the Snake River, although the south flank of the study area for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area drains to the south into the interior Humboldt River Basin in central Nevada.

Within the four study areas, the oldest rocks are Precambrian quartzite and schist and small quartz monzonite intrusions in the easternmost part of the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area; similar rocks may underlie Paleozoic shelf-slope sedimentary rocks (mostly carbonates) that crop out widely in the eastern part of this study area. Paleozoic rocks were overthrust, starting in the Late Devonian and continuing through the Mesozoic, by successively younger packages of deepwater marine sediments, which crop out in the central part of the study areas as the Roberts Mountains, Golconda, and Fencemaker allochthons. The far western part of the study areas is mostly covered by Cenozoic volcanic rocks; basement there probably consists of Paleozoic sedimentary and Mesozoic volcanic arc rocks of the Black Rock and Pueblo terranes, which crop out between the study areas for the Sheldon-Hart Mountain National Wildlife Refuge Complex and Southeastern Oregon and North-Central Nevada Sagebrush Focal Areas.

Paleozoic and early Mesozoic sedimentary rocks throughout the study areas are intruded by Jurassic and Cretaceous granitic plutons emplaced during subduction of the Farallon Plate beneath western North America. Following a Late Cretaceous to early Tertiary hiatus, attributed to a change in subduction zone geometry, magmatism resumed with eruption of Eocene to early Miocene silicic to intermediate composition lava flows and tuffs. Beginning about 17 Ma, magmatism was dominated by bimodal basalt-rhyolite volcanism related to the Yellowstone Hot Spot. Miocene flood basalts, caldera-derived rhyolite ash-flow tuff, and rhyolite lava flows blanket much of the study areas. Extensional faulting has been ongoing since at least the middle Miocene, forming the present-day Basin and Range topography and creating numerous basins filled with sediments shed from the rising mountain ranges.

Locatable Mineral Commodities

Numerous locatable mineral commodities, including metallic and nonmetallic (also known as industrial) mineral commodities, occur in and near the four study areas. Many of these commodities have been mined, and numerous unmined deposits have been identified (resource; table 3). Metallic commodities (for example, copper, silver, and lead) commonly occur in several deposit types as determined by comparison to deposit type models, and two or more metals (for example, gold and silver) often have been produced from one deposit. Deposit types that occur in the study areas include epithermal gold, silver, and mercury, and gallium, gemstones, lacustrine diatomite, volcanogenic uranium, orogenic low-sulfide gold-quartz vein, hectorite (lithium-rich clay), specialty clays, zeolites, hydroallogenic uranium, Carlin-type gold, bedded barite, and numerous intrusion-related deposit types including porphyry copper, porphyry molybdenum, polymetallic skarn, replacement, and vein, tungsten greisen, and distal disseminated silver-gold. Favorable stratigraphy for lacustrine diatomite, intrusion-related, volcanogenic massive sulfide copper, Carlin-type gold, black shale vanadium, sedimentary exhalative zinc-lead-silver-gold, Mississippi Valley-type lead and zinc, and bedded barite deposits occurs in the study areas.

Forty-six locatable metallic and nonmetallic mineral commodities, and 14 commodities that are locatable or salable (depending largely on quality and value), were evaluated for assessment (table 1). Of these, 17 commodities were assessed that (1) occur as unmined resources, and (or) (2) have potential to occur in undiscovered deposits in each study area. Assessment of these 17 commodities was based primarily on (1) deposits (mines, resources, prospects, and occurrences) containing the assessed commodity or commodities (table 3); (2) geological, geochemical, alteration, geophysical, and other characteristics of the deposits and deposit types which included the assessed commodity or commodities (appendix 2); (3) records of active and historical mining claims and surface-management plans provided by the Bureau of Land Management (BLM) and U.S. Forest Service (USFS); and (4) market analyses (appendix 5 and section I, Day and others, 2016). Locatable mineral commodities that were considered for assessment but were not assessed are briefly described in appendix 3.

Mineral potential assessment of the 17 commodities included (1) delineation of tracts that enclose rocks with favorable characteristics of deposit types (a) known to contain the assessed commodities, and (b) known to exist in the tract; (2) assignment of potential for undiscovered deposits in the tract (high, moderate, low, or none); and (3) assignment of relative certainty of mineral potential (A, least certain, to D, most certain). Tracts are described and justified in the separate report sections on each study area. Maps showing tract outlines and selected tract-defining characteristics accompany tract descriptions.

Assessment Tracts

In the study area for the Sheldon-Hart Mountain National Wildlife Refuge Complex Sagebrush Focal Area, tract SHEP01, Coyote Hills, has moderate potential (certainty level C) for epithermal gold, silver, and mercury deposits; tract SHEP02, Sheldon West, has moderate potential (certainty level B) for epithermal mercury deposits; and tract SHSS01, Dust Devil, has high potential (certainty level D) for sunstone deposits. Tract SHDT01, Washoe-Lake-Harney, encloses exposures of stratigraphic sections that contain lacustrine diatomite beds, and stratigraphy favorable for lacustrine diatomite deposits.

In the study area for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area, tract ONEP01, Cordero, has high potential (certainty level D) for epithermal mercury, gold, silver, and gallium deposits; tract ONEP02, Lucky Boy, has moderate potential (certainty level C) for epithermal mercury deposits; tract ONEP03, Buckskin, has high potential (certainty level D) for epithermal gold, silver, and mercury deposits; tract ONEP04, Paradise Valley, has moderate potential (certainty level C) for epithermal silver and gold deposits; tract ONVU01, Kings Valley, has high potential (certainty level D) for volcanogenic uranium deposits; tract ONOG01, Orovada, has moderate potential (certainty level C) for orogenic low-sulfide gold-quartz vein deposits; tract ONAG01, McDermitt Gemstones, has high potential (certainty level D) for semiprecious gemstone deposits; tract ONLI01, West Lith, has high potential (certainty level D) for hectorite (lithium-rich clay) deposits; tract ONLI02, Whitehorse Lithium, has moderate potential (certainty level B) for hectorite (lithium-rich clay) deposits; tract ONCL01, Colloid, has high potential (certainty level D) for specialty clay deposits; tract ONCL02, Whitehorse Clay, has moderate potential (certainty level

B) for specialty clay deposits; tract ONZE01, Nor Zeo, has high potential (certainty level D) for zeolite deposits; tract ONZE02, Whitehorse Zeolite, has moderate potential (certainty level C) for zeolite deposits; and tract ONDT01, Whitehorse Diatomite, has moderate potential (certainty level C) for lacustrine diatomite deposits. Tract ONDT02, Harney-Malheur, encloses exposures of stratigraphic sections that contain lacustrine diatomite beds and stratigraphy favorable for lacustrine diatomite deposits.

In the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area ten tracts have potential for epithermal gold, silver, and (or) mercury deposits: tract INEP01, Burner, moderate potential (certainty level C); tract INEP02, Cornucopia, moderate potential (certainty level C); tract INEP10, Good Hope, moderate potential (certainty level C); tract INEP03, Wood Gulch, high potential (certainty level D); tract INEP04, Jarbidge, high potential (certainty level D); tract INEP05, TJ, moderate potential (certainty level B); tract INEP06, Angel Wing, high potential (certainty level C); tract INE07, Oakley, high potential (certainty level D); tract INEP08, Star Lake, moderate potential (certainty level B); and tract INEP09, Gollaher, moderate potential (certainty level C). Tract INHU01, Racetrack, has high potential (certainty level D) for hydroallogenic uranium deposits. Five tracts have low potential (certainty level B); four of these have the word “permissive” in the tract name.

Fifteen tracts and tract groups (cospatial tracts assessed for several deposit types) were assessed with high to moderate potential (certainty levels B, C, and D) for various intrusion-related deposits, including porphyry copper and molybdenum deposits, polymetallic (copper-lead-zinc-tungsten-silver-gold) skarn, replacement, and vein deposits, and distal disseminated silver-gold deposits: tract, INPR01, Pluton-related Permissive; tract INPR02, Mountain City Porphyry Copper, Mountain City Porphyry Molybdenum, and Mountain City Polymetallic Vein; tract INPR03, Cobb Creek; tract INPR04, Blue Jacket Polymetallic Replacement, Blue Jacket Polymetallic Vein, and Blue Jacket Tungsten Vein; tract INPR05, Alder Polymetallic Vein and Alder Tungsten-Molybdenum Skarn; tract INPR06, Island Mountain Distal Disseminated Gold-Silver and Island Mountain Polymetallic Vein and Skarn; tract INPR07, Charleston; tract INPR08, Elk Mountain Polymetallic Vein, Elk Mountain Copper Skarn, and Elk Mountain Tungsten-Molybdenum Skarn; tract INPR09, Contact Porphyry Copper, Contact Copper Skarn, Contact Tungsten Skarn, and Contact Polymetallic Vein; tract INPR10, Delano; tract INPR11, Indian Springs; tract INPR12, Gold Basin; tract INPR13, Texas Canyon; tract INPR14, Scraper Springs; tract INPR15, Ashbrook Polymetallic Replacement, Ashbrook Distal Disseminated Silver-Gold, and Ashbrook Polymetallic Vein.

Two tracts (including nested tracts) have potential for volcanogenic massive sulfide (VMS) copper deposits: tract INMS01, VMS Permissive, has low potential (certainty level B); and tracts INMS02 and INMS03, Rio Tinto 1 and Rio Tinto 2, have high potential (certainty levels D and C).

Five tracts (including nested tracts) have potential for Carlin-type gold deposits: tract INCT01, Carlin Permissive, has low potential (certainty level B); tracts INCT02 and INCT03, Willow 1 and Willow 2, have moderate potential (certainty levels D and C); tracts INCT04 and INCT05, Big Springs 1 and Big Springs 2, have high potential (certainty levels D and C); tracts INCT06 and INCT07, Doby George 1 and Doby George 2, have high potential (certainty levels D and C); and tracts INCT08 and INCT09, North Star 1 and North Star 2, have moderate potential (certainty level D and C).

Four tracts have potential for lacustrine diatomite deposits: tract INDT01, Dickshooter, has high potential (certainty level D); tract INDT02, Dickshooter North, has moderate potential (certainty level C); tract INDT03, Owyhee-Twin Falls, has moderate potential (certainty level B); and tract INDT04, Owyhee-Twin Falls-Cassia-Elko, has low potential (certainty level B).

Two tracts (including nested tracts) have potential for bedded barite deposits: tract INBB01, Bedded-barite Permissive, has low potential (certainty level B); and tracts INBB02 and INBB03, Snake Mountains 1 and Snake Mountains 2, have high potential (certainty levels D and C).

In the study area for Nevada additions, no tracts were delineated and rated because there is insufficient evidence of mineral potential in much of the area. However, assessment tracts in the study area for Southeastern Oregon and North-Central Nevada Sagebrush Focal Area cover parts of the Nevada additions. These overlapping tracts are tract ONEP04, Paradise Valley; and tract ONOG01, Orovada. Tracts with low potential (favorable or permissive stratigraphy) for certain deposit types in the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area also extend into the Nevada Addition study area. These tracts consist of favorable stratigraphy for bedded barite, Carlin-type gold, lacustrine diatomite, volcanogenic massive sulfide copper, and intrusion-related deposits (porphyry copper, porphyry molybdenum, polymetallic [copper-lead-zinc-tungsten-silver-gold] skarn, replacement, and vein, and distal disseminated silver-gold deposits).

Leasable and Salable Mineral Commodities

Leasable solid and fluid mineral commodities in the four study areas, including oil and gas, coal, potash, phosphate, borates, and geothermal (table 1), were qualitatively evaluated. None of these commodities has been produced within the study areas. There has been episodic exploration and leasing for oil and gas, coal, potash, phosphate, and geothermal, and favorable stratigraphy for these commodities exists in the four study areas. Two unmined coal fields and favorable stratigraphy for phosphate deposits that occur in and near the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area have low production potential because of low quality (value) and (or) quantity.

Salable mineral commodities, or mineral materials, in the four study areas including common varieties (low unit value) of sand and gravel, aggregate, crushed rock, dimension stone, decorative stone, petrified wood, cinders, clay, and pumice (volcanic cinder), were qualitatively evaluated. There are numerous permits for salable commodities in the four study areas; most permits are for sand and gravel which has been produced from numerous sites. Other permits are for stone (including specialty, weathered, riprap, crushed, and dimension stone) gemstones, common clay, and pumice.

Introduction

The U.S. Department of the Interior has proposed to withdraw approximately 10 million acres of Federal lands identified within more than 165 million acres of lands defined as Sagebrush Focal Areas in Idaho, Montana, Nevada, Oregon, Utah, and Wyoming from mineral entry, subject to valid existing rights (U.S. Department of the Interior, 2015a,b). The purpose of the proposed action is to protect the greater sage-grouse (*Centrocercus urophasianus*) and its habitat from adverse effects of locatable mineral exploration and mining, subject to valid existing rights (Bureau of Land Management, 2015a,b,c). The Sagebrush Focal Areas consist of those public and National Forest System lands shown as Sagebrush Focal Areas on a map posted on the Bureau of Land Management (BLM) Web site (http://blm-egis.maps.arcgis.com/apps/webappviewer/index.html?id=45b2d7896c36467aac3990b739d75a26). In February 2016, the BLM requested assessments of two additional areas in Nevada, termed the “Nevada additions,” which lie to the south of the Southern Idaho and Northern Nevada Sagebrush Focal Area and the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area (fig. 1). The proposed withdrawal areas within the three Sagebrush Focal Areas and the Nevada additions that span the borders of Nevada, Oregon, Idaho, and Utah encompass ~6,454,896 acres (~26,122 square kilometers [km^2]; ~10,086 square miles [mi^2]), of which, the BLM manages ~5,895,064 acres (~23,856 km^2; ~9,211 mi^2). The remaining land (~559,831 acres) is managed primarily by the U.S. Forest Service.

Purposes of the Report

The purposes of this report are to (1) assess the occurrence potential of deposits containing certain locatable mineral commodities, and (2) summarize the current status of locatable, leasable, and salable mineral commodities within four U.S. Geological Survey (USGS) study areas, including three Sagebrush Focal Areas that span the Nevada, Oregon, Idaho, and Utah borders, and the Nevada additions. The four USGS study areas include the Sheldon-Hart Mountain National Wildlife Refuge Complex Sagebrush Focal Area, the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area, the Southern Idaho and Northern Nevada Sagebrush Focal Area, and the Nevada additions (fig. 1). The area studied includes the proposed withdrawal areas in southern Idaho, southern Oregon, northern Nevada, and northwestern Utah. The USGS study area boundaries coincide with Public Land Survey System (PLSS) townships that enclose parts of the proposed withdrawal area. The mineral-resource potential of each study area is described in separate sections of this report.

Potential for occurrence of mineral deposits within the study areas was evaluated only for deposits of locatable mineral commodities. Locatable metallic and nonmetallic mineral commodities that were considered for evaluation are listed in table 1. A subset of those commodities was selected for assessment on the basis of commodities in mined deposits and unmined resources, and commodities that are the focus of current exploration programs within the four study areas. Assessed metallic mineral commodities are copper, gallium, gold, lead, lithium, mercury, molybdenum, silver, tungsten, uranium, and zinc. Assessed nonmetallic mineral commodities are barite, bentonite, diatomite, and zeolite. Deposit types in the study areas that contain the assessed metallic and nonmetallic mineral commodities include epithermal gold, silver, and mercury deposits, sunstone deposits, volcanogenic uranium deposits, hydroallogenic uranium deposits, lithium clay deposits, specialty clay deposits, a variety of intrusion-related porphyry and polymetallic deposits, Carlin-type gold deposits, volcanogenic massive sulfide (VMS) copper deposits, sedimentary exhalative (SEDEX) lead, zinc, and silver deposits, Mississippi Valley-type (MVT) lead and zinc deposits, lacustrine diatomite deposits, bedded barite deposits, zeolite deposits, and bentonite deposits (Day and others, 2016).

This report was prepared as required by the Federal Land Policy and Management Act of 1976 (FLPMA; Pub. L. 94–579; 90 Stat. 2743) for an application for withdrawal of lands. This report follows guidance provided in BLM Manual Sections 3031 and 3060 for mineral assessments and mineral reports. The information and interpretations in this report do not include field examinations; instead, they are based on published descriptions (including documents available on Web sites) of stratigraphy, structure, mining districts, alteration, and exploration programs. The content of this report draws from the experience and knowledge of USGS geologists who have worked in the Sagebrush Focal Areas for more than 50 years.

Organization and Terminology of this Report

This report is based on guidance published in the BLM Manual Sections 3031 and 3060. To the extent possible, the information in this report has been organized to reflect BLM technical and legal language. Information and interpretations are organized by the types of mineral commodities defined by the BLM.

This report includes separate sections for each of the three Sagebrush Focal Areas, Sheldon-Hart Mountain National Wildlife Refuge Complex, Southeastern Oregon and North-Central Nevada, Southern Idaho and Northern Nevada, and for the Nevada additions, in which locatable mineral commodities were considered for assessment. Locatable mineral commodities that were assessed as numbered assessment tracts are grouped by deposit type on the basis of comparison to deposit type models (Day and others, 2016) in each study area. Leasable and salable mineral commodities that occur within the four study areas are broadly discussed in the following paragraphs. Deposits of several leasable mineral commodities are described in corresponding study area report sections.

Within the study areas, some lands, such as BLM wilderness study areas, have already been excluded from mineral entry. There are also inholdings of State and private lands within the study areas. Examples include the two sections set aside in every PLSS township to support State schools, mineral patents, and

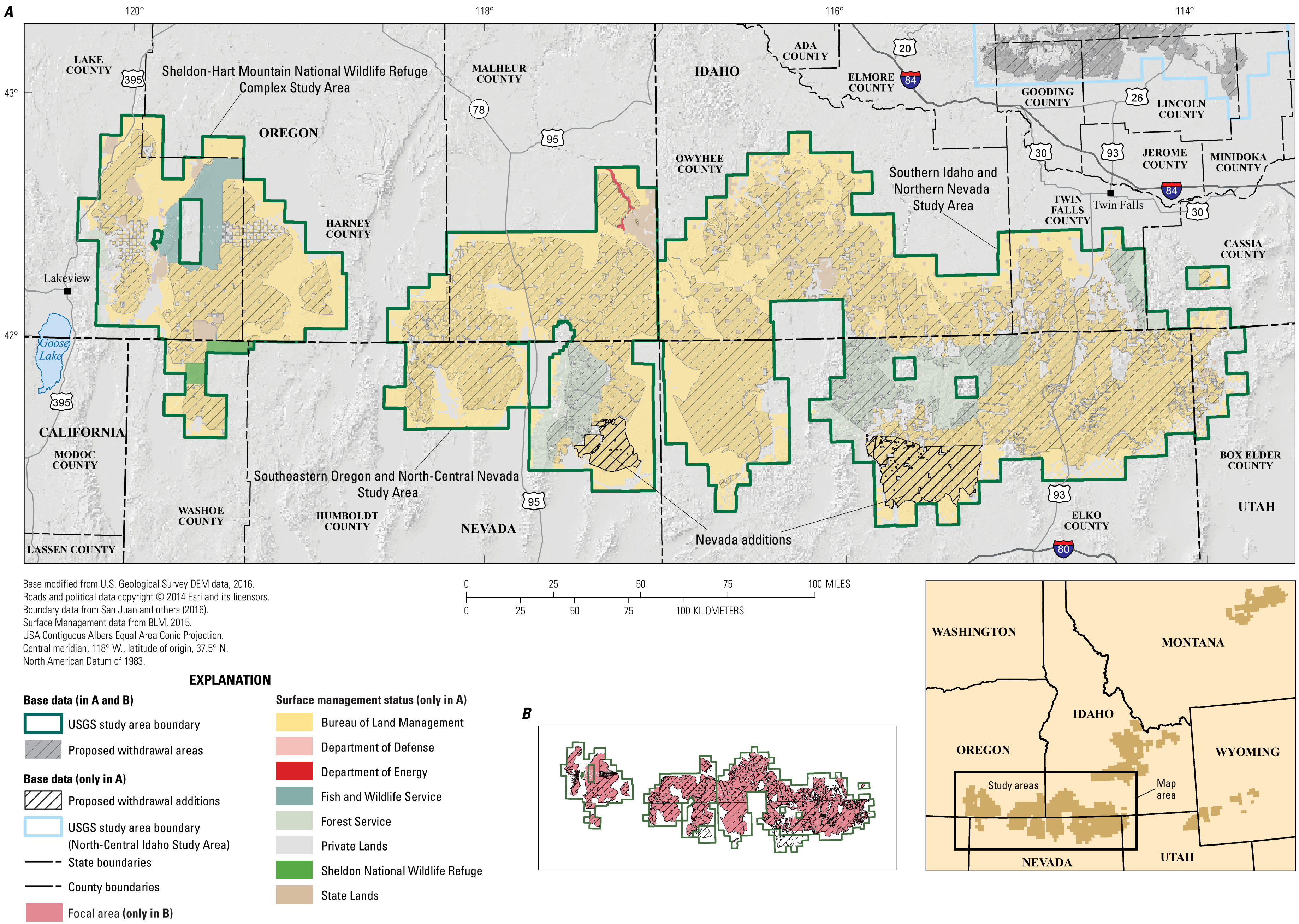


Figure 1. Surface land management map of the four USGS study areas that include three Sagebrush Focal Areas and the Nevada additions. USGS, U.S. Geological Survey.

Table 1. Locatable metallic (metals, metalliferous minerals) and nonmetallic (industrial) minerals, locatable or salable nonmetallic minerals, leasable minerals, salable minerals, and deposit types for locatable mineral commodities in the four USGS study areas. Locatable mineral commodities that were assessed are bold font. USGS, U.S. Geological Survey.

Locatable metals/ metalliferous minerals		Locatable nonmetallic (industrial) minerals	Leasable minerals	Salable minerals
Aluminum	**Molybdenum**	**Barite**	Borates, sodium	Clay (common)
Antimony	Nickel	**Bentonite**	Coal	Sand and gravel
Beryllium	Niobium (Columbium)	Borates, calcium	Geothermal	Stone, building
Bismuth	Platinum group metals	Carbon	Oil and gas	Stone, crushed (aggregate)
Carbon	Rare earth elements	Diamond	Phosphate	Stone, dimension
Chromium	Silicon	**Diatomite**	Potash	—
Cobalt	**Silver**	Fluorspar (fluorite)	Sodium	—
Copper	Tantalum	Travertine	—	—
Gallium	Tellurium	Vermiculite	—	—
Germanium	Thorium	**Zeolite**	—	—
Gold	Tin	—	—	—
Iron	Titanium	—	—	—
Lead	**Tungsten**	—	—	—
Lithium	**Uranium**	—	—	—
Magnesium	Vanadium	—	—	—
Manganese	**Zinc**	—	—	—
Mercury	Zirconium	—	—	—

Deposit types for locatable commodities		
Epithermal gold-silver (mercury)	Lead-zinc skarn	Volcanogenic massive sulfide
Basalt-hosted sunstone	Polymetallic replacement	Sedimentary-exhalative lead-zinc-silver (SEDEX)
Porphyry copper	Polymetallic veins	Bedded barite
Arc-related porphyry molybdenum (low-fluorine)	Distal disseminated silver-gold (antimony)	Mississippi Valley-type lead and zinc
Climax-type porphyry molybdenum	Carlin-type gold (silver, mercury, antimony)	Orogenic low-sulfide gold-quartz vein
Molybdenum-tungsten greisen	Black shale vanadium	Hectorite (lithium clay)
Copper skarn	Hydroallogenic uranium	Specialty clay
Tungsten skarn	Volcanogenic uranium	Zeolites

Classification based on quality

Locatable or salable nonmetallic (industrial) minerals, depending on quality	**Quality criteria for locatable or salable determination**
Building stone	Salable; locatable if uncommon
Clay, specialty	Locatable (for example, ceramic grade); otherwise salable
Garnet	Locatable if high quality (for example, abrasive)
Gemstone	Salable; locatable if uncommon (semi- and nonprecious)
Geodes	Salable; locatable if uncommon
Gypsum	Locatable if high quality (for example, optical grade)
Limestone	Salable; locatable if high quality (for example, chemical, cement grade)
Mica	Locatable if high quality (for example, large sheets, books)
Mineral specimens	Locatable if uncommon
Perlite	Locatable if high quality (for example, industrial or construction grade)
Pozzolan	Salable; locatable if uncommon (for example, concrete additive specifications)
Pumice	Salable; locatable if one dimension ≥2 inches
Silica and silica sand	Salable; locatable if uncommon or high purity (for example, fracking proppant)
Stone, decorative	Locatable; otherwise salable

homesteads. With these exclusions, the proposed withdrawal areas have irregular and patchy shapes. To ensure complete coverage of the withdrawal areas, USGS used a study area that is made up of all the townships that include areas proposed for withdrawal. The townships include those first described by BLM (Bureau of Land Management, 2015c), as formally proposed by DOI (U.S. Department of the Interior, 2015a,b), plus amendments proposed by the State of Nevada (the "Nevada additions") on January 15, 2016 (http://gov.nv.gov/uploadedFiles/govnvgov/Content/News_and_Media/Press/2016_Images_and_Files/Final Transmittal Letter 1.15.16 Signed-reduced-combined.pdf), and further amended by BLM through correspondence (Anthony Titolo, BLM, written commun., April 22, 2016).

Combinations of chemical, economic, geological, and legislated schemes are used to classify mineral commodities. Distinction is made between commodities mined or processed for metals (metallic) and those that are nonmetallic (nonmetallic or industrial). Another scheme differentiates commodities that are extracted out of solid rock (lode) from those that are concentrated in sediments by moving water (placer). Common variety mineral commodities are generally abundant and have wide application but relatively low unit value; they are largely mined from sites determined by transportation costs. Uncommon variety mineral commodities are relatively scarce (high unit value) and have specific qualities; their production is less sensitive to mining, processing, and transportation costs. Strategic and critical mineral commodities are distinguished by high importance to national security and prosperity. Other classification schemes distinguish mineral commodities on the basis of the source (for example, magma; sediments) and concentrating mechanism (for example, hydrothermal fluid; surface water) of the deposit containing the commodity of interest, resulting in deposits referred to as "magmatic-hydrothermal" and "placer," for example.

The BLM differentiates "locatable," "leasable," and "salable" minerals. These legal terms, derived from the General Mining Act of 1872 (30 U.S.C.22–42), distinguish mineral commodities by the procedure required to enable their acquisition (ownership) and extraction on Federal lands. Locatable minerals include metallic mineral commodities as well as some uncommon varieties of industrial minerals with special qualities and uses. Rights to explore for, develop, and extract locatable mineral commodities can be acquired by U.S. citizens by claim location of tracts of public domain Federal lands. Claim location by lode (hard rock) and placer (unconsolidated sediments) claims is limited to 20 acres per claim, claim boundaries must be designated by appropriate monuments, and pre-existing claims must be avoided. Leasable minerals refer to mineral commodities that can be extracted under discretionary leases issued by the BLM (Mineral Leasing Act of 1920 [30 U.S.C. 181–287 et seq.]; the Geothermal Steam Act of 1970, as amended; or the Acquired Lands Act of 1947, as amended). Examples of leasable mineral commodities include oil, gas, coal, oil shale, sodium, potash, phosphate, and all minerals within acquired lands. Salable minerals are those mineral commodities extracted under discretionary sales contracts between the producer and BLM (Mineral Materials Act of 1947 [30 U.S.C. 601 et seq.]). Salable minerals produced from sales sites are generally common variety, low unit value mineral commodities such as sand, gravel, and aggregate. Surface disturbance associated with mineral exploration and production must be approved and authorized according to surface-management notices and plans (43 Code of Federal Regulations [CFR] 3809 and 36 CFR 228 Subpart A).

Land use status of Federal lands within each of the study areas that span the borders of Nevada, Oregon, Idaho, and Utah, including number and type of claims, leases, sales sites, and surface-management (43 CFR 3809 and 36 CFR 228 Subpart A) authorizations, are tabulated in the study area report sections.

Description of Geology

Geologic Framework

Physiography

The Sheldon-Hart Mountain National Wildlife Refuge Complex, Southeastern Oregon and North-Central Nevada, and Southern Idaho and Northern Nevada Sagebrush Focal Areas, and the Nevada additions span the common borders of Nevada, Oregon, Idaho, and Utah. The four study areas encompass the northern parts of the Basin and Range physiographic province (fig. 2), a large, arid region of alternating north-trending rugged mountain ranges and low-relief intermontane basins. Parts of the study areas also cover the high lava plateaus of southern Idaho and the Nevada-California-Oregon border region. The Columbia Plateau physiographic province is characterized by subdued topography underlain by widespread, thick deposits of stratified volcanic rocks and isolated volcanic cinder cones. The study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area includes the southwestern part of the Snake River Plain, a broad northeast-trending basin floored by basaltic lavas. The study areas drain largely to the north and then west via the Snake River, although the south flank of the study area for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area drains to the south into the interior Humboldt River Basin in central Nevada.

Regional Geology and Tectonic Setting

The geologic history of the study areas has been synthesized by Christiansen and Yeats (1992), Doebrich (1996), Wallace and others (2004), and Dickinson (2006, 2013). Pre-Cenozoic rocks can be divided into fault-bounded tectonostratigraphic packages that generally become younger westward across the study areas. The oldest rocks are Precambrian quartzite and schist that host small quartz monzonite intrusions in the easternmost part of the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area (Compton, 1972; Doelling and others, 1980); similar

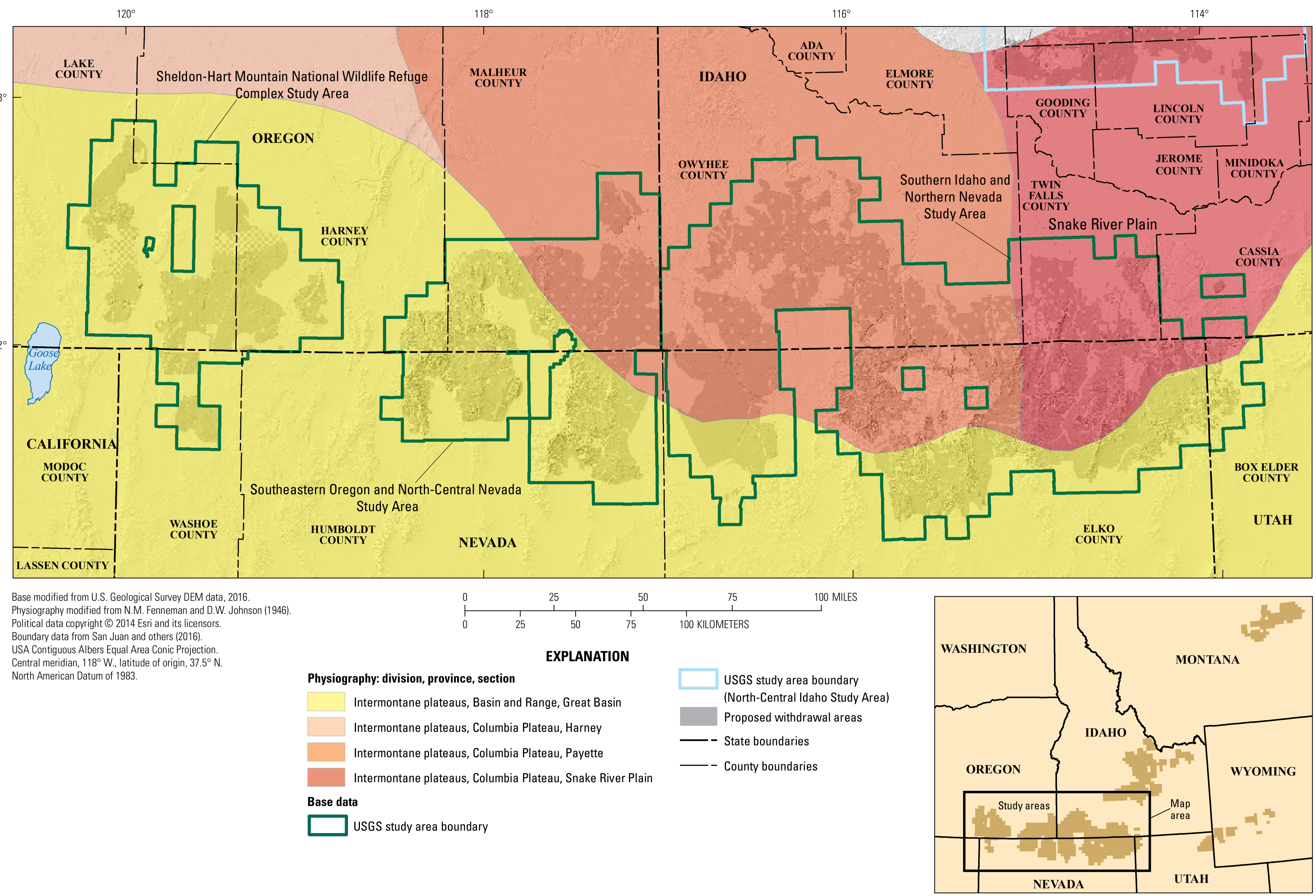


Figure 2. Physiographic map of the four USGS study areas that span the borders of Nevada, Oregon, Idaho, and Utah. USGS, U.S. Geological Survey.

rocks may underlie the Paleozoic shelf-slope sedimentary rocks (mostly carbonates) that crop out widely in the eastern part of this study area. Paleozoic rocks were overthrust, starting in the Late Devonian and continuing through the Mesozoic, by successively younger packages of deepwater marine sediments, which crop out in the central part of the study areas as the Roberts Mountains, Golconda, and Fencemaker allochthons. The far western part of the study areas is mostly covered by Cenozoic volcanic rocks, but basement there probably consists of Paleozoic sedimentary and Mesozoic volcanic arc rocks of the Black Rock (Darby and others, 2000) and Pueblo terranes, which crop out between the study areas for the Sheldon-Hart Mountain National Wildlife Refuge Complex and Southeastern Oregon and North-Central Nevada Sagebrush Focal Areas.

Paleozoic and early Mesozoic sedimentary rocks throughout the study areas are intruded by Jurassic and Cretaceous granitic plutons emplaced during subduction of the Farallon Plate beneath western North America. Following a Late Cretaceous to early Tertiary hiatus, attributed to a change in subduction zone geometry, magmatism resumed with eruption of Eocene to early Miocene silicic to intermediate composition lava flows and tuffs. Beginning about 17 Ma, magmatism was dominated by bimodal basalt-rhyolite volcanism related to the Yellowstone Hot Spot. Miocene flood basalts, caldera-derived rhyolite ash-flow tuff, and rhyolite lava flows blanket much of the study areas. Extensional faulting has been ongoing since at least the middle Miocene, forming the present-day Basin and Range topography and creating numerous basins filled with sediments shed from the rising mountain ranges.

Geologic History

Paleozoic Continental Margin

Precambrian basement rocks are exposed in a few ranges just east, southeast, and south of the study areas (Compton and others, 1977), and are presumed to represent the basement of the Paleozoic continental shelf sequence that is widely exposed in northeastern Nevada. The initial $^{87}Sr/^{86}Sr = 0.706$ isopleth, which is generally considered to mark the boundary between continental crust to the east and oceanic or transitional crust to the west (Kistler and Peterman, 1978; Tosdal and others, 2000), trends northerly through central Nevada but bends eastward in northern Nevada, which relegates the majority of the study areas to a position west of the rifted continental margin (fig. 3).

Deposition of carbonate and siliciclastic sedimentary rocks in eastern Nevada, western Utah, and southwestern Idaho began in the Neoproterozoic and continued through the Triassic to Early Jurassic. These rocks were deposited in shelf, slope, and foreland basin environments along the western margin of North America and constitute a westward-thickening wedge composed of shale, limestone, dolomite, quartzite, conglomerate, and other siliciclastic rocks that reaches an aggregate thickness of more than 10 km. Carbonate units in this sequence are potential skarn host rocks, and the lower Paleozoic carbonates are of particular importance because they host large tonnage Carlin-type gold deposits throughout northern Nevada (Willden, 1964; LaPointe and others, 1991; Doebrich, 1996; Wallace and others, 2004).

During the middle Paleozoic and Mesozoic, shelf and slope rocks were overthrust by successive packages of deeper water rocks that young from east to west. The oldest package is the Roberts Mountains allochthon, a highly deformed sequence of lower Paleozoic chert, argillite, quartzite, and greenstone widely exposed in northeastern Nevada. The Roberts Mountains allochthon was thrust eastward over coeval shelf and slope strata during the Late Devonian–Mississippian Antler orogeny along the regionally extensive Roberts Mountains thrust (Roberts and others, 1958; Stewart, 1980). Throughout northern Nevada, rocks of the Roberts Mountains allochthon host a variety of epigenetic mineral deposits (Willden, 1964; LaPointe and others, 1991).

The Golconda allochthon is a highly deformed package of Mississippian to Permian chert, argillite, shale, and mafic volcanic rocks deposited in an ocean basin and now exposed throughout north-central Nevada (for example, Silberling and Roberts, 1962; Brueckner and Snyder, 1985; Murchey, 1990). These rocks were thrust eastward over the Roberts Mountains allochthon and its Pennsylvanian-Permian overlap sequence along the Golconda thrust during the late Permian-Early Triassic Sonoma orogeny (for example, Miller and Miller, 1991). Rocks within the Golconda allochthon, especially those south of the study areas, contain diverse types of syngenetic and epigenetic mineral deposits (Willden, 1964; LaPointe and others, 1991).

Mesozoic Magmatism and Crustal Shortening

During the Triassic, a thick sequence of fine-grained sedimentary and minor carbonate rocks accumulated in a back-arc basin in what is now western Nevada. The lower part includes carbonate-rich rocks deposited on the continental shelf, whereas the upper part, rocks of the Auld Lang Syne Group (Burke and Silberling, 1973), consists of pelitic turbidite flows deposited as submarine fan deposits in a subsiding marine basin (Compton, 1960; Oldow and others, 1990; Wyld, 2002). The siliciclastic rocks, part of the Fencemaker allochthon of the Luning-Fencemaker fold and thrust belt (Oldow and others, 1990; Wyld and Wright, 2001; Wyld and others, 2003), were thrust eastward over carbonate shelf strata during the Early to Middle Jurassic, isoclinally folded, and metamorphosed to greenschist facies. Fencemaker allochthon rocks host polymetallic vein deposits and epithermal precious metal and antimony veins in the Santa Rosa Range (Willden, 1964; Doebrich, 1996). Middle Jurassic deformation in eastern Nevada and western Utah, some structures of which lie within the southeastern part of figure 3*A* (Thorman and Peterson, 2011), is in part coeval with the Luning-Fencemaker fold and thrust belt.

The Pine Forest Range, Jackson Mountains, and Pueblo Mountains in northwestern Nevada expose Triassic to Middle Jurassic magmatic arc rocks and underlying Paleozoic basement assigned to the Black Rock and Pueblo terranes (Oldow, 1984; Silberling, 1991; Wyld and Wright, 2001), including lava flows, hypabyssal intrusive rocks, volcaniclastic

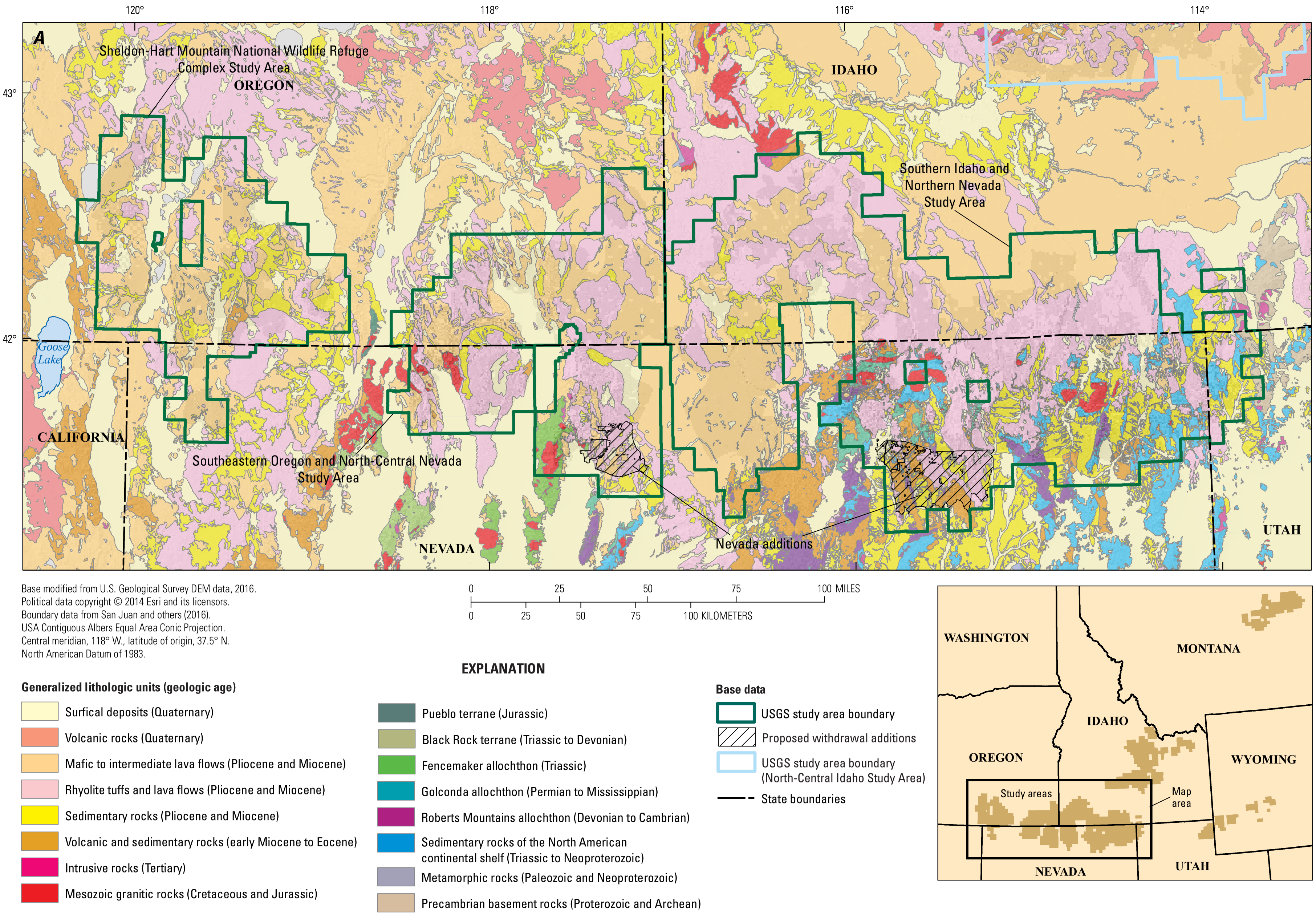


Figure 3. Simplified geologic map (*A*) and lithostratigraphic column (*B*) of the four USGS study areas that span the borders of Nevada, Oregon, Idaho, and Utah. USGS, U.S. Geological Survey. *B*, Stratigraphic and tectonic relationships in the area of the geologic map. Map was synthesized from state geologic maps of Nevada, Oregon, Idaho, California, and Utah (Jennings and others, 1977; Walker and MacLeod, 1991; Hintze and others, 2000; Saucedo and others, 2000; Miller and others, 2002; Crafford, 2007; Lewis and others, 2012).

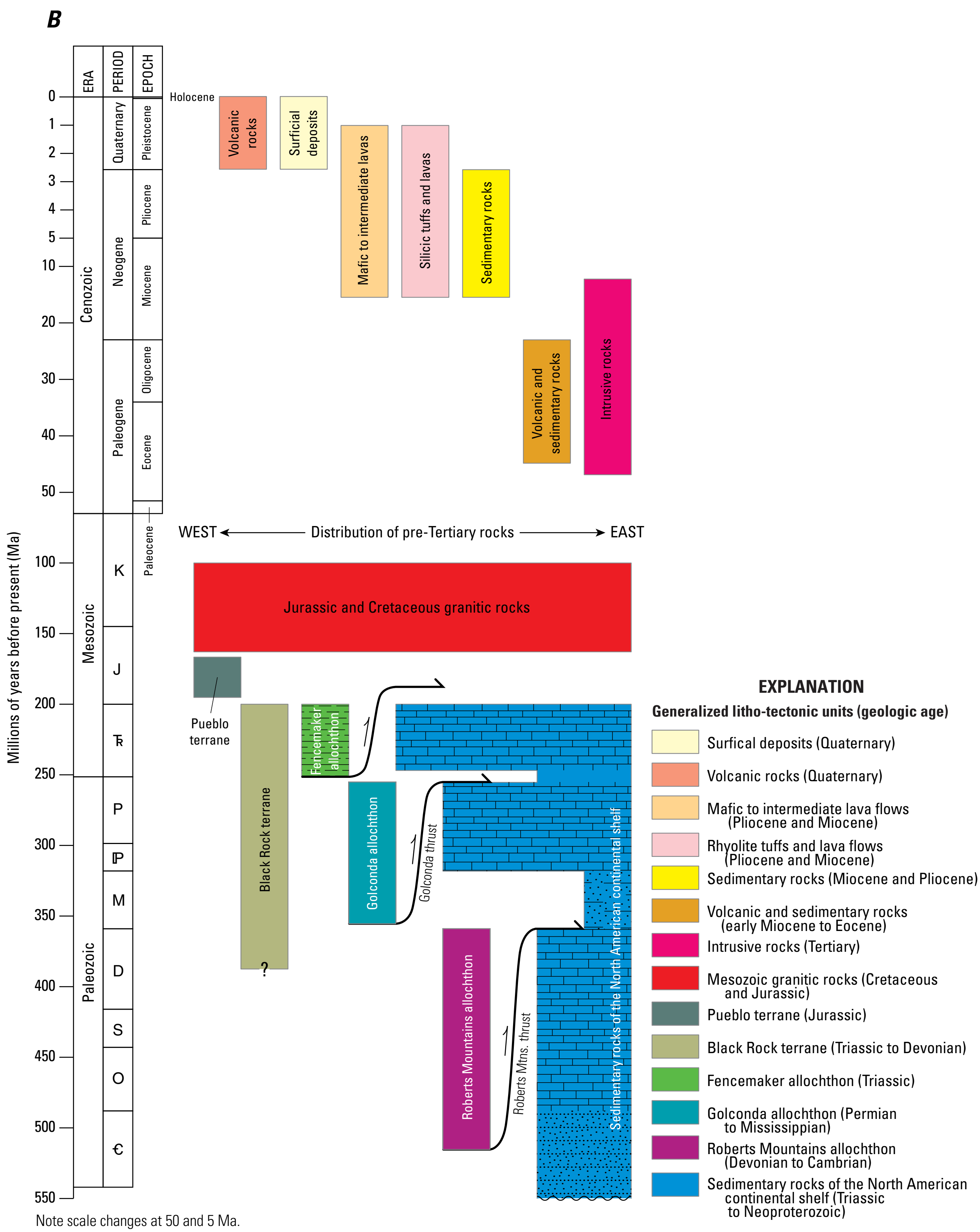


Figure 3. Simplified geologic map (*A*) and lithostratigraphic column (*B*) of the four USGS study areas that span the borders of Nevada, Oregon, Idaho, and Utah. USGS, U.S. Geological Survey. *B*, Stratigraphic and tectonic relationships in the area of the geologic map. Map was synthesized from state geologic maps of Nevada, Oregon, Idaho, California, and Utah (Jennings and others, 1977; Walker and MacLeod, 1991; Hintze and others, 2000; Saucedo and others, 2000; Miller and others, 2002; Crafford, 2007; Lewis and others, 2012).—Continued

rocks, clastic sedimentary rocks, and limestone (Wyld, 1996; Quinn and others, 1997). These rocks do not crop out within the study areas but probably represent basement to the volcanic rocks that underlie the study area for the Sheldon-Hart Mountain National Wildlife Refuge Complex Sagebrush Focal Area.

Mesozoic igneous activity in the study areas was fundamentally driven by subduction of the Farallon Plate beneath the western edge of North America, which caused continental arc magmatism. Jurassic magmatism was dominated by the large granodiorite intrusion near Contact, Nevada (table 2). Several additional, very small volume Jurassic stocks and plugs are distributed across northern Nevada. Compositions of these intrusions (Streckeisen, 1976) range from granite to diorite, though medium- to coarse-grained granite and granodiorite are most common (fig. 3*A*; table 2).

Cretaceous granitic magmatism produced numerous, large, holocrystalline granitic intrusions distributed across northern Nevada and southern Idaho (table 2; fig. 3*A*). Compositions of these medium- to coarse-grained Cretaceous intrusions are almost exclusively granite to granodiorite. Porphyry copper and molybdenum (Seedorff and others, 2005), skarn (Meinert and others, 2005), and polymetallic vein and replacement deposits (Willden, 1964; LaPointe and others, 1991) are closely related to Cretaceous intrusions throughout the study areas.

Cretaceous convergence between the Farallon and North America Plates led to crustal shortening over a broad area of the western United States known as the Sevier fold and thrust belt (for example, Armstrong, 1968; DeCelles, 2004). Paleozoic and lower Mesozoic rocks in eastern Nevada and western Utah were deformed in the hinterland of this belt, primarily into open, upright folds. These structures generally trend north, but bend to an east-trending orientation along the Idaho border in the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area. Magmatism and deformation ceased in the Late Cretaceous as the angle of the subducting slab is inferred to have shallowed and extinguished the Cretaceous arc (for example, Humphreys and others, 2003).

Cenozoic Magmatism

Following Late Cretaceous to early Cenozoic magmatic and tectonic quiescence, magmatism in northern Nevada and southern Idaho resumed in the Eocene and migrated south and west across Nevada during the Oligocene and early Miocene. Southward-sweeping middle Tertiary magmatism is generally attributed to progressive rollback or delamination of the formerly shallow Farallon slab (for example, Humphreys and others, 2003). In the study areas, slab rollback magmatism is largely restricted to rocks erupted about 43–22 Ma (Ludington and others, 1996) in a small area north of Elko, Nevada, and to rocks erupted about 38–24 Ma in northwestern Nevada (Colgan and others, 2006b; Lerch and others, 2008). These rocks include voluminous ash-flow tuffs erupted from calderas in northeastern Nevada (Henry and John, 2013), tuffaceous sediments, flow dome complexes, andesitic lava flows, and volumetrically minor intrusive rocks. Small, Eocene to Oligocene stocks at Mount Neva and Fourmile Creek (table 2), just south of the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, are composed of granodiorite and rhyolite to dacite, respectively (du Bray and Crafford, 2007). The close temporal, spatial, and inferred genetic relations between Eocene intrusions in north-central Nevada and Carlin-type gold deposits have been documented by Ressel and Henry (2006) and Muntean and others (2011).

In contrast, some Cenozoic volcanic rocks in the study area for the Sheldon-Hart Mountain National Wildlife Refuge Complex Sagebrush Focal Area reflect magmatism related to the ancestral Cascades Arc (du Bray and others, 2014). These rocks are consistent with steepening subduction and continued southwest-directed slab rollback that localized magmatism progressively further to the southwest (Dickinson, 2006). The ancestral Cascades Arc was established as a north-northwest-trending array of magmatic centers, principally composite volcanoes, lava dome complexes, and less common shield volcanoes, extending to the southeast from south-central Oregon. Ancestral Cascades Arc rocks in the Coyote Hills and Warner Mountains, in and near the study area for the Sheldon-Hart Mountain National Wildlife Refuge Complex Sagebrush Focal Area, include Oligocene to Miocene basalt, andesite, and rhyolite erupted from composite and shield volcanoes or flow dome complexes (Thomas, 1981; Colgan and others, 2011). Volcanic rocks in the Warner Mountains and Coyote Hills are associated with epithermal mineralization in the High Grade (Keats, 1985) and Lost Cabin (Thomas, 1981) districts, respectively.

Most Cenozoic igneous rocks in the study areas are Miocene to Holocene basalt and rhyolite erupted after about 17 Ma. Voluminous bimodal Miocene volcanism in this region is generally attributed to west-southwest-directed passage of the North American Plate over the Yellowstone Hot Spot (for example, Pierce and Morgan, 1992). The earliest eruptions attributed to the hot spot are voluminous basaltic lava flows of the Steens–Columbia River flood basalt province. Between about 16.6 and 15.0 Ma, about 235,000 cubic kilometers (km^3) of basaltic lava was erupted from fracture zones in the vicinity of the Oregon-Idaho border (Camp and Ross, 2004; Camp and Hanan, 2008), and flowed across large parts of what is now southeastern Oregon and northwestern Nevada. Similar age basalt flows and dikes form the northern Nevada rift, which extends south-southeast from the northern Santa Rosa Range across the study area for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area (Zoback and others, 1994; John and others, 2000).

Basaltic volcanism was closely followed by eruptions of rhyolite tuffs and lava flows, forming the 16.5 to 15.5 Ma McDermitt and High Rock caldera complexes (Rytuba and McKee, 1984; Coble and Mahood, 2016) and Santa Rosa–Calico volcanic field (Breuseke and Hart, 2009) in northwestern Nevada and southeastern Oregon. Voluminous flows of the Jarbidge Rhyolite also blanketed much of the Nevada-Idaho border area about 16 to 15 Ma (Brueseke and others, 2014). Caldera-forming eruptions migrated northeast from northwest Nevada, along the Snake River Plain, becoming progressively younger as the North American Plate moved over the stationary

Table 2. Names, ages, and modal compositions of igneous intrusions, and additional adjacent igneous intrusions in the study areas for the Sheldon-Hart Mountain National Wildlife Refuge Complex, Southeastern Oregon and North-Central Nevada, and Southern Idaho and Northern Nevada Sagebrush Focal Areas.

A. Names, ages, and modal compositions of igneous intrusions, listed from youngest to oldest.

[Polygon centroids identify the central points of all mapped polygons associated with an individual intrusion. ID, Idaho; NV, Nevada; UT, Utah]

Intrusion name	State	Age (Ma)	Modal composition	Polygon centroid(s)	References
Buckskin Mountain	NV	16	Rhyolite	−117.5574, 41.7912	du Bray, 2007; Vikre, 2007
Canyon Creek	NV	16	Rhyolite	−117.5904, 41.7079	du Bray, 2007; Vikre, 2007
Hinkley Summit	NV	16	Dacite	−117.5315, 41.6510	du Bray, 2007; Brueseke and Hart, 2009
National	NV	16	Rhyolite	−117.5882, 41.7767	du Bray, 2007; Vikre, 2007
Wildhorse	NV	Tertiary	Granite	−115.9335, 41.6492	du Bray, 2007
Red Butte	UT	25	Monzogranite	−113.7592, 41.7031; −113.7607, 41.6744	Miller and others, 2012
Almo	ID	29	Granite	−113.8563, 42.0612; −113.7131, 42.0738; −113.6774, 42.1423; −113.6323, 42.1435; −113.7063, 42.1216; −113.8319, 42.0130; −113.7271, 42.0145	Miller and others, 2008
Bearpaw Mountain	NV	75	Granite	−115.5719, 41.9317	du Bray, 2007
Skull Creek	NV	83	Granite	−116.0238, 41.9330; −116.0059, 41.9525	du Bray, 2007
Castle Creek	ID	87–60	Granodiorite	−116.4044, 42.8199; −116.4077, 42.7661	Ekren and others, 1981
Cottonwood Creek west	NV; ID	91–88	Granodiorite	−115.8520, 41.9756; −115.8211, 41.9968; −115.8403, 41.9741; −115.8294, 42.0017	du Bray, 2007
McDonald Creek	NV	91	Granodiorite	−115.9383, 41.9173; −115.8307, 41.9216	du Bray, 2007
Mountain City	NV	93	Granite	−115.8628, 41.8388; −115.8405, 41.8321; −115.8482, 41.8509; −115.9064, 41.8589	du Bray, 2007
White Elephant Butte	NV	100	Granodiorite	−115.0757, 41.8957	du Bray, 2007
Bilk Creek	NV	105	Granite-quartz monzonite	−118.4692, 41.8715; −118.5710, 41.9081	du Bray, 2007; Colgan and others, 2006b
Coffeepot	NV	105–93	Granite	−115.5422, 41.8259; −115.6408, 41.8321	du Bray, 2007
Santa Rosa	NV	105	Granodiorite	−117.6653, 41.5335	du Bray, 2007; Colgan and others, 2006b
Enright Hill	NV	110	Granodiorite	−115.8095, 41.8897; −115.8165, 41.8877	du Bray, 2007
Indian Springs	NV	139–137	Monzogranite-granodiorite	−114.2518, 41.6284	du Bray, 2007
Horse Heaven	NV	Cretaceous	Granite	−115.8856, 41.9431; −115.8775, 41.9551; −115.8649, 41.9671	du Bray, 2007
Long Canyon Copper Mountains	NV	Cretaceous	Granite	−115.6157, 41.9684	du Bray, 2007
Silver Creek	NV	Cretaceous	Granite	−116.0846, 41.7446	du Bray, 2007
Trail Creek	NV	Cretaceous	Granodiorite	−116.0541, 41.6920	du Bray, 2007
White Rock	NV	Cretaceous	Quartz diorite	−116.1196, 41.7003; −116.1387, 41.7007	du Bray, 2007
Columbia	NV	150	Quartz diorite	−116.0574, 41.6711; −116.0684, 41.6814; −116.1615, 41.7049	du Bray, 2007

Table 2. Names, ages, and modal compositions of igneous intrusions, and additional adjacent igneous intrusions in the study areas for the Sheldon-Hart Mountain National Wildlife Refuge Complex, Southeastern Oregon and North-Central Nevada, and Southern Idaho and Northern Nevada Sagebrush Focal Areas.—Continued

Intrusion name	State	Age (Ma)	Modal composition	Polygon centroid(s)	References
Contact	NV	156–124	Granodiorite	−114.7755, 41.7442; −114.5474, 41.7760; −114.8065, 41.7587; −114.6636, 41.7399	du Bray, 2007
Cottonwood Creek east	NV	Jurassic	Diorite	−115.1891, 41.7945	du Bray, 2007
Hammond Canyon	NV	156	Granite	−115.7327, 41.7327	du Bray, 2007
Ninemile Mountain	NV	Jurassic	Granodiorite	−114.4584, 41.4747	du Bray, 2007
Seventy Six Creek	NV	Jurassic	Granite	−115.4950, 41.6987; −115.4872, 41.7056; −115.5053, 41.7123	du Bray, 2007
Ingham Peak	UT	Precambrian	Metamorphosed quartz monzonite	−113.6113, 41.7024; −113.7333, 41.7071; −113.7536, 41.7696	Doelling and others, 1980
Vipont Mountains	UT	Precambrian	Metamorphosed quartz monzonite	−113.7853, 41.8827	Doelling and others, 1980
Granite Peak Santa Rosa	NV	Tertiary-Cretaceous	Granodiorite	−117.5991, 41.6696	du Bray, 2007
Buttermilk Creek	NV	Tertiary-Cretaceous	Granodiorite	−117.4909, 41.5879	du Bray, 2007
Sawtooth	NV	Cretaceous	Granodiorite	−117.7467, 41.5739	du Bray, 2007
Disaster Peak	NV	Cretaceous	Granodiorite-quartz diorite	−118.2699, 41.9724; −118.2025, 41.9004	du Bray, 2007
Trident Peak	NV; OR	Cretaceous	Granodiorite	−118.3413, 41.8178; −118.3321, 41.8366; −118.3467, 41.8487; −118.4261, 41.8928; −118.3869, 41.9058	du Bray, 2007

B. Additional adjacent igneous intrusions.

[ID, Idaho; NV, Nevada; UT, Utah]

Intrusion name	State	Age (Ma)	Modal composition	Polygon centroid(s)	References
McGinty	UT	37	Monzogranite to granodiorite	−114.0344, 41.3083	Miller and others, 1987
Fourmile Creek	NV	Oligocene-Eocene	Rhyolite-dacite	−116.4720, 41.4035; −116.4612, 41.4052	du Bray, 2007
Mount Neva	NV	39	Granodiorite	−116.3566, 41.3179; −116.3436, 41.3228; −116.3344, 41.3231; −116.3186, 41.3262; −116.3577, 41.3267; −116.3573, 41.3498	du Bray, 2007
Rocky Pass	UT	Tertiary	Quartz monzonite	−113.6299, 41.4929; −113.6393, 41.4994; −113.7717, 41.5095; −113.6328, 41.5117; −113.7561, 41.5145; −113.6185, 41.5110; −113.6653, 41.5050; −113.6929, 41.5245; −113.7202, 41.5288; −113.6434, 41.5288; −113.7534, 41.5363	Doelling and others, 1980
South Mountain	ID	50–45	Quartz diorite to granodiorite	−116.9025, 42.7738; −116.8866, 42.7176	Ekren and others, 1981

Table 2. Names, ages, and modal compositions of igneous intrusions, and additional adjacent igneous intrusions in the study areas for the Sheldon-Hart Mountain National Wildlife Refuge Complex, Southeastern Oregon and North-Central Nevada, and Southern Idaho and Northern Nevada Sagebrush Focal Areas.—Continued

Intrusion name	State	Age (Ma)	Modal composition	Polygon centroid(s)	References
Summit Creek	NV	Cretaceous	Granodiorite	−116.1054, 41.8596	du Bray, 2007
Winter Creek	NV	Cretaceous	Granite	−116.1096, 41.7869	du Bray, 2007
Boone Peak	ID	87–60	Granodiorite	−116.6964, 42.9061	Ekren and others, 1981
Duffer Peak	NV	96	Granodiorite	−118.6949, 41.6898; −118.6330, 41.6270; −118.7586, 41.6479	Smith, 1973
Mahogany Mountain	NV	105	Granodiorite	−118.6348, 41.7873	Colgan and others, 2010
Rattlesnake Spring	NV	106	Quartz monzodiorite	−118.6348, 41.7873	Colgan and others, 2010
Thacker Canyon	NV	108	Granodiorite	−118.6348, 41.7873	Colgan and others, 2010
Lone Mountain	NV	110	Quartz monzodiorite	−118.6754, 41.8554	Colgan and others, 2010
Cold Spring	NV	111	Quartz monzodiorite	−118.6754, 41.8554	Colgan and others, 2010
New York Peak	NV	Cretaceous	Quartz monzonite	−118.7586, 41.6479	Smith, 1973
Emigrant Pass	NV	162	Granite	−118.6542, 41.8880	Colgan and others, 2010
Happy Creek	NV	173	Monzogranite-granodiorite	−118.4528, 41.4515	du Bray, 2007
Rocky Canyon Jackson	NV	Tertiary-Cretaceous	Granodiorite	−117.6358, 41.3537	du Bray, 2007
Strawberry Butte	NV; OR	176	Quartz diorite	−118.6593, 42.0152; −118.6632, 41.9989; −118.6459, 42.0287; −118.6290, 42.0482; −118.6896, 41.9822	Wolak, 1994
Baltazor	NV	182	Unspecified	−118.6433, 41.9279	Wolak, 1994
Theodore	NV	184	Quartz diorite	−118.6514, 41.6674; −118.6261, 41.6710; −118.6098, 41.6851; −118.6895, 41.7356	Colgan and others, 2010
Cowden Creek	NV; OR	188	Tonalite to quartz diorite	−118.7027, 41.9453	Wolak, 1994
Andorno	NV	Tertiary-Cretaceous	Granodiorite	−117.7465, 41.4296	du Bray, 2007
Austin Creek	NV	Tertiary-Cretaceous	Granodiorite	−117.7349, 41.4479	du Bray, 2007
Davey Town	NV	Tertiary-Cretaceous	Granodiorite	−117.9255, 41.3146	du Bray, 2007
Flynn	NV	Tertiary-Cretaceous	Granodiorite	−117.7613, 41.2670	du Bray, 2007
Porcupine Creek	NV	Tertiary-Cretaceous	Granodiorite	−117.7193, 41.3802	du Bray, 2007
Stonehouse	NV	Tertiary-Cretaceous	Granodiorite	−117.6827, 41.4131	du Bray, 2007
Dennis Hill	UT	Precambrian	Metamorphosed quartz monzonite	−113.6138, 41.7968; −113.6354, 41.8075; −113.6203, 41.8059; −113.6733, 41.8107; −113.6250, 41.8185; −113.6335, 41.8330; −113.6139, 41.8364	Compton, 1972
Century Hollow	UT	Precambrian	Metamorphosed quartz monzonite	−113.5294, 41.8563; −113.5137, 41.8596; −113.4905, 41.8685; −113.4482, 41.8798	Compton, 1972
Cedar Hills	UT	Precambrian	Metamorphosed quartz monzonite	−113.7251, 41.9495; −113.7111, 41.9846	Compton, 1972

Yellowstone Hot Spot; most of these younger calderas are now buried by younger mafic lava flows (Pierce and Morgan, 1992).

The exceptionally high-volume, bimodal volcanism associated with the Yellowstone Hot Spot inundated the land surface throughout the study areas, covering older rocks and—potentially—mineral deposits. Most epithermal gold, silver, and mercury deposits throughout the study areas are closely associated with Miocene bimodal volcanism (Vikre, 1985b, 2007; John, 2001; Saunders and others, 2008). An unusually wide variety of epithermal deposit types, including gold, silver, mercury, uranium, lithium, and gallium deposits, are spatially and temporally associated with peralkaline volcanism and formation of the McDermitt caldera at about 16.5 Ma (Rytuba and Glanzman, 1979; Castor and Henry, 2000; Rytuba and others, 2003; Myers and Underhill, 2005; Carew, 2008).

Cenozoic Structure and Sedimentary Basins

The study areas are coincident with the northern edge of the Basin and Range Province, a region of fault-block mountain ranges formed during Cenozoic crustal extension. Most extensional faulting was accommodated by large half-graben or horst-and-graben normal faults with kilometers of offset, which formed the north-trending ranges and intermontane valleys that give the province its name. In northwestern Nevada, major fault-block ranges began forming about 12 to10 Ma (Colgan and others, 2006a,b) and extensional faulting has continued to the present, becoming overall younger to the north in southeastern Oregon (for example, Scarberry and others, 2010). Extensional faulting in northeastern Nevada occurred locally as early as the Eocene (Rahl and others, 2002), but the main episode began about 17 to 16 Ma and has continued to the present (Colgan and Henry, 2009). Middle Miocene sedimentary rocks deposited in extensional basins during this period are widely exposed throughout northeastern Nevada (fig. 3). The northern and western parts of the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area encompass the Owyhee Plateau and part of the Snake River Plain (fig. 3), which are north of the Basin and Range proper, and, although cut by many faults, were much less affected by Cenozoic extension.

Cenozoic extension influenced the formation and distribution of mineral deposits in three major ways: (1) pre- and synmineralization extensional faults and fracture systems provided conduits for fluids in the shallow crust, influencing the location of deposits formed during and after extension; (2) postmineralization extensional faults locally dismembered deposits, increasing or decreasing deposit depth and continuity; and (3) sedimentary rocks deposited in extensional basins potentially buried deposits formed during earlier periods of mineralization.

Valleys between major fault-bounded ranges are filled with fluvial and lacustrine deposits consisting of silt, sand, and gravel eroded from the bounding ranges and by volcanic tephra and lava flows. These valley-fill deposits range from tens of meters to kilometers in thickness (Blakely and Jachens, 1991). Most high, steep mountain ranges are flanked by fan deposits consisting of massive, poorly sorted, unconsolidated deposits with silt- to boulder-size clasts in a silty to sandy matrix. These deposits form aprons at the break in slope where drainages emerge from steeper upland areas. During the Miocene and Quaternary, some low-lying regions were inundated by large pluvial lakes in which fine-grained sediments were deposited (Wallace and others, 2004). Surficial deposits may host placer and diatomite deposits and may conceal deposits in the underlying bedrock. Epithermal gold and silver deposits are locally forming in unconsolidated surficial and basin-fill deposits in upflow zones of active thermal systems along basin-bounding faults in the study areas (Breit and others, 2011; Coolbaugh and others, 2011).

Locatable Minerals

Numerous locatable mineral commodities, including metallic and nonmetallic (also known as industrial) mineral commodities, occur in and near the four study areas. Many metallic commodities (for example, copper, silver, and lead) occur in several deposit types as determined by comparison to deposit type models (Day and others, 2016), and two or more metals (for example, gold and silver) commonly have been produced from one deposit. Commodities that (1) have been mined within the USGS study area boundary (fig. 1; table 3); (2) are known to exist within the USGS study area boundary from exposures in prospects and exploration drill holes; and (3) are suspected to exist within the USGS study area boundary on the basis of stratigraphy (including intrusions) and structures known to contain mined deposits, are included in table 1. Of the 46 locatable metallic and nonmetallic mineral commodities in table 1, and 14 commodities that are locatable or salable (depending largely on quality and value), 17 commodities were assessed for potential to occur in undiscovered deposits in each study area. Assessment of these 17 commodities was based primarily on (1) deposits (mines, resources, prospects, and occurrences) containing the assessed commodity or commodities (table 3); (2) geological, geochemical, alteration, geophysical, and other characteristics of the deposits and deposit types which included the assessed commodity or commodities (appendix 2; Day and others, 2016); (3) records of active and historical mining claims and surface-management plans provided by the BLM and USFS were also used in the assessment process; and (4) market analyses (appendix 5 and section I, Day and others, 2016). Locatable mineral commodities that were considered for assessment but were not assessed are briefly described in appendix 3.

Mineral potential assessment of the 17 commodities included (1) delineation of tracts that enclose rocks with favorable characteristics of deposit types (a) known to contain the assessed commodities, and (b) known to exist in the tract; (2) assignment of potential for undiscovered deposits in the tract; (3) assignment of relative certainty of mineral potential. Characteristics of deposits, including production, resources, stratigraphy and geochemistry of host rocks, structural control of deposits, and alteration mineral associations, are tabulated for each tract (appendix 2). Tracts are described and justified in the separate report sections on each study area. Maps showing tract

Table 3. Mined deposits, with production, and resources of locatable mineral commodities within the USGS study areas. USGS, U.S. Geological Survey.

[Some sources are in Fernette and others, 2016a. Nevada mining districts are from Tingley (1992). One flask of mercury = 76 pounds of mercury; one unit of tungsten = 20 pounds of tungsten trioxide (WO_3) or 15.86 pounds of tungsten; est., estimate; g/metric ton, grams per metric ton; ID, Idaho; kg, kilogram; lbs, pounds; M+I+I, measured plus indicated plus inferred; MST, million short tons; NV, Nevada; opt, troy ounce per short ton; OR, Oregon; oz, troy ounce; ppm, part per million; ST, short ton; U_3O_8, triuranium octoxide; UT, Utah; WO_3, tungsten trioxide; @, at; %, weight percent; $, U.S. dollars; M, million]

Mine/ Deposit name	Assessment tract name	Mining district	County, state	Commodity	Production years	Production	Resource	Notes; source
Sheldon-Hart Mountain National Wildlife Refuge Complex study area								
Antelope Mine	SHEP02, Sheldon West	Lone Pine	Washoe, NV	Mercury	1939	5 flasks mercury	—	Ross (1941), Bailey and Phoenix (1944), Holmes (1965), Bonham and Papke (1969)
Gray Mine	SHEP01, Coyote Hills	—	Lake, OR	Mercury	1941–43	7 flasks mercury	—	Fernette and others (2016a)
Farnham, Mogul, Rabbit Hole Mines	—	—	Washoe, NV; Lake, OR	Mercury	1919/1942	34 flasks mercury	—	Fernette and others (2016a)
Southeastern Oregon and North-Central Nevada study area								
National Mine	ONEP03, Buckskin	National	Humboldt, NV	Gold and silver	1909–1929	175,502 oz gold; 457,190 oz silver	—	Vanderburg (1938)
Buckskin National Mine	ONEP03, Buckskin	National	Humboldt, NV	Gold and silver	1908–1941	24,000 oz gold; 300,000 oz silver	138,351 ST @ 0.363 opt gold; 3.37 opt silver	Fernette and others (2016a), Vikre (1985b)
McCormick/Paradise Mine	ONEP03, Buckskin	National	Humboldt, NV	Mercury	1930s	58 flasks mercury	est. 2,000–3,000 flasks	Vanderburg (1938), Roberts (1940)
Silver Butte claims	ONEP04, Paradise Valley	Paradise Valley	Humboldt, NV	Silver and gold	1879–1935	est. $1.5–3M	—	Vanderburg (1938)
Cordero	ONEP01, Cordero	Opalite	Humboldt, NV	Gold and silver	—	—	—	—
Cordero Mine	ONEP01, Cordero	Opalite	Humboldt, NV	Mercury	1941–43	105,636 flasks mercury	—	Yates (1942); Bailey and Phoenix (1944); Rytuba (1976); Speer (1977); NI 43-101 NV Cordero Gold Silver Project August 1, 2007 technical report; Fernette and others (2016a)
Cordero (McDermitt) Mine	ONEP01, Cordero	Opalite	Humboldt, NV	Mercury	1975–1986	269,580 flasks mercury	1,070,000 ST @ 7.25 lbs mercury/ ST	
Bretz Mine	ONEP01, Cordero	Opalite	Malheur, OR	Mercury	1931–1968	14,807 flasks mercury	—	
Opalite Mine	ONEP01, Cordero	Opalite	Malheur, OR	Mercury	—	12,367 flasks mercury	—	
Ruja Mine	ONEP01, Cordero	Opalite	Humbolt, NV	Mercury	—	6,000 flasks mercury	—	
Cordero (McDermitt) Mine	ONEP01, Cordero	Opalite	Humboldt, NV	Gallium	—	—	21,562,700 million metric tons @ 46.5 ppm gallium (M+I+I)	Carew (2008)
Moonlight Mine	ONVU01, Kings Valley	Opalite	Humboldt, NV	Uranium	—	600 kg (~1,320 lbs)	479,000 ST @ 0.108% U_3O_8	Castor and Henry (2000), Fernette and others (2016a)
Kings Valley South; Kings Valley North	ONVU01, Kings Valley	Opalite	Humboldt, NV	Uranium	—	—	2,499,000 ST @ 0.076% U_3O_8	NI 43-101 NV Kings Valley Project December 20, 2007 technical report; Eggleston and others (2007)

Table 3. Mined deposits, with production, and resources of locatable mineral commodities within the USGS study areas. USGS, U.S. Geological Survey.—Continued

Mine/ Deposit name	Assessment tract name	Mining district	County, state	Commodity	Production years	Production	Resource	Notes; source
Southeastern Oregon and North-Central Nevada study area—Continued								
Aurora	ONVU01, Kings Valley	Opalite	Malheur, OR	Uranium	—	—	76,390,184 ST @ 248 ppm U_3O_8	https://aurorauraniumlimited.wordpress.com/projects/, accessed January 14, 2016; Meyers and Underhill (2005)
Kings Valley Lithium	ONVU01, Kings Valley	Opalite	Humboldt, NV	Lithium	—	—	823 MST @ 0.30% lithium	Tetra Tech (2014), Eggleston (2008)
Southern Idaho and Northern Nevada study area								
Jarbidge	INEP04, Jarbidge	Jarbidge	Elko, NV	Gold and silver	1910–1950	355,707 oz gold; 1,666,222 oz silver	—	LaPointe and others (1991)
Alpha Mine	—	—	—	Gold and silver	1923–26	$12,512	—	Couch and Carpenter (1943)
Bluster	—	—	—	Gold and silver	1916–1929	$74,374	—	Couch and Carpenter (1943)
Wildcat	—	—	—	Barite	1955–58	2,727 ST	—	LaPointe and others (1991)
Coon Creek	—	—	—	Tungsten	1943–1956	608 units WO_3	—	Stager and Tingley (1988)
Buckeye and Ohio	INEP10, Good Hope	Good Hope	Elko, NV	Gold and silver	1880–1882; 1921	District: $100,000; ~91,000 oz gold	—	Emmons (1910), Knox (1970), LaPointe and others (1991)
—	—	—	—	Antimony	1950	"several thousand pounds"	—	Lawrence (1963), LaPointe and others (1991)
—	INEP02, Cornucopia	Cornucopia	Elko, NV	Silver and gold	Late 1800s	760,000 oz silver; 13,000 oz gold	—	Emmons (1910)
Diamond Jim, Rosebud, Gribble	INPR06, Island Mountain	Island Mountain	Elko, NV	Gold, silver, lead, zinc, copper, anti-mony, tungsten	1918–1982	District: 1,520 oz gold; 120,671 oz silver; 822 ST lead; 42 ST zinc; 5 ST copper; 11 ST antimony; 15 units tungsten	26,300,000 ST @ 0.019 opt gold	LaPointe and others (1991); Fern-ette, Bellora, and others (2016)
Doby George	INCT06, Doby George 1	Island Mountain	Elko, NV	Gold	—	—	27,100,000 ST @ 0.028 opt gold	Davis and others (2006); NV NI 43-101 Doby George-Wood Gulch-IL Ranch Properties April 24, 2008 technical report
Big Springs	INCT04, Big Springs 1	Independence Mountains	Elko, NV	Gold	1987–1993	386,000 oz gold	14.8 million metric tons @ 2 g/metric ton gold	Anova Metals Limited (2016)

Table 3. Mined deposits, with production, and resources of locatable mineral commodities within the USGS study areas. USGS, U.S. Geological Survey.—Continued

Mine/ Deposit name	Assessment tract name	Mining district	County, state	Commodity	Production years	Production	Resource	Notes; source
Southern Idaho and Northern Nevada study area—Continued								
Bull Run, Lucky Girl	—	Edgemont	Elko, NV	Gold, silver, lead, zinc, copper, tungsten	1902–1971	District: 39,121 oz gold; 90,649 oz silver; 100 ST lead; 2 ST zinc; 1 ST copper; 3 units tungsten	—	LaPointe and others (1991)
White Rock	INEP06, Angel Wing	—	Elko, NV; Box Elder, UT	Gold	2009	—	9,000,000 ST @ 0.018 opt gold; ~150,000 oz gold	Goodall (2003), Kehmeier (2009)
Gravel Creek	INEP03, Wood Gulch	—	Elko, NV	Gold and silver	—	—	16,940,000 ST @ 0.08 opt gold; 1.2 opt silver	Inventory; Fernette and others (2016a)
Wood Gulch	INEP03, Wood Gulch	—	Elko, NV	Gold	1988–1990	34,782 oz gold	Est. 780,000 ST @ 0.12 opt gold	NV NI 43-101 Doby George-Wood Gulch-IL Ranch Properties April 24, 2008 technical report
Blue Hill Creek	INE07, Oakley	—	Cassia, ID	Gold	—	—	14,400,000 ST @ 0.016 opt gold	Fernette and others (2016a)
Cleveland, Delano	INPR10, Delano	Delano	—	Gold, silver, lead, zinc, copper	1918–1980	District: 333 oz gold; 1,499,973 oz silver; 11,069 ST lead; 693 ST zinc; 84 ST copper; 384 units tungsten	—	LaPointe and others (1991)
Indian Springs	INPR10, Delano	Delano	Elko, NV	Tungsten	—	—	18,900,000 ST @ 0.17% WO_3	Stager and Tingley (1988), LaPointe and others (1991)
Blue Ribbon-Boyce	—	Aurum	Elko, NV	Antimony	1940	7 ST antimony	—	Lawrence (1963)
Rio Tinto, Mountain Laurel, Silver King	INPR02, Mountain City; INMS02, Rio Tinto 1	Mountain City	Elko, NV	Copper, gold, silver, lead	1869–1982	District: 101,984 ST copper; 20,557 oz gold; 559,561 oz silver; 54 ST lead; <1 ST zinc	—	LaPointe and others (1991)
Race Track, Rim Rock, South Fork-Pixley	INHU01, Racetrack	Mountain City	—	Uranium	1950s–1960s	20,876 lbs U_3O_8	1,100,000 lbs U_3O_8	Drilled resource 1967–1983; Bayswater Uranium Corporation (2007); Proffitt and others (1982)
Blue Jacket	INPR04, Blue Jacket	Aura	Elko, NV	Gold, silver, copper, lead, zinc	—	—	2 MST @ 0.01 opt gold; 2.2 opt silver; 0.25% copper; 2% lead; 1.8% zinc	Long and others (1998)

Table 3. Mined deposits, with production, and resources of locatable mineral commodities within the USGS study areas. USGS, U.S. Geological Survey.—Continued

Mine/ Deposit name	Assessment tract name	Mining district	County, state	Commodity	Production years	Production	Resource	Notes; source
Southern Idaho and Northern Nevada study area—Continued								
Contact	INPR09, Contact	Contact	Elko, NV	Copper, gold, silver, lead, tungsten	1908–1965	District: 2,876 ST copper; 1,222 oz gold; 126,901 oz silver; 180 ST lead; 9 ST zinc; 117 units WO_3	473,000,000 ST @ 0.19% copper	LaPointe and others (1991), Fernette and others (2016a)
Consolation-Boies, Big Ledge, Hunch, Jungle A, Jungle, Little Dry	INBB02, Snake Mountains 1	Snake Mountains	Elko, NV	Barite	1974–1985	District: 1,008,964 ST barite	—	LaPointe and others (1991)
Batholith	—	Charleston	Elko, NV	Tungsten	1954–56	452 units WO_3	—	Stager and Tingley (1988)
Prunty	—	—	—	Gold, silver, copper, lead, antimony, tungsten	—	District: 2,177 oz gold; 2,861 oz silver; 4 ST copper; 7 ST lead; <1 ST zinc; 16 ST antimony	—	LaPointe and others (1991)
Garnet	—	Alder	Elko, NV	Tungsten	—	—	748,000 ST @ 0.43% WO_3	LaPointe and others (1991)
Ashbrook	INPR15, Ashbrook	Ashbrook	Box Elder, UT	—	—	District: 180,000 ST ore; 3,440,000 oz silver	—	Gloyn and Krahulec (2006)

outlines and selected tract-defining characteristics accompany tract descriptions (San Juan and others, 2016).

Leasable Minerals

Leasable solid and fluid mineral commodities covered in this report are oil and gas, coal, potash, phosphate, borates, and geothermal (table 1). None of these commodities has been produced within the USGS study area boundaries. No exploration and leasing activity for borates has occurred and there is apparently no permissive stratigraphy for borates in the four study areas. Exploration and leasing activity, and permissive stratigraphy for oil and gas, coal, potash, phosphate, and geothermal are briefly summarized below. Two unmined coal fields and favorable stratigraphy for phosphate deposits occur within the USGS study area boundary of the Southern Idaho and Northern Nevada Sagebrush Focal Area. The coal fields and favorable phosphate stratigraphy, which have low production potential because of low quality (value) and (or) quantity, are described in the report section "Mineral-Resource Potential of the Study Area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, Nevada, Idaho, and Utah."

Oil and Gas

The four study areas lie within the Eastern Great Basin, Idaho-Snake River Downwarp, and Western Great Basin oil and gas provinces. According to IHS Enerdeq well data (IHS Energy Group, 2016), there has been no significant oil or gas production within the study areas (fig. 4; appendix 4). Some oil has been produced in Elko County, Nevada, about 15 mi south of the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, Nevada, Idaho, and Utah, in the Toano Draw Field and the Deadman Creek Field. About 367 barrels were produced from the Miocene Humboldt Formation in the 1990s before the well became inactive (LaPointe and others, 2007). Many dry wells are present in the study areas.

The four study areas have been assessed for potential hydrocarbon resources. Two plays (Miocene Lacustrine, and older Tertiary [nonquantitative]) from the 1995 assessment of the Idaho-Snake River Downwarp Province include some northeast PLSS townships within study areas. Some 1995 plays from the western part of the Great Basin Province include some western PLSS townships within study areas. These plays include the Eastern Oregon Neogene Basins, Cretaceous Source Rocks of Northwestern Nevada, and the Neogene Source Rocks of Northwestern Nevada and Eastern California; however, these are hypothetical plays and were not quantitatively assessed. There are also assessment units in the Eastern Great Basin Province that overlap some study areas. Overall, there are seven assessment units or plays in three oil and gas provinces included in parts of the four study areas. Within the Idaho-Snake River Downwarp Province, there are assessed mean potential resources of 0.9 million barrels of oil (MMBO), and 11.2 billion cubic feet (BCF) of gas (Peterson, 1995). Within the Eastern Great Basin Province, the USGS assessed potential mean resources of almost 1,300 MMBO, 1,302 BCF of gas, and 60 million barrels of natural gas liquids (NGLs) (U.S. Geological Survey Eastern Great Basin Assessment Team, 2007).

Of the 565 townships in the four study areas, 208 are not associated with an oil and gas assessment unit. Although some potential oil and gas resources have been accessed in the area and near some of the study areas, there has been no significant hydrocarbon production within the study areas and overall potential appears to be low to moderate considering the presence of several dry wells within the study areas.

Coal

Two low-quality lignite coal fields are in the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area (fig. 5). A coal field is a discrete area underlain by strata containing one or more coal beds (Wood and others, 1983). In the context for this report, a coal field is considered an area where coal is or has been produced or has significant potential to be produced economically, and a coal region is considered as an area underlain by coal-bearing formations. These two low-quality lignite coal fields are described in the report section "Mineral-Resource Potential of the Study Area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, Nevada, Idaho, and Utah; Coal."

No coal resources and no coal-bearing formations occur in the study area for the Sheldon-Hart Mountain National Wildlife Refuge Complex Sagebrush Focal Area. The USGS report of coal fields in the conterminous United States (East, 2013) shows that this study area is not within any known coal region and no coal fields or regions are within the 25-km buffer zone (Smith and Roe, 2015). Rocks and strata exposed at the surface within the proposed withdrawal area include Quaternary alluvium, and Tertiary, Miocene, and Pliocene basalts, andesites, and volcaniclastic strata.

Potash

No potash production has occurred, and no potash deposits are in the four study areas. Closed and expired potash leases are in the study area for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area (fig. 6; table 1). Favorable geologic environments in and near the four study areas, and the potash leases, are described in the report section "Mineral-Resource Potential of the Study Area for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area, Nevada and Oregon; Occurrence of Leasable Minerals; Potash."

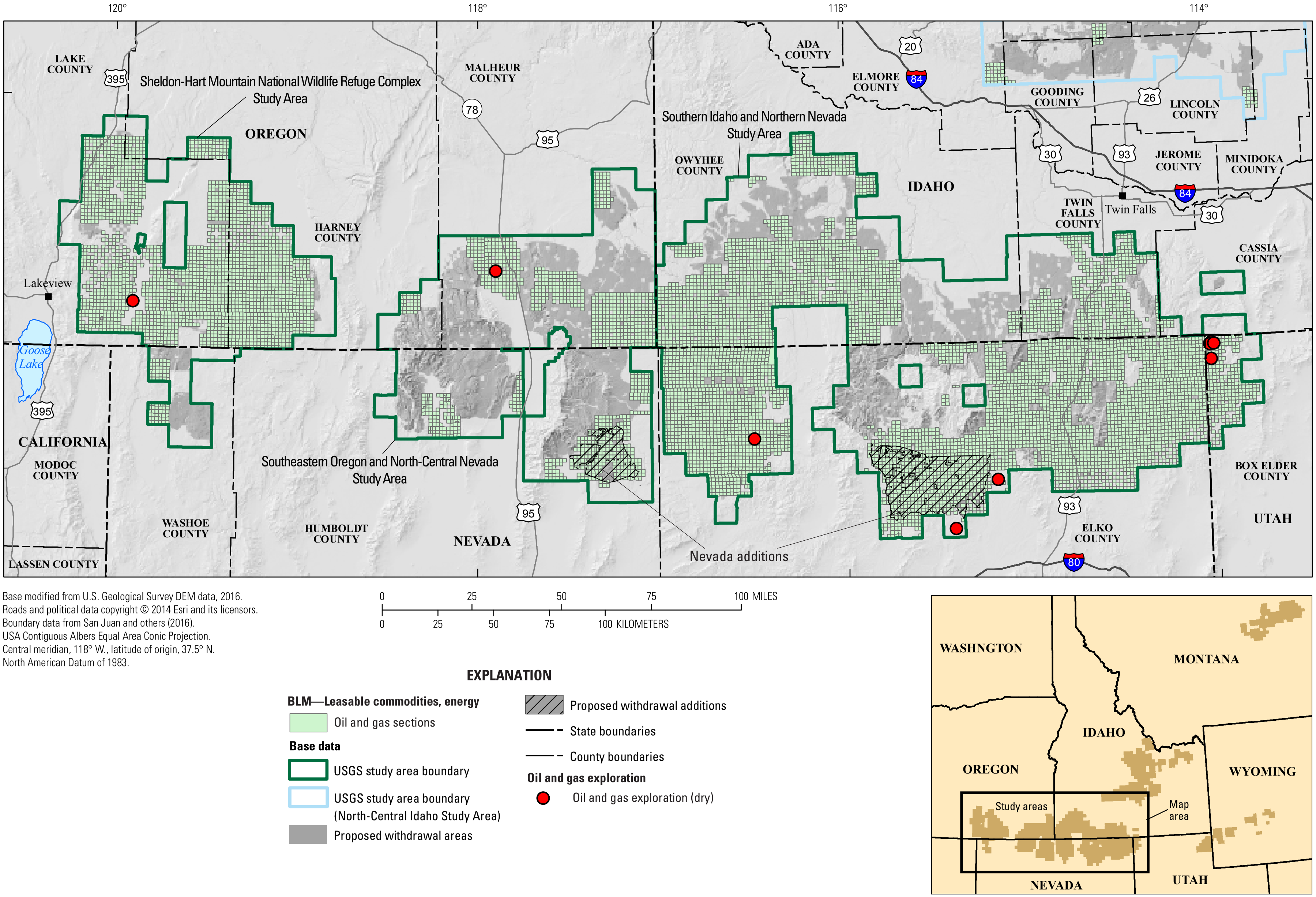


Figure 4. Map showing Public Land Survey System (PLSS) sections that contain Bureau of Land Management (BLM) oil and gas leases and oil and gas exploration (dry) in the four USGS study areas (Dicken and San Juan, 2016; IHS Energy Group, 2016; Gunther and others 2016a,b). USGS, U.S. Geological Survey.

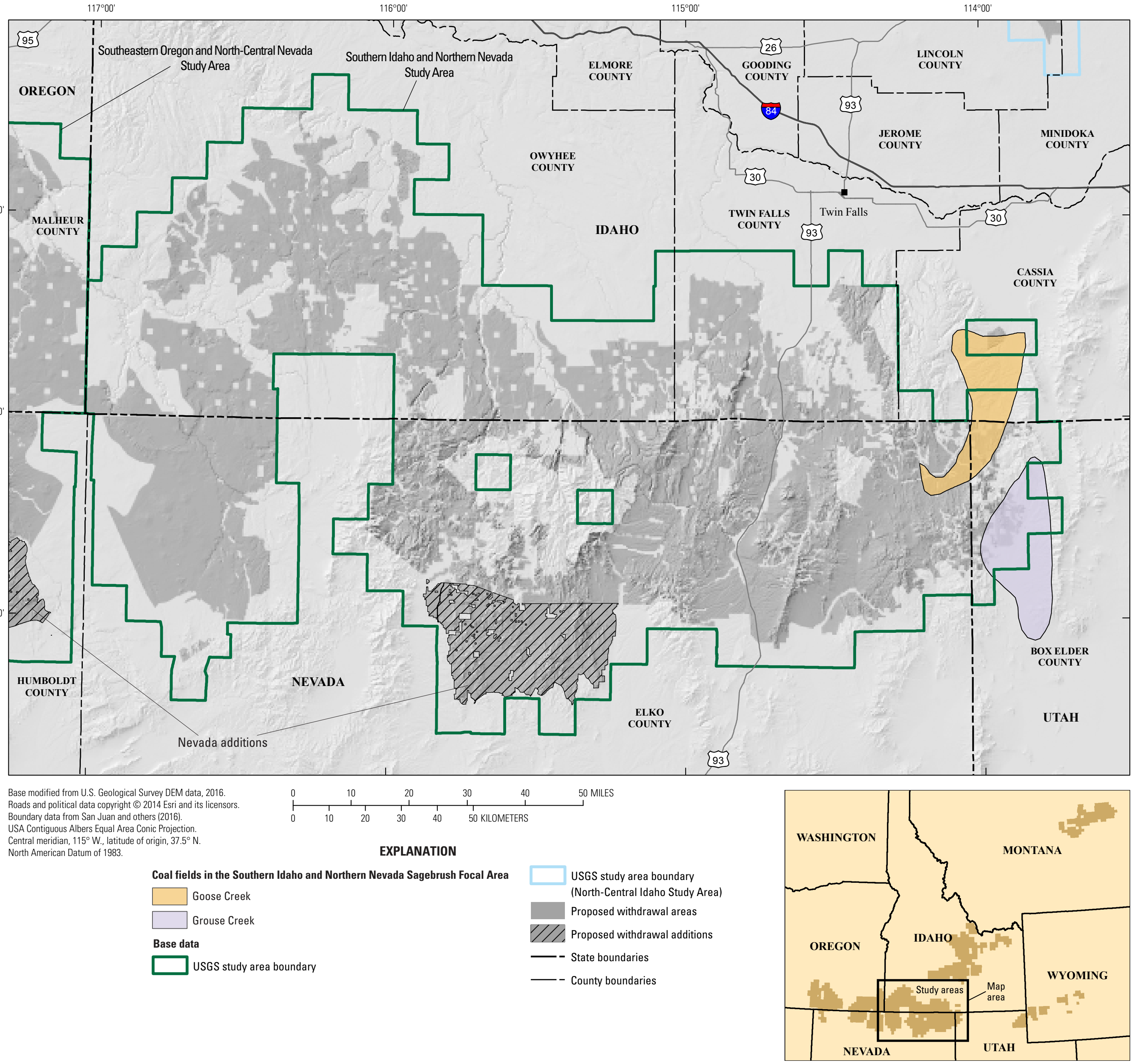


Figure 5. Map showing coal fields in the study area for Southern Idaho and Northern Nevada Sagebrush Focal Area (East, 2013). The Goose Creek and Grouse Creek coals are low-quality lignite that has not been mined. USGS, U.S. Geological Survey.

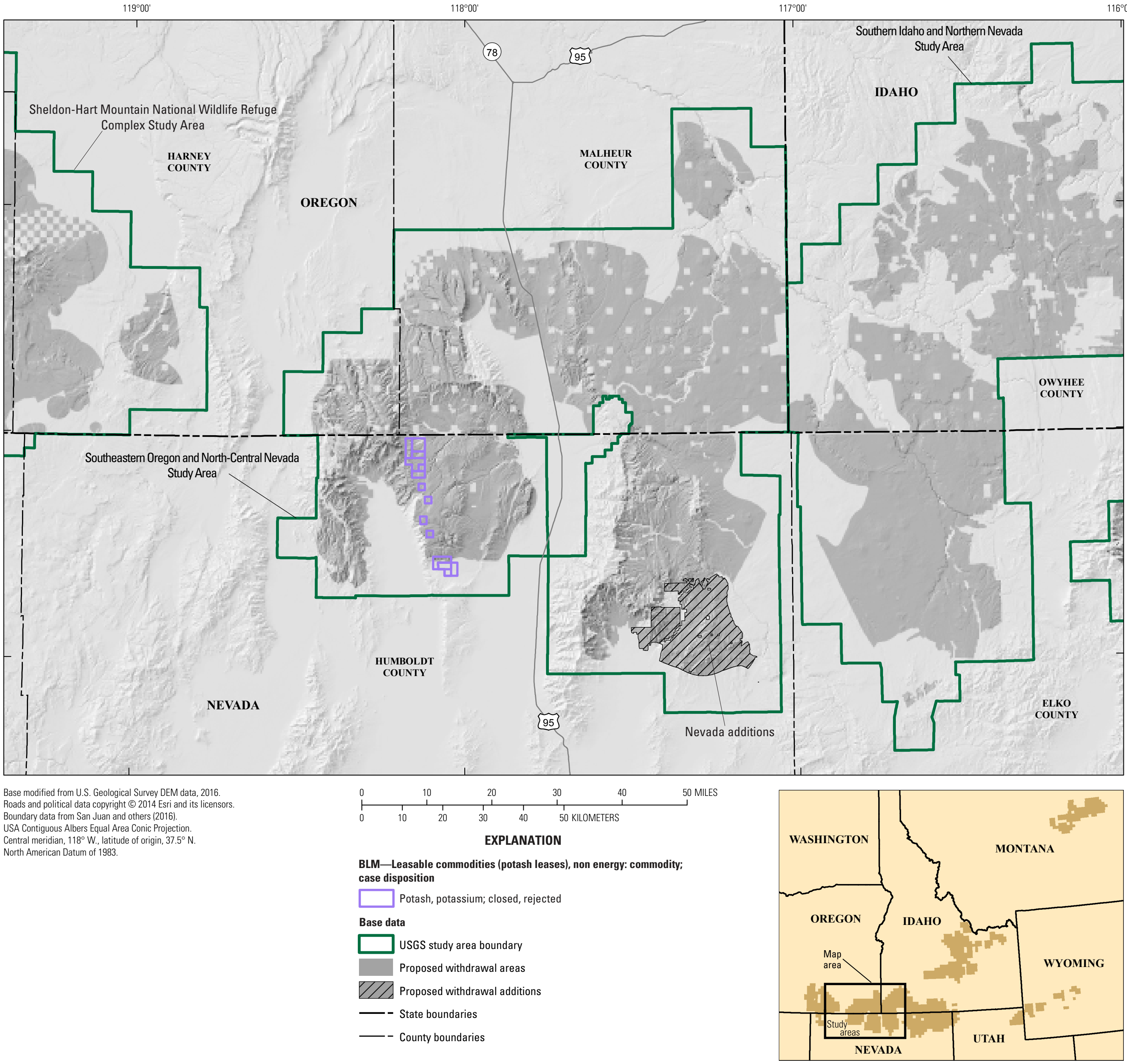


Figure 6. Map showing Bureau of Land Management (BLM) potash leases in the study area for the Southeast Oregon and North-Central Nevada Sagebrush Focal Area. No potash is currently being mined within the proposed withdrawal areas and U.S. Geological Survey (USGS) study area boundary (Dicken and San Juan, 2016).

Phosphate

No phosphate production has occurred, and there are no phosphate deposits in the four study areas. However, mined phosphate deposits in southern Idaho occur in Permian Phosphoria Formation strata, which extend into the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area. Phosphate also occurs in the Mississippian Deseret Limestone, Woodman Formation, and Chainman Shale in the study area (fig. 7). Phosphate deposits in southern Idaho constitute a major source of phosphorous products and vanadium, a minor source of uranium, and a potential source of rare earth elements. The depositional environment of phosphate, phosphate resources, and phosphate occurrences are described in the report section “Mineral-Resource Potential of the Study Area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, Nevada, Idaho, and Utah; Phosphate.”

Geothermal

The Great Basin is within the Basin and Range Province, which is characterized by active crustal extension and elevated heat flow relative to the rest of the continental craton (Sass and others, 2005). It represents one of the largest geothermal provinces in the world; more than 20 power plants with about 550 megawatts (mW) of installed capacity are in the Great Basin. Based on a 2008 assessment (Williams and others, 2008) geothermal systems in the Great Basin have the potential to produce about 30,000 mW. The high potential of the province is attributed to crustal thinning from high extensional strain rates (Blewitt and others, 2005; Faulds and others, 2012) that cause elevated crustal temperature gradients in much of the Great Basin. Many geothermal systems have little or no surface manifestation (Coolbaugh and others, 2006; Faulds and Hinz, 2015), and additional power generation will largely be derived from concealed and enhanced geothermal systems (Williams and others, 2008, 2011). The Snake River Plain along the northern margin of the Great Basin is also characterized by high heat flow and represents a potential geothermal resource area (Brott and others, 1981; Fleischmann, 2006; Shervais and others, 2016; Welhan, 2016).

Geothermal systems in the Great Basin are either magmatic or amagmatic. Magmatic systems derive heat from mid- to shallow-crustal magmas and are typically larger and higher temperature than amagmatic systems, which derive heat from deep circulation of water in extensional fault regimes (Duffield and Sass, 2003; Williams and others, 2008). High-temperature (more than 150 degrees Celsius, °C) magmatic systems generate electrical power more efficiently than lower temperature amagmatic systems. Most magmatic systems are concentrated along the western margin of the Great Basin and in the Snake River Plain, whereas most amagmatic systems occur in the western interior of the Great Basin.

Numerous low- and moderate- to high-temperature systems (90 °C to more than 150 °C) are within and adjacent to the four study areas (fig. 8). Although no geothermal power plants are in the study areas, four producing sites in Oregon, Idaho, and Nevada are within 100 km of the USGS study area boundary, and numerous are in development stages (National Renewable Energy Laboratory, 2016). Areas with elevated geothermal potential include parts of the proposed withdrawal areas based on geothermal resource favorability of both identified and undiscovered systems (Williams and others, 2008).

Salable Minerals

Salable mineral commodities, or mineral materials, discussed in this report are common varieties (low unit value) of sand and gravel, aggregate, crushed rock, dimension stone, decorative stone, petrified wood, cinders, clay, and pumice. Some mineral commodities can be locatable or salable, depending on value or physical properties such as hardness, color, and appearance (table 1; appendix 3). Salable mineral commodities are used for road and building construction, agriculture, and landscaping. There are 670 authorizations (contracts; 110 authorized, 545 closed, 7 pending, 6 expired, 1 rejected, and 1 withdrawn) for salable mineral commodities within the USGS study area boundary for the four study areas. The number of authorizations and maps of salable mineral commodity authorization sites within each study area are included in the report sections on each study area.

Most authorizations in the four study areas are for sand and gravel produced from numerous sites. Other authorizations are for stone (including specialty, weathered, riprap, crushed, and dimension stone) gemstones, common clay, and pumice (volcanic cinder). Some gemstones, including sunstones mined in the study area for the Sheldon-Hart Mountain National Wildlife Refuge Complex Sagebrush Focal Area, have high unit value. High-value gemstones are locatable mineral commodities, and deposits of them are covered by lode mining claims. No authorizations for petrified wood exist in the four study areas.

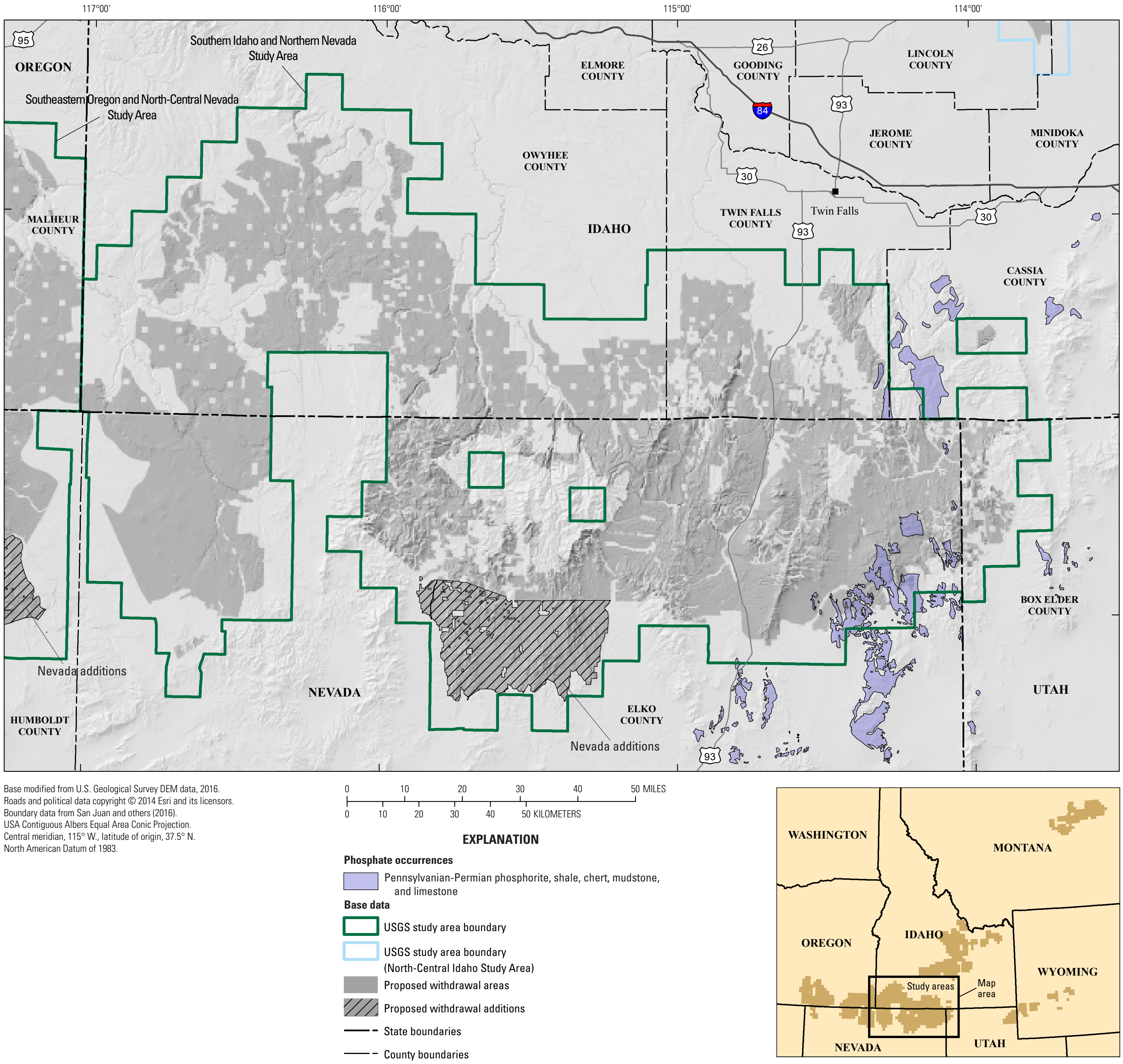


Figure 7. Map showing phosphate-bearing rocks in the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area. Most phosphate in and adjacent to the Sagebrush Focal Area occurs in beds (as phosphorite) within sedimentary rock of the Pennsylvanian-Permian Phosphoria Formation (Compiled from Hintze and others, 2000; Crafford, 2007; Lewis and others, 2012). USGS, U.S. Geological Survey.

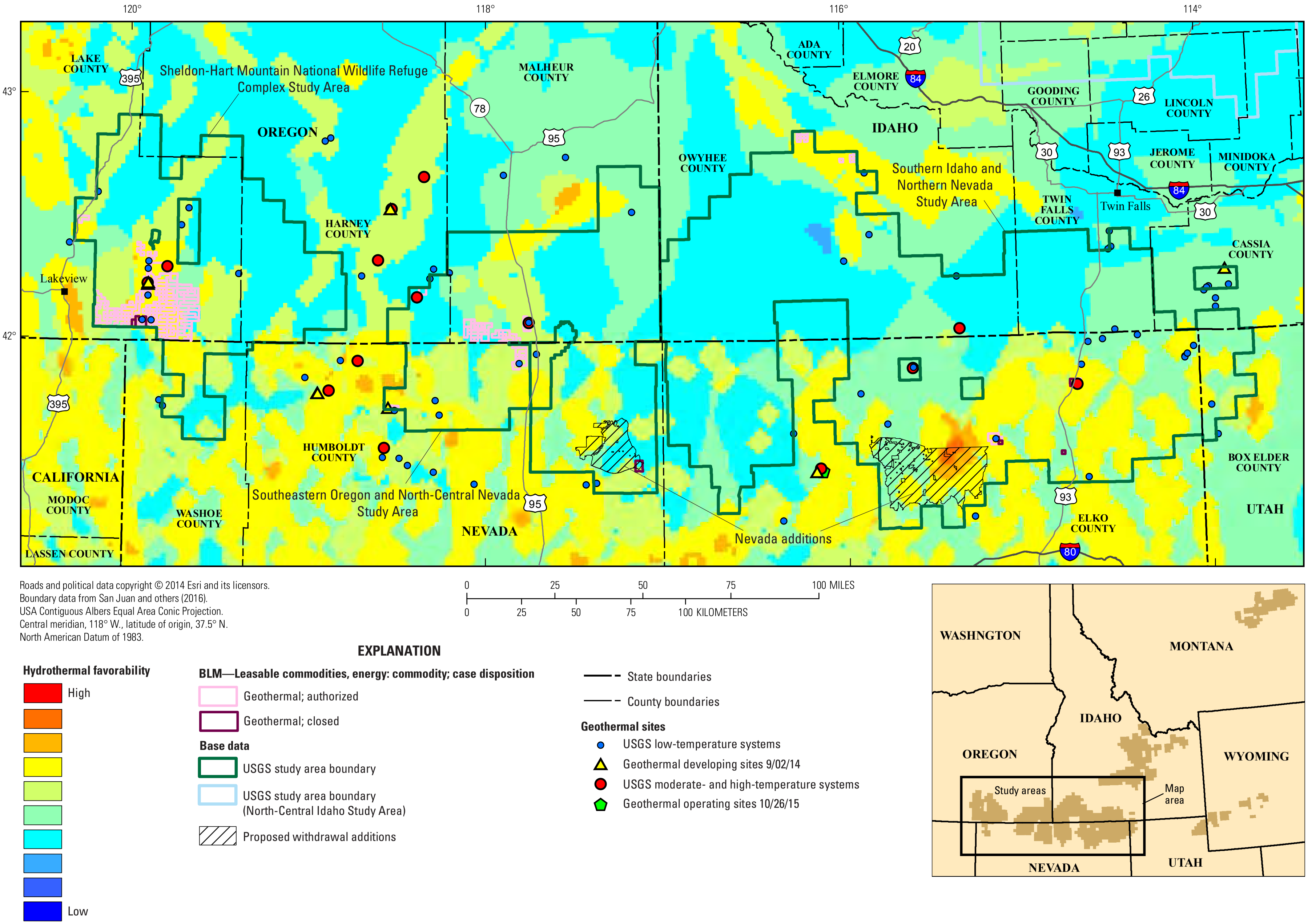


Figure 8. Map showing Bureau of Land Management (BLM) geothermal leases, favorability, sites, and systems in the four USGS study areas (Dicken and San Juan, 2016; Williams and others, 2008a,b). USGS, U.S. Geological Survey.

Mineral-Resource Potential of the Study Area for the Sheldon-Hart Mountain National Wildlife Refuge Complex Sagebrush Focal Area, Nevada and Oregon

Introduction

The study area for the Sheldon-Hart Mountain National Wildlife Refuge Complex Sagebrush Focal Area spans the border of Oregon and Nevada and includes parts of Washoe County, Nevada, and Harney and Lake Counties, Oregon (fig. 9). This report section describes the mineral potential of the proposed withdrawal area within the study area for the Sheldon-Hart Mountain National Wildlife Refuge Complex Sagebrush Focal Area. This study area includes parts of the proposed withdrawal area described in the "Introduction" section of this report. The proposed withdrawal area within this study area encompasses 943,866 acres (~3,820 km^2; 1,475 mi^2) which are managed by the BLM.

Description of Geology

Paleozoic, Mesozoic, Tertiary, and Quaternary rocks are exposed within the study area for the Sheldon-Hart Mountain National Wildlife Refuge Complex Sagebrush Focal Area, Nevada and Oregon, and the USGS study area boundary (fig. 10). Paleozoic and Mesozoic rocks include volcanic and sedimentary rocks of the Black Rock (Devonian to Triassic) and Pueblo (Jurassic) terranes, and granitic rocks (Jurassic and Cretaceous). Tertiary strata are predominantly volcanic lava flows and tuffs, and sedimentary rocks (Miocene and Pliocene). Quaternary strata include volcanic rocks and surficial deposits. The terranes were juxtaposed by compressional tectonism during the Mesozoic. Terranes and Tertiary volcanic strata have been laterally displaced by late Tertiary extensional tectonism which produced the modern landforms of alternating, north-south-oriented mountain ranges separated by broad, relatively flat valleys (Basin and Range topography).

More complete descriptions of these strata, and their tectonic evolution, are in report section "Introduction; Description of Geology."

Mineral-Resource Potential

Mineral Deposit Types

Characteristics of metallic and nonmetallic locatable mineral deposits, prospects, and host rocks in the study area for the Sheldon-Hart Mountain National Wildlife Refuge Complex Sagebrush Focal Area, Nevada and Oregon (appendix 2), are compatible with classification of these deposits as epithermal gold, silver, and mercury deposits, gemstone deposits, and lacustrine diatomite deposits (Day and others, 2016).

Epithermal gold, silver, and mercury deposits are shallowly formed vein, stockwork, disseminated, and replacement deposits that are mined primarily for gold and silver. Hot-spring-type mercury deposits are often the near-surface expression of gold and silver deposits that occur at deeper levels below mercury-enriched sinter and volcaniclastic strata. Epithermal gold, silver, and mercury deposits in the western United States occur largely in Eocene-Miocene volcanic fields and have been mined primarily for gold and silver, and lesser mercury (on the basis of mass and value).

There are few deposit type models for gemstone deposits because of the small deposit size, small market, and limited number of most gemstone deposits, and because demand for most is based entirely on appearance. The gemstone deposits evaluated in this study area, sunstones, are a gem-quality form of copper-included feldspar which occur locally in weathered Tertiary basalt flows in several areas of Oregon.

Lacustrine diatomite deposits consist of chalklike, earthy siliceous sedimentary strata composed of diatoms. In volcanic terranes, diatomaceous lake sediments typically occur within sequences of volcanic and sedimentary rocks. Lacustrine diatomite deposits in the western United States occur primarily in high-silica sequences of middle Miocene flows and tuffs.

Geology and Occurrence of Mineral Deposit Types

The study area for the Sheldon-Hart Mountain National Wildlife Refuge Complex Sagebrush Focal Area is entirely underlain by Tertiary and Quaternary volcanic and sedimentary rocks (fig. 10). Epithermal gold and silver deposits in Tertiary volcanic rocks occur in the Coyote Hills, Lake County, Oregon; and epithermal mercury deposits occur in Tertiary volcanic rocks in the Antelope district, Washoe County, Nevada. Gemstone deposits occur in Tertiary basalts in Lake County, Oregon. Lacustrine diatomite occurs in Tertiary volcanic flows, tuffs, and associated epiclastic sedimentary strata.

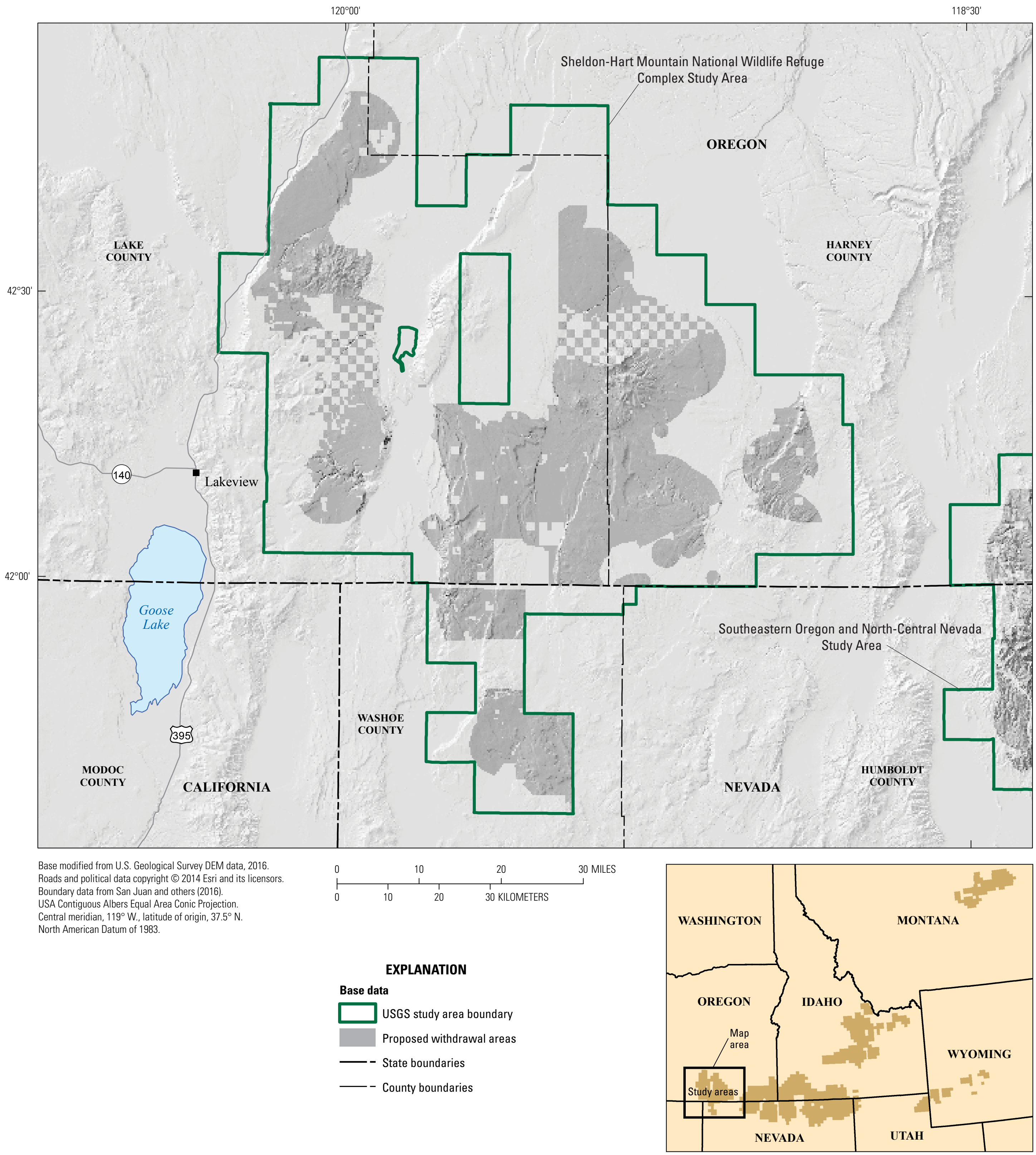


Figure 9. Map showing proposed withdrawal areas that comprise the Sheldon-Hart Mountain National Wildlife Refuge Complex Sagebrush Focal Area, Nevada and Oregon, and boundary of the U.S. Geological Survey (USGS) study area. The study area boundary corresponds to townships that enclose the withdrawal areas.

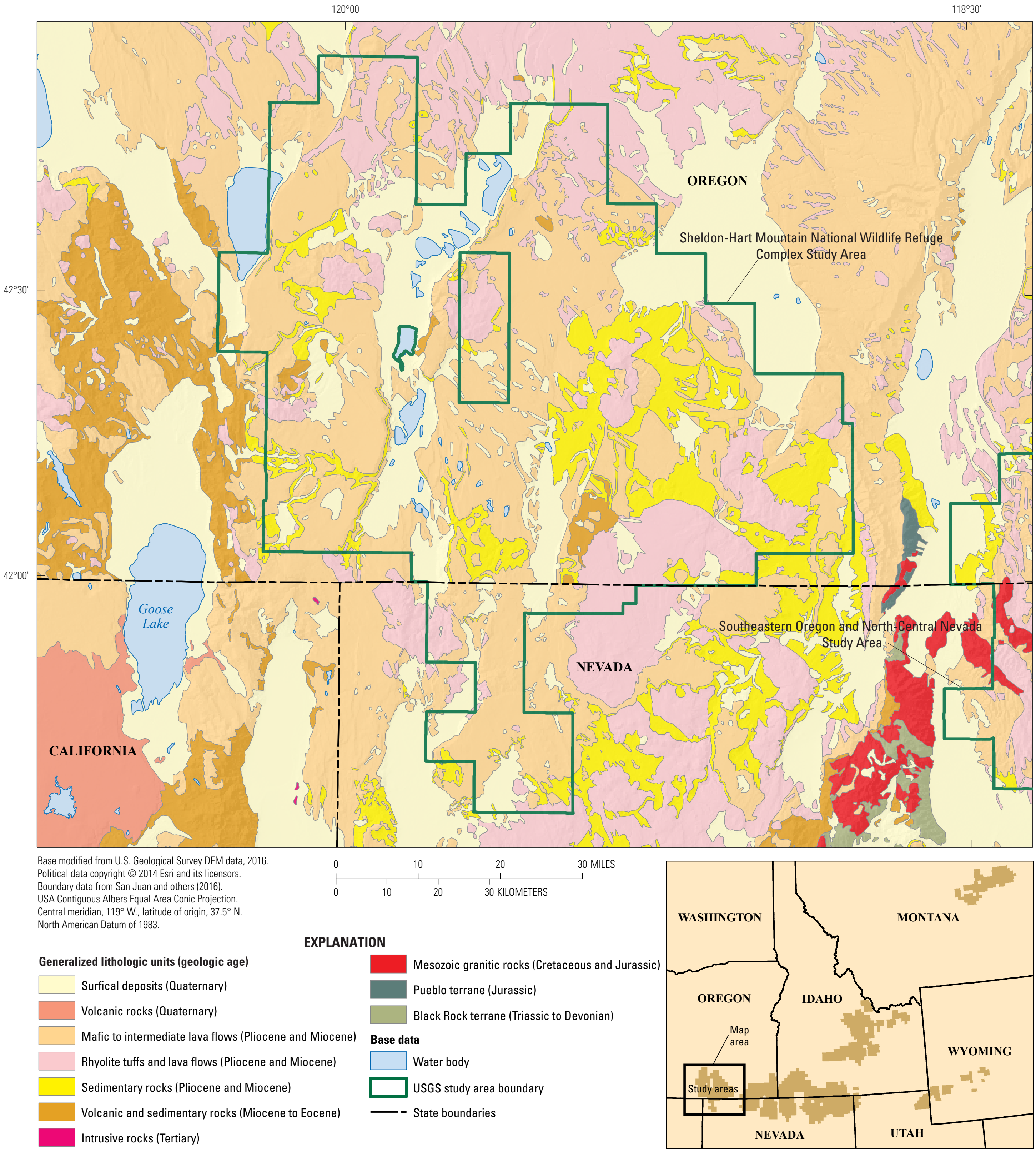


Figure 10. Simplified geologic map of the study area for the Sheldon-Hart Mountain National Wildlife Refuge Complex Sagebrush Focal Area, Nevada and Oregon. Synthesized from Jennings and others (1977), Walker and MacLeod (1991), Saucedo and others (2000), Miller and others (2002), and Crafford (2007).

Exploration and Mining Activity for Locatable Minerals

Metallic and nonmetallic locatable mineral commodities that have been mined and explored for in the study area for the Sheldon-Hart Mountain National Wildlife Refuge Complex Sagebrush Focal Area include gold, silver, mercury, and gemstones. Numerous lode and placer claims have been staked in the study area (fig. 11; tables 4, 5), and several plans of operations and notices covering mineral exploration have been approved or are pending (fig. 11; tables 6, 7). In addition, numerous claims were staked and filed in the study area from 1976 to 2007 (Causey, 2007, 2011; fig. 12).

Within the study area, two mercury deposit were mined for mercury with recorded production of 12 flasks (one flask of mercury is equal to 76 pounds of mercury) (table 8; Bailey and Phoenix, 1944; Fernette and others, 2016a). Gemstones have been mined from several sites in the study area, three of which are active mines, but production has not been published. Numerous mines and prospects excavated for mercury, gold, and silver deposits occur in several parts of the study area (fig. 13).

A qualitative estimate of past mining activity for locatable metallic (and nonmetallic) mineral commodities was made by counting mining-related symbols on USGS topographic maps that cover the study area (Fernette and others, 2016b). There are 156 mine features shown on USGS 7.5-minute topographic maps, 8 of which are adits or mine shafts and 80 are prospect pits. These symbols are commonly associated with mining and exploration of locatable minerals and provide a broad indication of the extent of past mining activity in the area. Other mine symbols include borrow pits, gravel pits, and cinder pits, which are commonly associated with production of salable minerals.

A second qualitative estimate of past mining activity was made by extracting mines and deposits with the statuses "producer" and "past producer" from the USGS Mineral Resources Data System (MRDS). The MRDS database contains 32 records of "producer" and (or) "past producer," 3 of which were mined for mercury, 5 for gemstones, 1 for nonmetallic (industrial) minerals (perlite), and 23 for stone, sand, and gravel (U.S. Geological Survey, 2005). However, some MRDS records may be duplicates. The MRDS database contains no production data for these mines and deposits.

Table 4. Type, number, and status of mining claims, leases for leasable mineral commodities (coal, geothermal, non-energy solid mineral, oil and gas leases), mineral material sales sites for salable mineral commodities, and surface-management plans in the proposed withdrawal area within the study area for the Sheldon-Hart Mountain National Wildlife Refuge Complex Sagebrush Focal Area, Nevada and Oregon (Dicken and San Juan, 2016).

[Source: Dicken and San Juan, 2016. The number of cases is for the complete Public Land Survey System (PLSS) section that includes a proposed withdrawal area]

Type	Mineral type	Number of unique cases	Active	Authorized	Pending	Closed	Cancelled	Expired	Rejected	Withdrawn
Mining claims	Locatable	830	101	—	—	729	—	—	—	—
Coal leases	Leasable	—	—	—	—	—	—	—	—	—
Geothermal leases	Leasable	69	—	—	—	69	—	—	—	—
Non-energy solid mineral leases	Leasable	—	—	—	—	—	—	—	—	—
Oil and gas leases	Leasable	195	—	—	—	195	—	—	—	—
Mineral materials sales sites	Salable	29	—	10	1	18	—	—	—	—
Surface-management plans	—	44	—	5	3	35	—	—	—	1

Table 5. Summary of active and closed mining claims for locatable minerals in Public Land Survey System (PLSS) sections that include the proposed withdrawal area within the study area for the Sheldon-Hart Mountain National Wildlife Refuge Complex Sagebrush Focal Area, Nevada and Oregon.

[Source: Dicken and San Juan, 2016. The number of cases is for the complete Public Land Survey System (PLSS) section that includes a proposed withdrawal area]

Area	Active lode claims	Closed lode claims	Active placer claims	Closed placer claims	Active millsites	Closed millsites
Sections containing proposed withdrawal area	101	685	0	44	0	0

Table 6. Status and number of 43 Code of Federal Regulations (CFR) 3809 notices and plans of operations for locatable minerals in the proposed withdrawal area within the study area for the Sheldon-Hart Mountain National Wildlife Refuge Complex Sagebrush Focal Area, Nevada and Oregon.

[Source: Dicken and San Juan, 2016. The number of cases is for the complete Public Land Survey System (PLSS) section that includes a proposed withdrawal area]

Authorization type	Number of unique cases	Active	Authorized	Pending	Closed	Cancelled	Expired	Rejected	Withdrawn
Plans of operations	5	—	1	2	1	—	—	—	1
Notice	39	—	4	1	34	—	—	—	—

Table 7. Active 43 Code of Federal Regulations (CFR) 3809 notices and plans of operations summarized by locatable commodity in the proposed withdrawal area within the study area for the Sheldon-Hart Mountain National Wildlife Refuge Complex Sagebrush Focal Area, Nevada and Oregon.

[Source: Dicken and San Juan, 2016. The number of cases is for the complete Public Land Survey System (PLSS) section that includes a proposed withdrawal area]

Commodity	Active notices	Active plans of operations
Gemstone, semiprecious silica	4	3
Gold, lode	1	0

Table 8. Mined deposits with production in the study area for the Sheldon-Hart Mountain National Wildlife Refuge Complex Sagebrush Focal Area, Nevada and Oregon.

[Sources from Fernette and others, 2016a,b. Mining districts are from Tingley (1992); One flask of mercury = 76 pounds of mercury; OR, Oregon; NV, Nevada]

Mine/ Deposit name	Assessment tract	Mining district	County, state	Commodity	Production years	Production	Resource	Notes; source
Antelope Mine	SHEP02, Sheldon West	Lone Pine	Washoe, NV	Mercury	1939	5 flasks mercury	—	Ross (1941), Bailey and Phoenix (1944), Holmes (1965), Bonham and Papke (1969)
Gray Mine	SHEP01, Coyote Hills	—	Lake, OR	Mercury	1941–1943	7 flasks mercury	—	Brooks (1965), Fernette and others (2016a)
Farnham, Mogul, Rabbit Hole Mines	—	—	Washoe, NV Lake, OR	Mercury	1919/1942	34 flasks mercury	—	Fernette and others (2016a)

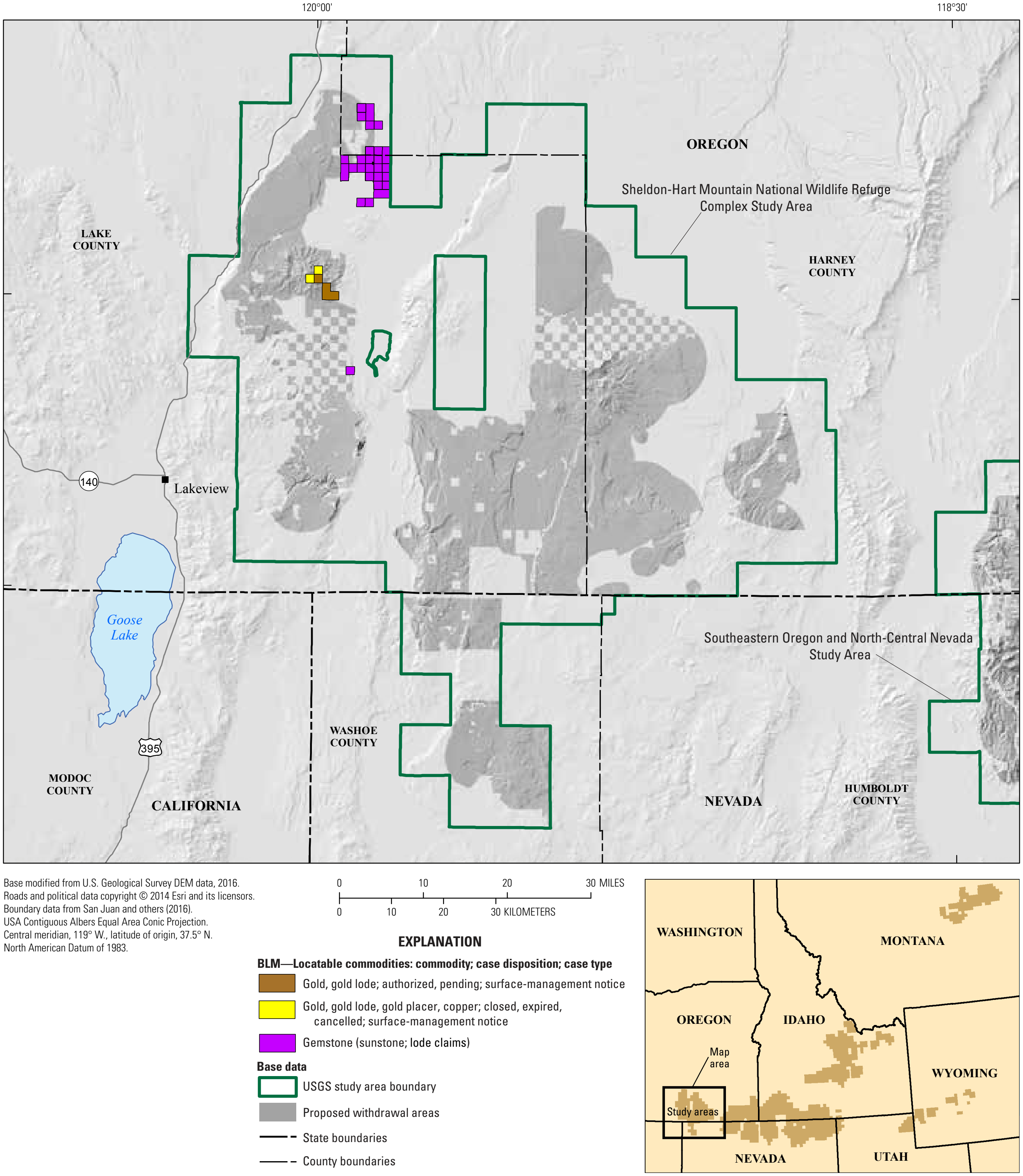


Figure 11. Map showing active and closed Bureau of Land Management (BLM) surface-management plans of operations and notices for locatable mineral commodities in the study area for the Sheldon-Hart Mountain National Wildlife Refuge Complex Sagebrush Focal Area, Nevada and Oregon (Dicken and San Juan, 2016). USGS, U.S. Geological Survey.

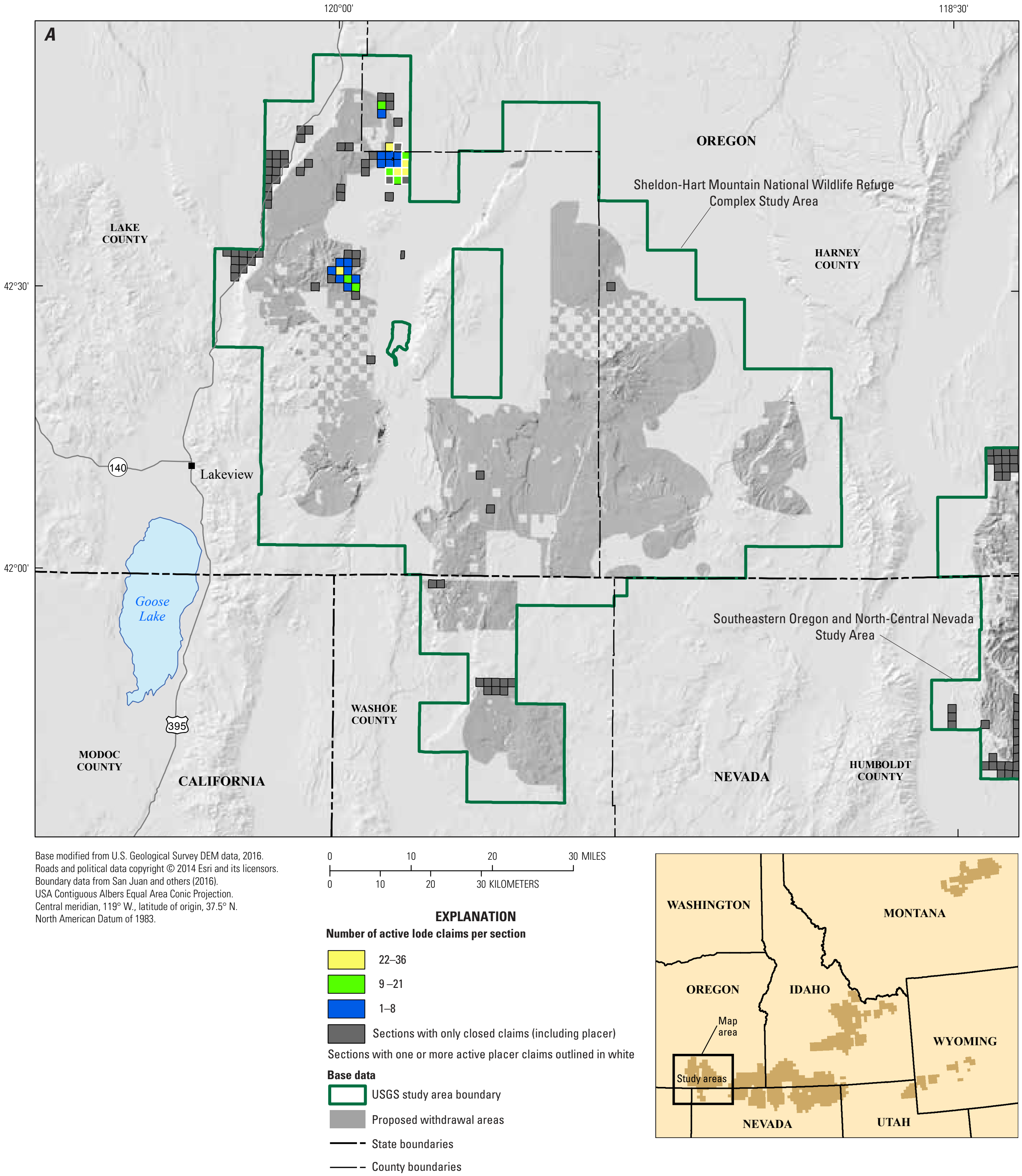


Figure 12. Maps showing mining claims by Public Land Survey System (PLSS) section in the study area for the Sheldon-Hart Mountain National Wildlife Refuge Complex Sagebrush Focal Area, Nevada and Oregon. *A*, Number of active lode claims and placer claims per section (Dicken and San Juan, 2016). *B*, Thirty-five year averages of the number of active lode claims by section for mining claims located between 1976 and 2010 (Causey, 2007, 2011).

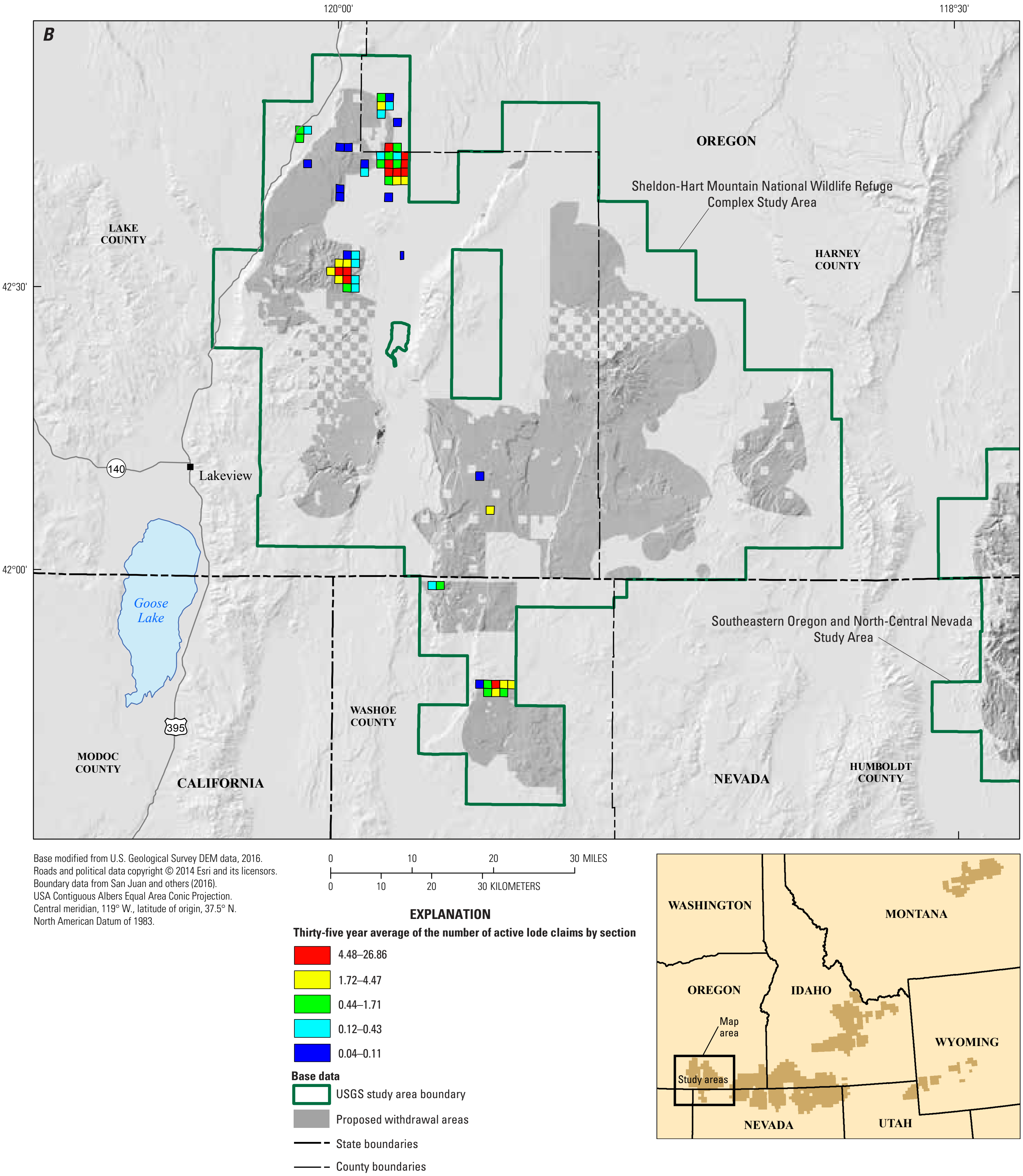


Figure 12. Maps showing mining claims by Public Land Survey System (PLSS) section in the study area for the Sheldon-Hart Mountain National Wildlife Refuge Complex Sagebrush Focal Area, Nevada and Oregon. *A*, Number of active lode claims and placer claims per section (Dicken and San Juan, 2016). *B*, Thirty-five year averages of the number of active lode claims by section for mining claims located between 1976 and 2010 (Causey, 2007, 2011).—Continued

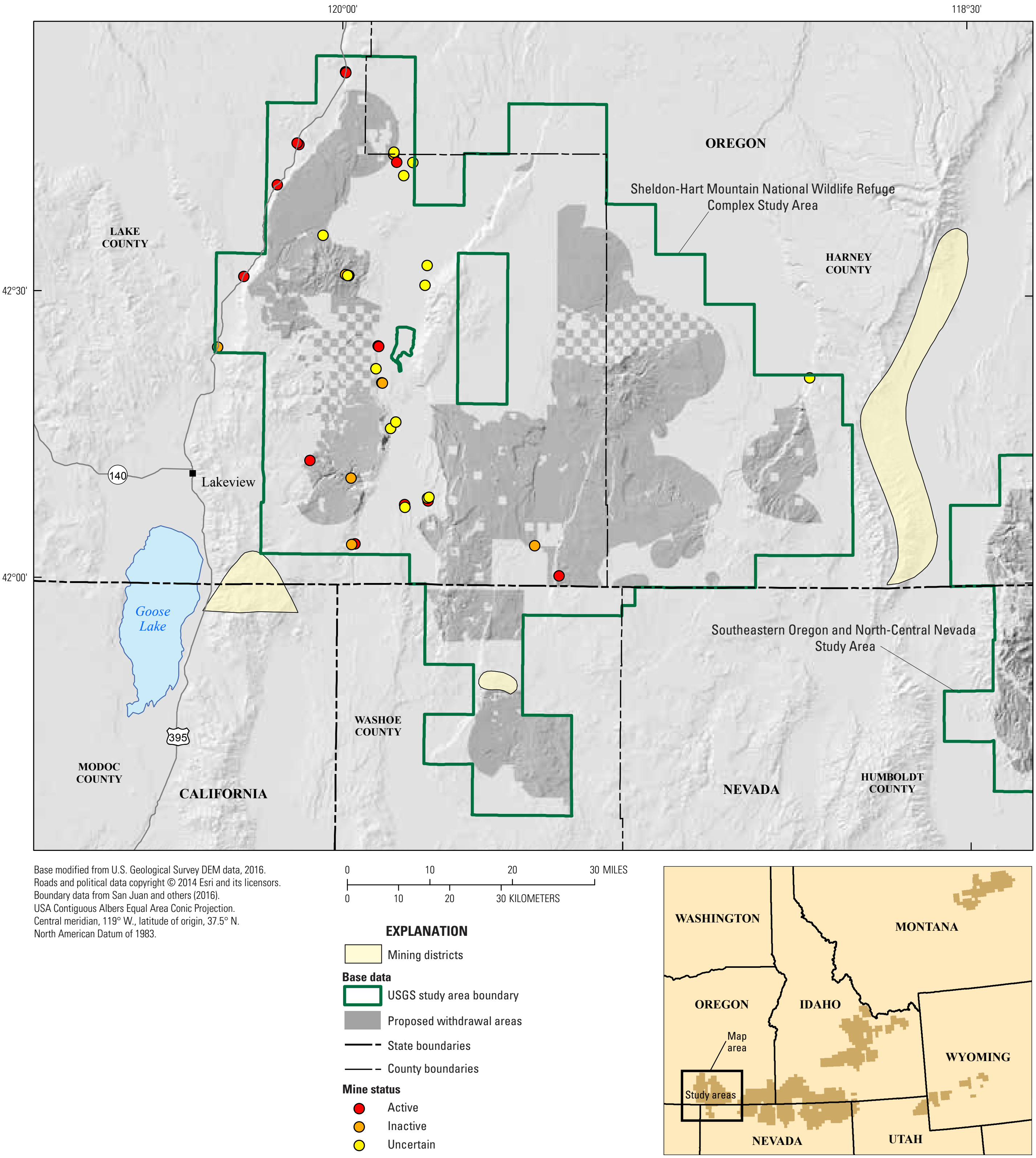


Figure 13. Map showing mining districts and mine status in or near the study area for the Sheldon-Hart Mountain National Wildlife Refuge Complex Sagebrush Focal Area, Nevada and Oregon (Fernette and others, 2016a). USGS, U.S. Geological Survey.

Mineral Potential of Locatable Minerals

Potential for undiscovered deposits of locatable mineral commodities (metallic locatable minerals and nonmetallic locatable minerals) within this study area was evaluated for the locatable commodities gold, silver, mercury, gemstones, and diatomite. These mineral commodities were selected for evaluation on the basis of deposits in this study area with past and present production, prospects, hydrothermal alteration, stratigraphy of host rocks, and other geological characteristics of deposit types for these commodities (Day and others, 2016; appendix 2; table 1). Records of active and historic mining claims and surface-management plans provided by the BLM and USFS were also used in the assessment process. Mineral-resource potential is represented by rated tracts; these tracts consist of areas favorable for undiscovered deposits of one or more commodities that are enclosed by a tract boundary and are assigned qualitative potential (high, moderate, or low/permissive) and a level of potential certainty. The tract boundaries include a buffer of variable dimension that reflects spatial uncertainty of one or more of the characteristics used to delineate the tract. The qualitative mineral potential ratings are derived from a classification matrix that merges mineral potential and level of certainty. The methodology used to assess locatable mineral-resource potential and levels of certainty are reviewed in Day and others (2016) and are summarized in appendix 1.

Delineation and rating of tracts are based entirely on publications from libraries and Web sites; technical reports, documents, and maps from active Web sites and Web sites that are no longer maintained; and documents provided by companies with mineral rights on lands included in the proposed withdrawal area. Technical reports, documents, and maps that are not available on Web sites, and those provided by companies, can be accessed in a database (Fernette and others, 2016a) that includes mineral deposits with production and resources, and mineral exploration sites within the study areas. All publications, technical reports, documents, and maps used to delineate and rate tracts are cited in tract descriptions, in tables of tract characteristics, and in tables of deposit production, resources, and mineral exploration sites. We did not perform field examinations, mapping, or analyses of the tracts, deposits, and resources described in this report section.

Mineral Potential Tracts for Epithermal Gold, Silver, and Mercury Deposits

Two mineral potential tracts for epithermal gold, silver, and mercury deposits were delineated and rated: tract SHEP01, Coyote Hills, which has moderate potential for epithermal gold, silver, and mercury deposits, and tract SHEP02, Sheldon West, which has moderate potential for epithermal mercury deposits. These commodities occur in one well-defined deposit type, epithermal gold, silver, and mercury deposits (fig. 14*A*).

Tract SHEP01, Coyote Hills—A moderate potential (M), with certainty level C, for epithermal gold, silver, and mercury deposits is assigned to an area enclosing numerous prospects in the Coyote Hills, Lake County, Oregon (tract SHEP01, Coyote Hills; fig. 14*A*; appendix 2). The area consists of an Oligocene(?) rhyolite-dacite lava dome complex emplaced into Eocene to Oligocene andesite and basalt lava flows and breccias and volcaniclastic sedimentary rocks (Thomas, 1981; Walker and MacLeod, 1991). Faulting and hydrothermal activity shortly followed emplacement of the dome complex, which resulted in prominent areas of silicic and argillic alteration and low-grade precious and base metal mineralization. A minor production of mercury (less than 10 flasks) during World War II was derived from cinnabar occurrences within the tract (Brooks, 1965; table 8).

The tract was delineated using a 3-km buffer around prospects in the Mineral Resources Data System and Mineral Information Layer for Oregon (MRDS, U.S. Geological Survey, 2005; MILO-Mineral Information Layer for Oregon, 2016) and encompasses the entire silicic dome complex as mapped by Thomas (1981). It is characterized by scattered areas of advanced argillic, kaolinitic argillic, sericitic, and iron-oxide alteration interpreted from ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) remote-sensing spectra (Rockwell and others, 2015), and a small, sharp, closed aeromagnetic low (Day and others, 2016), which may reflect the hydrothermal alteration. An anomalous gold concentration was noted in a stream-sediment sample from the center of the tract. Numerous active lode claims are in the tract (for example, Camino Minerals claims; fig. 1) and a pending notice for gold exploration (Fernette and others, 2016a). In addition, numerous closed lode claims are in the tract (Causey, 2007, 2011; fig. 12).

Tract SHEP02, Sheldon West—A moderate potential (M), with certainty level B, for epithermal mercury, gold, and silver deposits has been assigned to an area delineated by Eocene to Oligocene andesite and rhyolite flows in the western part of the Sheldon Antelope Refuge, Washoe County, Nevada (Crafford, 2007; tract SHEP02, Sheldon West; fig. 14*A*; appendix 2). Mercury, gold, and silver mineralization occurs in rhyolite and andesite flows and ash-flow tuffs, and in sedimentary rocks that have locally been altered along northwest-trending fault zones (Ross, 1941). Mercury production (5 flasks) is reported from the Antelope Mine (Bailey and Phoenix, 1944; table 8) and numerous prospects for mercury, gold, and silver are present in the tract (Fernette and others, 2016a). Anomalous concentrations of mercury, antimony, silver, and gold with potentially ore grade concentrations of gold (1.4 parts per million [ppm]) and silver (113 ppm) are locally present at the surface in altered andesite (Tuchek and others, 1984). Many closed lode claims are in the tract (Causey, 2007, 2011; fig. 12).

Buffering Epithermal Gold, Silver, and Mercury Tracts

The epithermal gold, silver, and mercury tracts described above were delineated from characteristics of epithermal gold, silver, and mercury deposits based on the deposit model, which was assembled from characteristics of well-documented

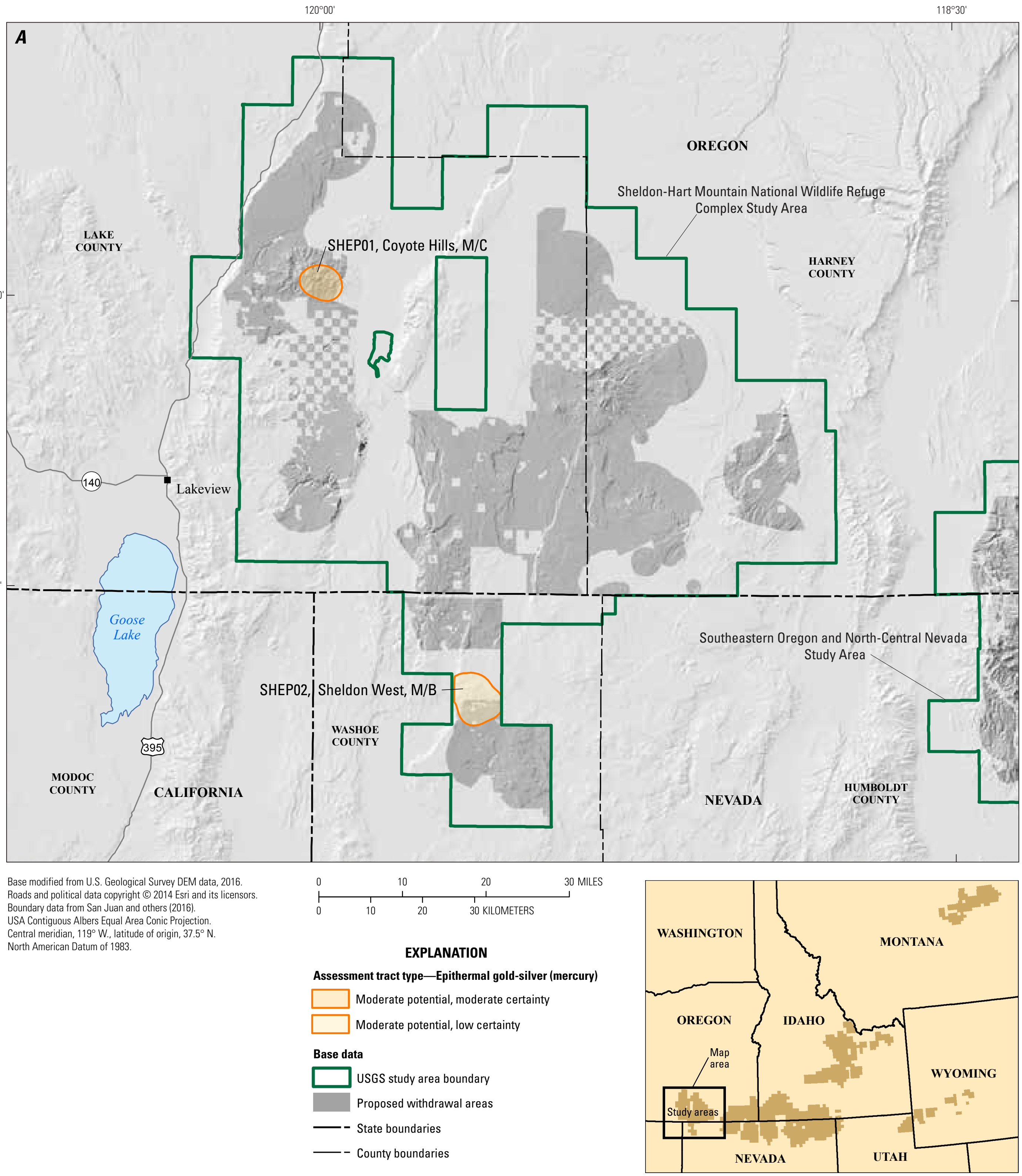


Figure 14. Maps showing assessment tracts and level of resource potential for metallic and nonmetallic locatable minerals in the study area for the Sheldon-Hart Mountain National Wildlife Refuge Complex Sagebrush Focal Area, Nevada and Oregon (San Juan and others, 2016); *A*, Assessment tracts for epithermal gold-silver (mercury); *B*, Assessment tract for sunstone; and *C*, Assessment tract for lacustrine diatomite. USGS, U.S. Geological Survey.

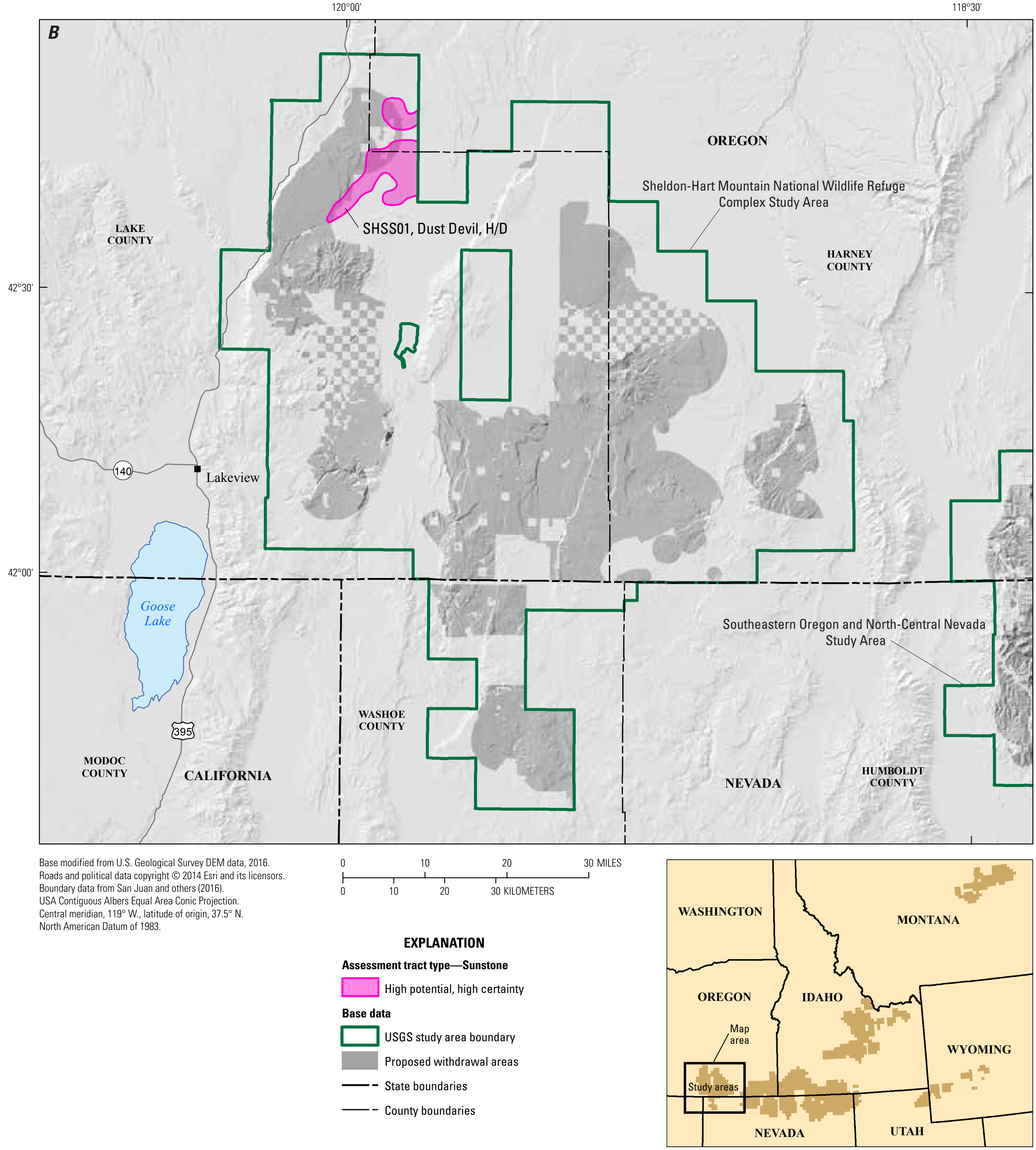


Figure 14. Maps showing assessment tracts and level of resource potential for metallic and nonmetallic locatable minerals in the study area for the Sheldon-Hart Mountain National Wildlife Refuge Complex Sagebrush Focal Area, Nevada and Oregon (San Juan and others, 2016); *A*, Assessment tracts for epithermal gold-silver (mercury); *B*, Assessment tract for sunstone; and *C*, Assessment tract for lacustrine diatomite. USGS, U.S. Geological Survey.—Continued

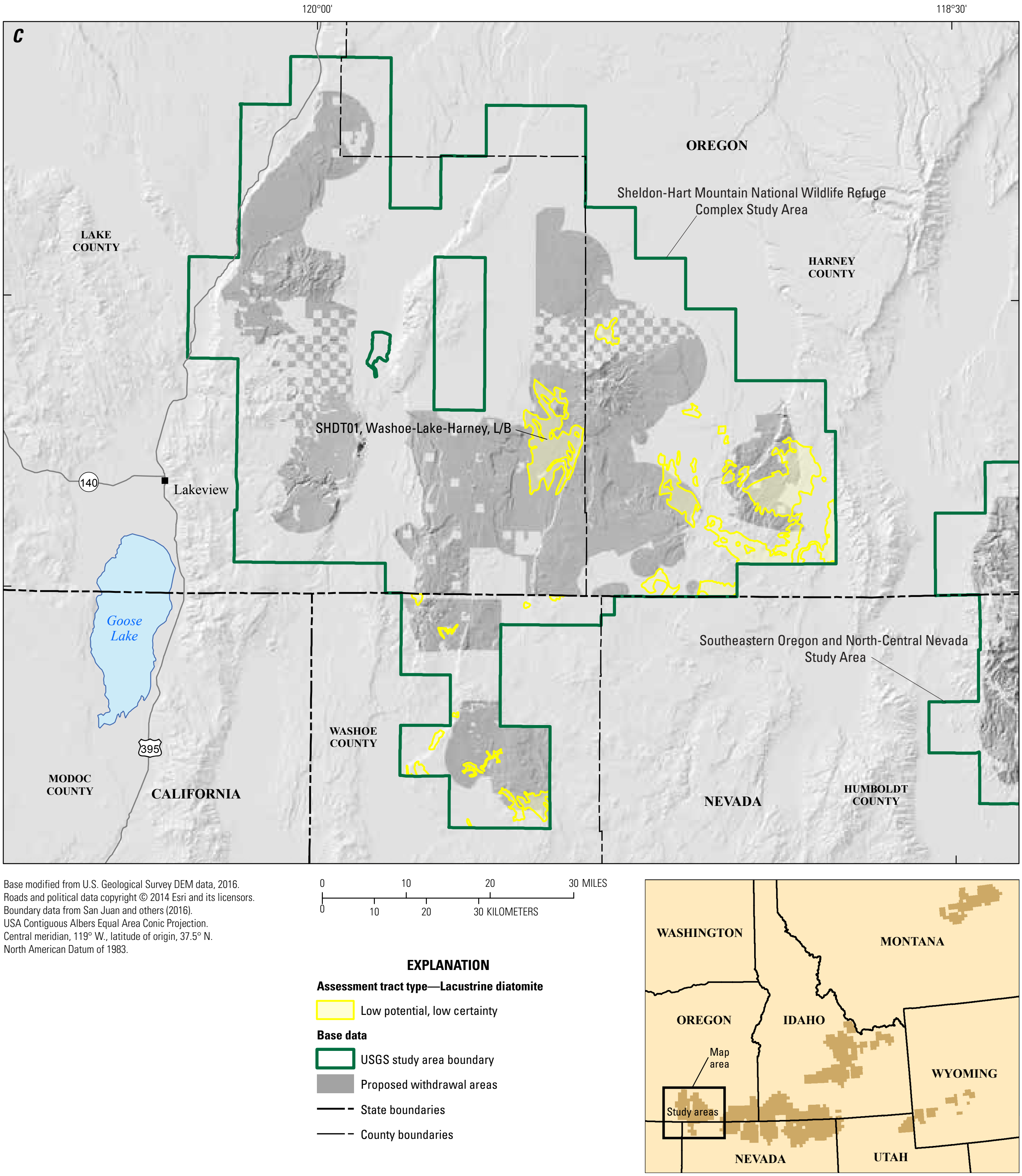


Figure 14. Maps showing assessment tracts and level of resource potential for metallic and nonmetallic locatable minerals in the study area for the Sheldon-Hart Mountain National Wildlife Refuge Complex Sagebrush Focal Area, Nevada and Oregon (San Juan and others, 2016); *A*, Assessment tracts for epithermal gold-silver (mercury); *B*, Assessment tract for sunstone; and *C*, Assessment tract for lacustrine diatomite. USGS, U.S. Geological Survey.—Continued

epithermal gold, silver, and mercury deposits and the magmatic-hydrothermal systems that formed the deposits (Day and others, 2016; appendix 2). Some of these characteristics may be concealed (for example, altered rocks covered by younger rocks; drill-defined gold and silver resources; deposits identified by drill-hole intercepts with elevated gold and silver values), and do not appear on published maps (geologic; topographic) or in other publications. Gold and silver occurrences on published maps and in other publications were the first criterion used to delineate possible concealed and unmapped epithermal gold and silver deposits. Other criteria used include the alteration and geochemical signatures of the magmatic-hydrothermal systems that form epithermal gold and silver deposits. The approximate diameters of footprints (surface exposures) of well-exposed epithermal gold and silver systems, based largely on mapped gold and silver occurrences, alteration, and geochemistry, range from several hundreds of meters to about 10 km, and are mostly 10–20 km^2 in the study areas (appendix 5). If the areas of well-exposed systems are geometrically represented by circles concentric to mapped or published gold and silver occurrences, then circles enclosing systems that formed epithermal gold and silver deposits in the study areas have radii of 1.8–2.6 km. Based on the distribution and spatial density of gold and silver occurrences in the study areas, a circle with radius of 3 km centered on occurrences was used to delineate tracts. Tract boundaries represent the merged circumferences of circles concentric to all gold and silver occurrences within the tract.

Market Analyses of Gold, Silver, and Mercury

Market analyses of gold, silver, and mercury are provided in appendix 5 and section I of Day and others (2016).

Mineral Potential Tracts for Gemstone Deposits and Lacustrine Diatomite Deposits

Two mineral potential tracts for gemstones deposits and lacustrine diatomite deposits were delineated and rated: tract SHSS01, Dust Devil, which has high potential for sunstone deposits, and tract SHDT01, Washoe-Lake-Harney, which encloses extensive exposures of stratigraphic sections that contain lacustrine diatomite beds and stratigraphy favorable for lacustrine diatomite deposits.

Tracts SHSS01, Dust Devil—A high potential (H), with certainty level D, for sunstone deposits has been assigned to two areas of porphyritic basalts in the High Lava Plains of Oregon (tract SHSS01, Dust Devil; fig. 14*B*; appendix 2). The two areas of the tract cover basalt flows in which there are sunstone mines, prospects, active mining claims, and active, authorized, and pending plans of operations and notices (fig. 11; tables 4, 5). The age of the basalts in which the sunstones occur is uncertain (Walker and MacLeod, 1991). Three operating sunstone mines are in the tracts: the Dust Devil, Sunstone Butte, and Spectrum Mines Area (figs. 13, 14*C*; table 8). Several prospects and occurrences occur within the tracts. The northern tract contains 2 PLSS sections with authorized plans of operations and notices, 5 PLSS sections in which surface-management plans are pending, and 9 PLSS sections in which surface-management plans for sunstone have been submitted (fig. 11; tables 6, 7). A 2-mi^2 area of the basalt flows that contain sunstones originally described by Peterson (1972) has been withdrawn from mineral entry and established by the BLM as a free public collecting area. In the mines and collecting area, sunstones are extracted from weathered basalt in the near surface. However, at the Sunstone Butte Mine that was discovered in 2011, the sunstones occur in fragmented basalt.

Sunstone, the Oregon state gemstone, is a variety of transparent plagioclase feldspar (labradorite) that contains small inclusions of native copper. The color of the sunstone systematically varies with the concentration and size of copper particles. Sunstones with less than 20 ppm copper are pale yellow, with about 100 ppm copper are green, and with as much as 200 ppm copper are red (Hofmeister and Rosstnan, 1985). Multicolored sunstones that are red and green also occur. Sunstones have also been termed heliolites (Pough, 1983). Specimens of Oregon sunstones are on display in major museums in the world. Sunstones are typically valued at $100 per carat but high-quality red or green sunstones may command as much as $1,000 per carat.

Tract SHDT01, Washoe-Lake-Harney—This tract has low potential (L) for lacustrine diatomite deposits at certainty level B (fig. 14*C*; appendix 2). It covers areas of northern Washoe County, Nevada, and Lake and Harney Counties, Oregon. The tract includes Miocene to Holocene stratigraphic units from the Nevada (Crafford, 2007) and Oregon (Walker and MacLeod, 1991) state geologic maps that include diatomite as a minor or incidental lithology among sedimentary units associated with volcanic units. Included in this tract is unit QTls, Holocene to Pliocene landslide and colluvium deposits with minor basalt and diatomite (Crafford, 2007) equivalent to unit Qls (Stewart and Carlson, 1978). Additionally, this tract transects a regional system of Miocene to Pleistocene lake deposits that variably host diatomite or diatomaceous sediments (Wallace, 2003). These units are represented in Nevada as unit Ts3 (Crafford, 2007), which includes the following units from Stewart and Carlson (1978): units Tts (minus units Ttsx1, Trd, and Trdx1) of the High Rock sequence, unit Tvv Virgin Valley beds of Merriam (1907), and unit Ttc Thousand Creek beds of Merriam (1907). This paleolake system containing diatomite extends into Oregon where it is represented as unit Ts, semiconsolidated lacustrine tuffaceous sandstone and siltstone, concretionary claystone, ash and ashy diatomite, conglomerate, minor fanglomerate, vitric-crystal and vitric-lithic tuff, pumice lapilli tuff, and tuff breccia; and is approximately correlative with the Banbury Basalt and Chalk Hills Formation, both of the Idaho Group (Walker and Repenning, 1966; Walker and MacLeod, 1991; Miller and others, 2002, 2005). The diatomite potential from three previous mineral resources assessments conducted in the tract area was moderate and at A or B certainty (U.S. Geological Survey and U.S. Bureau of Mines, 1989). No current or past mines, no identified prospects or occurrences, and no active BLM claims or notices for diatomite are in the tract area or within the study area.

Market Analysis of Diatomite

Market analysis of diatomite is provided in appendix 5 and section I of Day and others (2016).

Occurrence of Leasable Minerals

Leasable mineral commodities (leasable solid and fluid minerals) include oil and gas, geothermal, coal, and non-energy solid minerals, including phosphate, potash, and sodium. These commodities were not evaluated for assessment, but were qualitatively appraised for exploration and mining activity, lease status, and potential for deposits within the study area for the Sheldon-Hart Mountain National Wildlife Refuge Complex Sagebrush Focal Area. No production of leasable solid minerals (coal, phosphate, potash, and sodium) or production of leasable fluid minerals (oil and gas, and geothermal) has occurred in the study area. Favorable stratigraphy for coal, phosphate, and potash is not exposed, or has not been recognized, or is concealed within the study area. Based on comparison to deposits of these commodities elsewhere in the western United States with past or present production (including oil and gas fields, and geothermal fields), and current market conditions, neither concealed or exposed deposits of these commodities are likely to be explored for, or produced, in coming decades, with the possible exception of geothermal.

Although no oil and gas and geothermal have been produced, these commodities occur, or have been explored for in the study area for the Sheldon-Hart Mountain National Wildlife Refuge Complex Sagebrush Focal Area. There are closed leases for oil and gas, geothermal, and sodium indicating that exploration for these commodities has occurred in recent years (table 4).

Oil and Gas

There are 195 closed oil and gas leases in the study area for the Sheldon-Hart Mountain National Wildlife Refuge Complex Sagebrush Focal Area (table 4). There is one dry well within the USGS study area boundary but external to the proposed withdrawal area (fig. 15). Oil and gas exploration, assessment, and potential in the four study areas are described in report section “Introduction; Leasable Minerals.”

Geothermal

There are 69 closed geothermal leases in the study area for the Sheldon-Hart Mountain National Wildlife Refuge Complex Sagebrush Focal Area (fig. 16; table 4). Geothermal exploration, assessment, and potential in the four study areas are described in report section “Introduction; Leasable Minerals.”

Occurrence of Salable Minerals

Salable commodities, mainly sand and gravel, and aggregate, have been produced at several sites in the study area for the Sheldon-Hart Mountain National Wildlife Refuge Complex Sagebrush Focal Area. There are 29 salable commodity sites (mineral materials sales sites), 11 of which are authorized (approved) and pending, and 18 of which are closed (fig. 17; table 4). There are 9 approved (authorized) sites that are sand and gravel, 1 approved (authorized) site is crushed stone, and 1 pending site is specialty stone (table 9). There are 2 mine sites, basalt quarries, that are within the proposed withdrawal area (Fernette and others, 2016a).

Table 9. Active (approved and pending) mineral material sales sites in the proposed withdrawal area within the study area for the Sheldon-Hart Mountain National Wildlife Refuge Complex Sagebrush Focal Area, Nevada and Oregon.

[Source: Dicken and San Juan, 2016. The number of cases is for the complete Public Land Survey System (PLSS) section that includes a proposed withdrawal area]

Commodity	Number of approved sites	Number of pending sites
Sand and gravel, gravel	2	0
Sand and gravel	7	0
Stone, crushed and broken	1	0
Stone, specialty	0	1

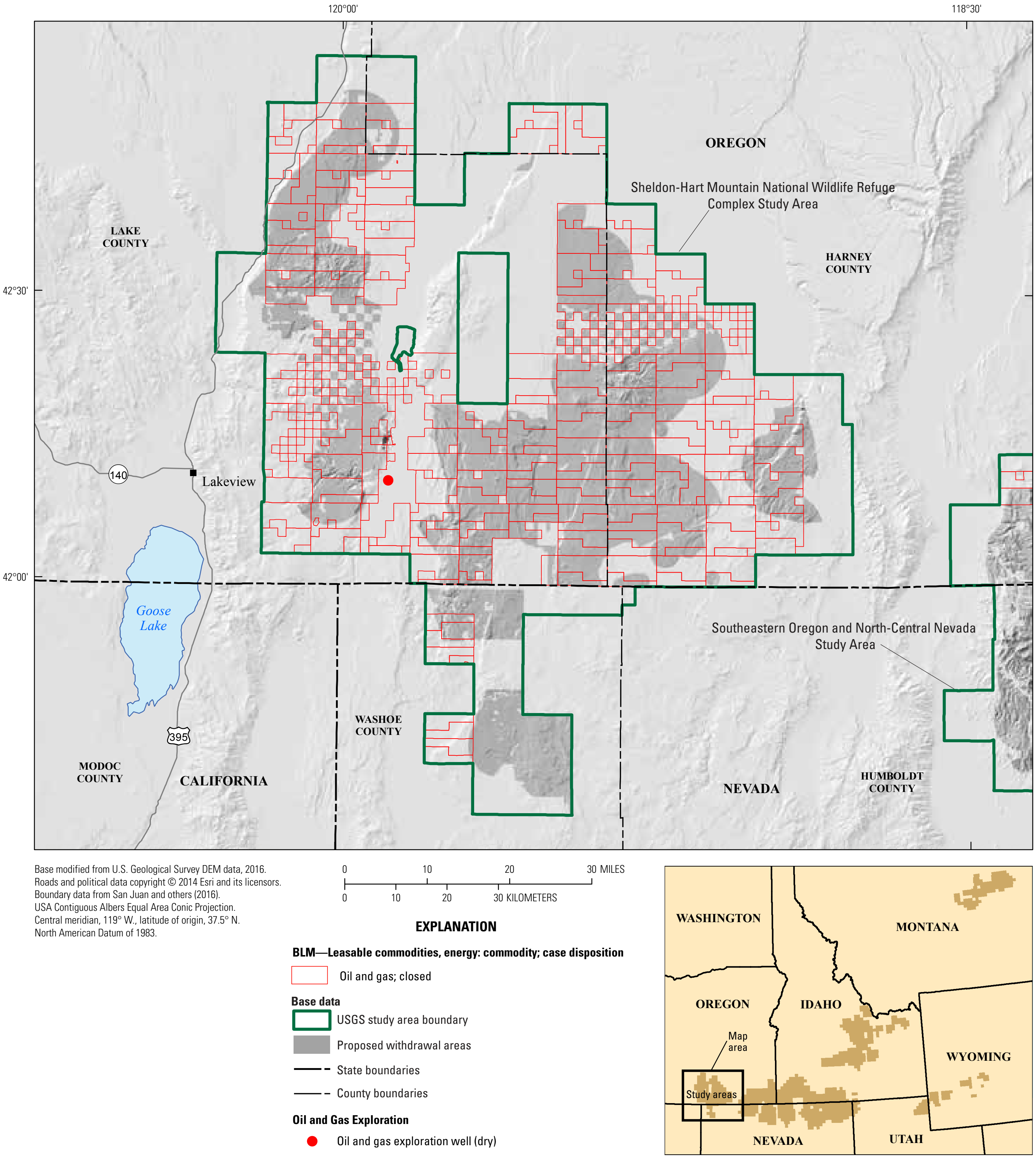


Figure 15. Map showing Bureau of Land Management (BLM) oil and gas leases in the study area for the Sheldon-Hart Mountain National Wildlife Refuge Complex Sagebrush Focal Area, Nevada and Oregon (Dicken and San Juan, 2016; Gunther and others 2016a,b; IHS Energy Group, 2016). USGS, U.S. Geological Survey.

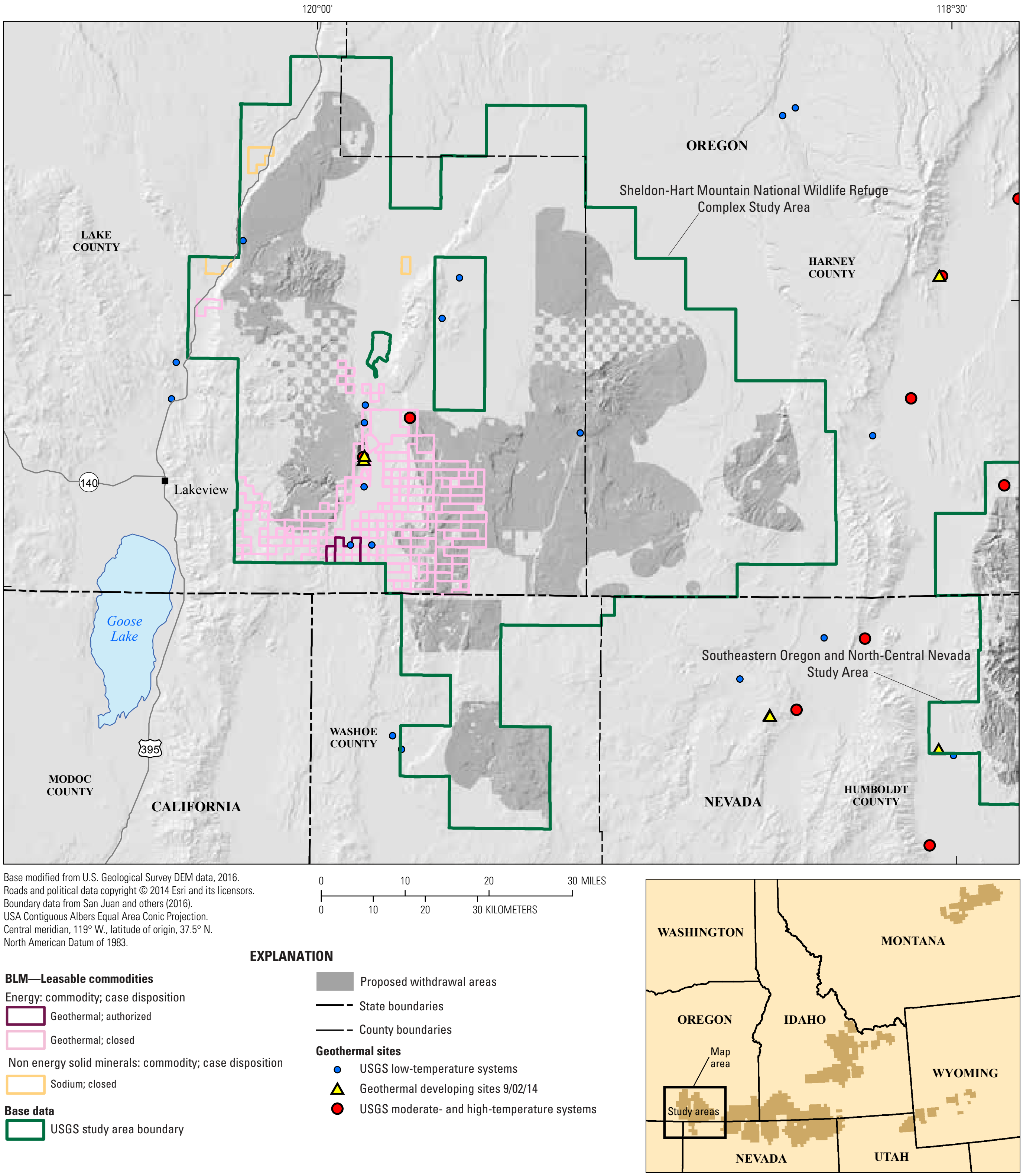
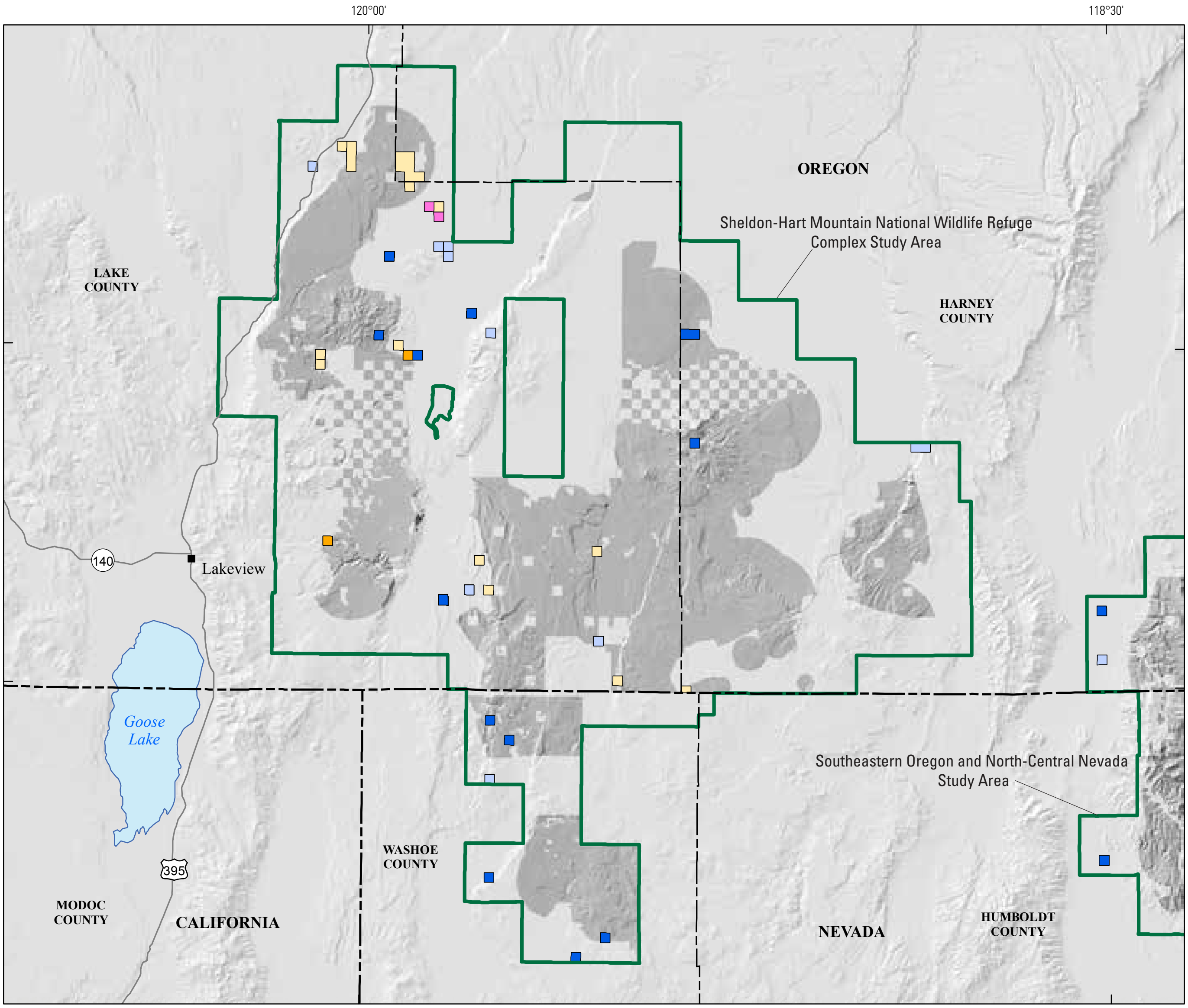


Figure 16. Map showing Bureau of Land Management (BLM) geothermal and sodium leases in the study area for the Sheldon-Hart Mountain National Wildlife Refuge Complex Sagebrush Focal Area, Nevada and Oregon (Williams and others, 2008a,b; Dicken and San Juan, 2016). USGS, U.S. Geological Survey.



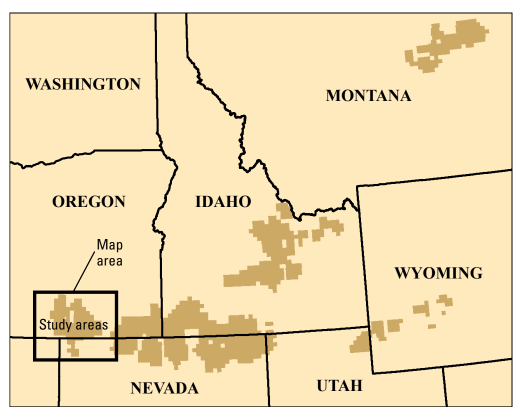


Figure 17. Map showing Bureau of Land Management (BLM) salable mineral commodity sites in the study area for the Sheldon-Hart Mountain National Wildlife Refuge Complex Sagebrush Focal Area, Nevada and Oregon (Dicken and San Juan, 2016). USGS, U.S. Geological Survey.

Mineral-Resource Potential of the Study Area for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area, Nevada and Oregon

Introduction

The study area for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area spans the border of Oregon and Nevada and includes parts of Humboldt County, Nevada, and Harney and Malheur Counties, Oregon (fig. 18). This report section describes the mineral potential of the proposed withdrawal area within the study area for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area. This study area includes parts of the proposed withdrawal area described in the "Introduction" section of this report. The proposed withdrawal area within this study area encompasses 1,382,477 acres (~5,595 km^2; 2,160 mi^2) of which the Bureau of Land Management (BLM) manages 1,213,644 acres and the U.S. Forest Service manages 168,833 acres.

Description of Geology

Neoproterozoic, Paleozoic, Mesozoic, and Cenozoic rocks are exposed within the study area for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area, Nevada and Oregon, and the USGS study area boundary (fig. 19). Neoproterozoic and Paleozoic rocks include metamorphosed sedimentary rocks. Paleozoic and Mesozoic sedimentary and volcanic rocks (Cambrian to Triassic) in part comprise the Roberts Mountains, Golconda, and Fencemaker allochthons, and the Black Rock (Devonian to Triassic) and Pueblo (Jurassic) terranes. These allochthons and terranes were intruded by granitic rocks (Jurassic, Cretaceous, and Tertiary). Tertiary strata are predominantly volcanic lava flows and tuffs, and sedimentary rocks (Eocene, Miocene and Pliocene). Quaternary strata include volcanic rocks and surficial deposits. The allochthons and terranes were juxtaposed by compressional tectonism during the Mesozoic. The allochthons, terranes, and Tertiary volcanic strata have been laterally displaced by late Tertiary extensional tectonism which produced the modern landforms of alternating, north-south-oriented mountain ranges separated by broad, relatively flat valleys (Basin and Range topography). Basin and Range topographic landforms and broad Tertiary volcanic uplands dominate the study area.

More complete descriptions of these strata and their tectonic evolution, are in report section "Introduction; Description of Geology."

Mineral-Resource Potential

Mineral Deposit Types

Characteristics of metallic and nonmetallic locatable mineral deposits, prospects, and host rocks in the study area for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area, Nevada and Oregon (appendix 2), are compatible with classification of these deposits as epithermal gold, silver, mercury, and gallium deposits, volcanogenic uranium deposits, gemstone deposits, specialty clay deposits, hectorite (lithium-rich clay) deposits, zeolite deposits, and lacustrine diatomite deposits (Day and others, 2016).

Epithermal gold, silver, mercury, and gallium deposits are shallowly formed vein, stockwork, disseminated, and replacement deposits that are mined primarily for gold and silver. Hot-spring-type mercury deposits are often the near-surface expression of gold and silver deposits that occur at deeper levels below mercury-enriched sinter and volcaniclastic strata. Only one gallium deposit occurs in the study area and it is in volcaniclastic strata subjacent to mercury deposits also in volcaniclastic strata. Epithermal gold, silver, and mercury deposits in the western United States occur largely in Eocene-Miocene volcanic fields, and have been mined primarily for gold and silver, and lesser mercury (on the basis of mass and value). No epithermal gallium deposits have been mined.

Volcanogenic uranium deposits include veins, stockworks, and stratabound deposits in felsic volcanic rocks and associated volcanoclastic sediments and tuffs in which uranium minerals are concentrated in fractures, faults, feeder zones, flow breccias, and permeable strata.

In the study area, gemstone and specialty clay deposits occur in Tertiary volcanic rocks that have been hydrothermally altered. There are few deposit type models for gemstone deposits because of the small size, small market, and limited number of most gemstone deposits, and because demand for most is based entirely on appearance. There are no deposit type models for specialty clay deposits because of small deposit size and market based on specific composition, color, purity, and other market factors.

Hectorite (lithium-rich clay) deposits form in closed-basin evaporative lake environments, including playas and calderas that contain large proportions of volcanic ash.

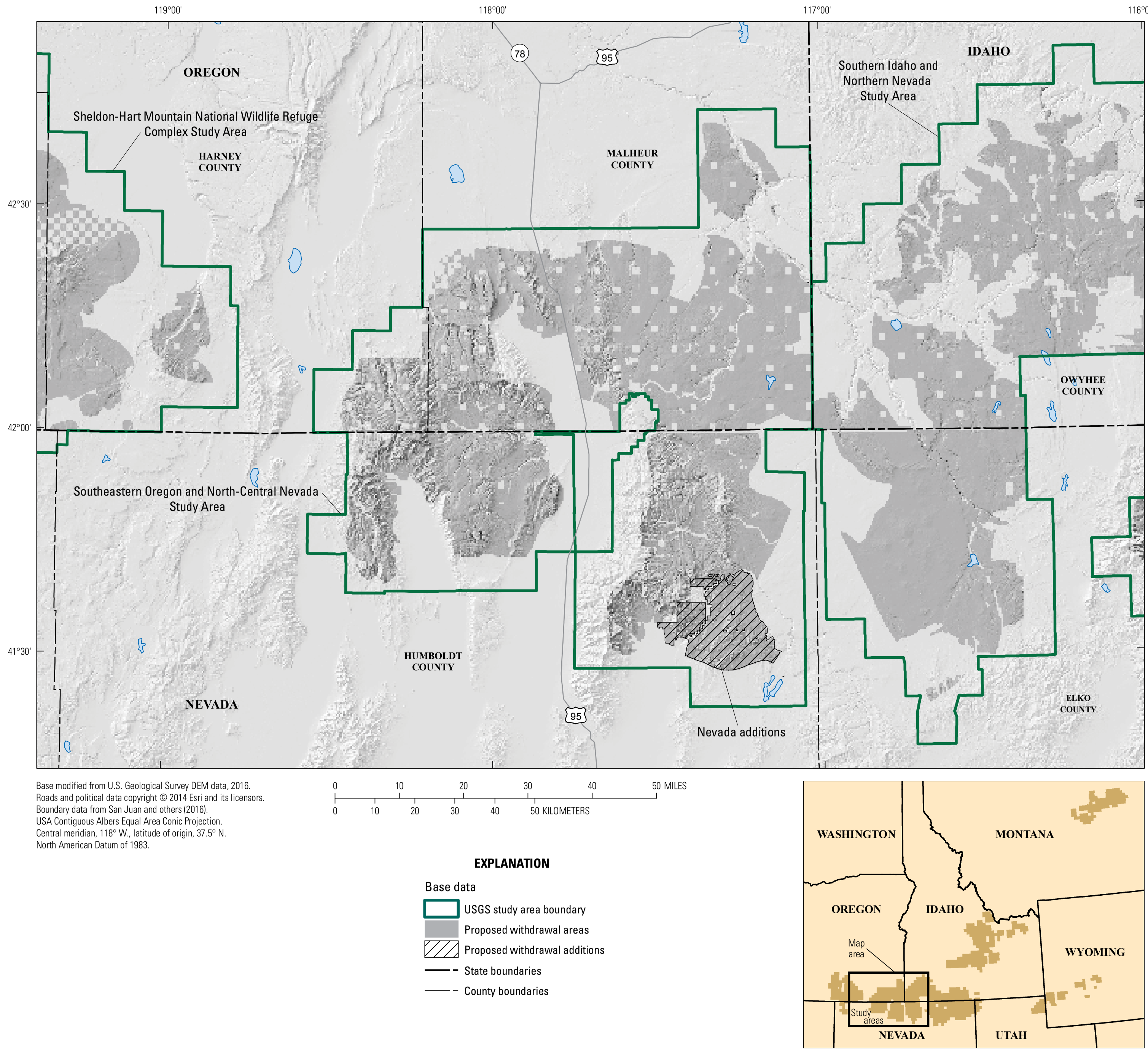


Figure 18. Map showing proposed withdrawal areas that comprise the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area, Nevada and Oregon, and boundary of the U.S. Geological Survey (USGS) study area. The study area boundary corresponds to townships that enclose the proposed withdrawal areas.

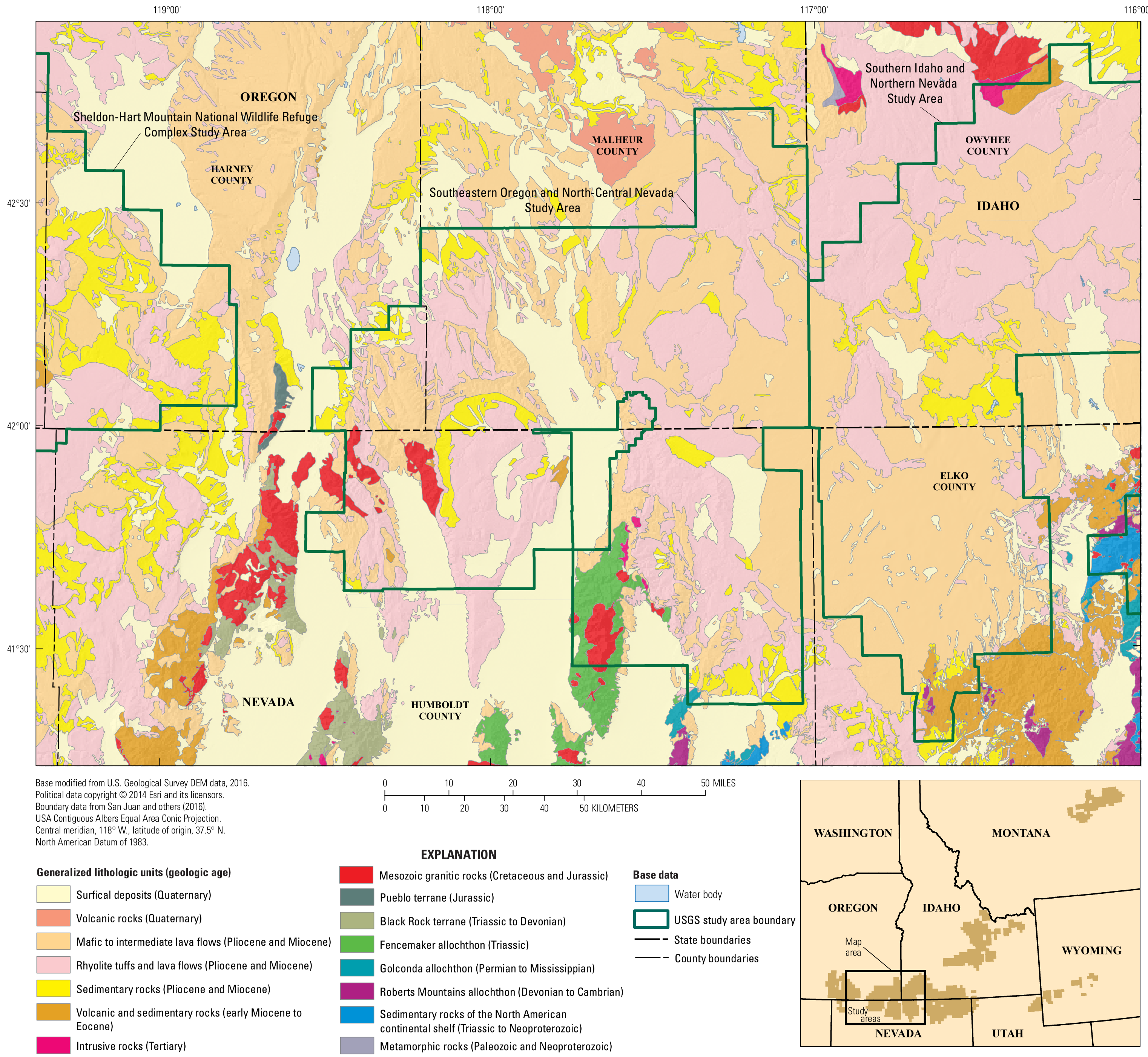


Figure 19. Simplified geologic map of the study area for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area, Nevada and Oregon. Synthesized from Walker and McLeaod (1991), Miller and others (2002), Crafford (2007), and Lewis and others (2012). USGS, U.S. Geological Survey.

Deposits consist of elevated concentrations of hectorite and other lithium minerals that have replaced pre-existing smectite clay and other minerals in lacustrine sediments. Lithium is thought to be derived from leaching by hydrothermal fluids of adjacent and subjacent volcanic ash and alkaline rocks.

Zeolite deposits consist of concentrations of numerous zeolite minerals in rhyolitic to dacitic vitric tuffs that have accumulated in arid, closed-basin, evaporative lake environments and have been altered by saline, carbonate-rich waters. Enclosing strata may include bedded evaporites (trona, halite, borates), mudstone, diatomite, and oil shale.

Lacustrine diatomite deposits consist of chalklike, earthy siliceous sedimentary strata composed of diatoms. In volcanic terranes, diatomaceous lake sediments typically occur within sequences of volcanic and sedimentary rocks. Lacustrine diatomite deposits in the western United States occur primarily in high-silica sequences of middle Miocene flows and tuffs.

Geology and Occurrence of Mineral Deposit Types

The study area for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area is predominantly underlain by Tertiary and Quaternary volcanic and sedimentary rocks. Mesozoic granitic intrusions are exposed in the western and southern parts of the study area. The southernmost exposures of granitic rocks are surrounded by siliciclastic strata of the Fencemaker allochthon (fig. 19). Epithermal gold, silver, mercury, and gallium, volcanogenic uranium, gemstone, specialty clay, lithium, zeolite, and lacustrine diatomite deposits, occur in Tertiary volcanic flows, intrusions, tuffs, and associated epiclastic sedimentary strata of the McDermitt and Whitehorse calderas, Humboldt County, Nevada, and Malheur and Harney Counties, Oregon, in the western part of the study area. Epithermal gold, silver, and mercury deposits occur in Tertiary volcanic rocks of the Santa Rosa-Calico volcanic field in the northern part of the Santa Rosa Range, and orogenic low-sulfide gold-quartz vein deposits occur in Mesozoic siliciclastic strata in the southern part of the Santa Rosa Range, Humboldt County, Nevada; these deposits are in the southeastern part of the study area.

Exploration and Mining Activity for Locatable Minerals

Metallic and nonmetallic locatable mineral commodities that have been mined and explored for in the study area for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area include gold, silver, mercury, gallium, uranium, gemstones, specialty clays, hectorite (lithium-rich clay), zeolites, and diatomite. Numerous lode and placer claims have been staked in the study area (fig. 20; tables 10, 11), there is an active plan of operations for uranium and there are numerous closed plans of operations and notices, indicative of current and recent mineral exploration (fig. 20; tables 12, 13). In addition, numerous claims were staked and filed in the study area from 1976 to 2007 (Causey, 2007, 2011; fig. 21).

Within the study area, two gold and silver deposits at the National and Buckskin National Mines were mined with recorded production of about 200,000 oz (troy ounces) gold and 760,000 oz silver (Vanderburg, 1938; Vikre, 1985b). Six mercury deposits (Cordero, Cordero [McDermitt], Bretz, Opalite, Ruja, and McCormick/Paradise) were mined with recorded production of about 408,000 flasks of mercury (Vanderburg, 1938; Yates, 1942; Bailey and Phoenix, 1944; Rytuba, 1976), and one uranium deposit was mined with recorded production of about 600 kilograms (kg) of uranium (Castor and Henry, 2000; table 14; fig. 22).

A resource of 138,351 short tons at 0.363 troy ounce per short ton gold and 3.37 troy ounces per short ton silver has been defined by drilling at the Buckskin National Mine. At the Cordero (McDermitt) Mine a mercury resource (1,070,000 short tons at 7.25 pounds [lbs] of mercury per ton) overlies a drill-identified gallium resource (21,562,700 million metric tons at 46.5 ppm [parts per million] gallium). An estimated resource of 2,000–3,000 flasks of mercury remains at the McCormick/Paradise Mine. Three uranium resources have been defined by drilling. The Kings Valley South and Kings Valley North resources (2,499,000 short tons at 0.076 weight percent U_3O_8), Aurora resource (76,390,000 short tons at 248 ppm U_3O_8), and Moonlight Mine resource (479,000 short tons at 0.108 percent U_3O_8), are active exploration projects (table 14). The National, Buckskin National, and McCormick Mines are within the proposed withdrawal area. The mercury and gallium resources at the Cordero (McDermitt) Mine are outside the proposed withdrawal area and are inside the USGS study area boundary. The Kings Valley South and Kings Valley North uranium resources are outside the proposed withdrawal area.

Several plans of operations and notices of mineral exploration for lithium, clays, and gemstones have been authorized, are pending, or are active, indicating recent and active mineral exploration in the study area (fig. 20; tables 12, 13).

Within the study area, a lithium resource of 823 million short tons at 0.30 percent lithium (Kings Valley Lithium; table 14) comprises five deposits that have been defined by drilling. The Stage I deposit, 374,443,027 short tons at 0.292 percent lithium occurs outside the proposed withdrawal area and within the USGS study area boundary. The Stage II, Stage III, Stage IV, and Stage V deposits have a combined resource of 449,528,206 short tons at 0.304 percent lithium (Fernette and others, 2016a).

A qualitative estimate of past mining activity for locatable metallic (and nonmetallic) mineral commodities was made by counting mining-related symbols on U.S. Geological Survey (USGS) topographic maps that cover the study area (Fernette and others, 2016b). There are 1,798 mine symbols shown on USGS 7.5-minute topographic maps, 99 of which are adits, shafts, or open-pit mines, and 1,634 are prospect pits. These symbols are commonly associated with mining and exploration of locatable minerals and provide a broad indication of the extent of past mining activity in the area. Other mine symbols include borrow pits, gravel pits, and cinder pits, which are commonly associated with production of salable minerals.

A second qualitative estimate of past mining activity was made by extracting mines and deposits with the statuses "producer" and "past producer" from the USGS Mineral Resources Data System (MRDS; U.S. Geological survey, 2005). The MRDS database contains 150 records of "producer" and (or) "past producer," including 59 deposits that were mined for metallic minerals, 46 for gemstones, 2 for uranium, 2 for industrial minerals, and the 41 for stone, sand, and gravel. However, it should be noted that some MRDS records may be duplicates. The MRDS database includes partial production data for one mine, the McDermitt mercury mine, but no production data for other mines.

Table 10. Type, number, and status of mining claims, leases, mineral material sales sites for salable mineral commodities, and surface-management plans in the proposed withdrawal area within the study area for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area, Nevada and Oregon.

[Leasable mineral commodities include coal, geothermal, non-energy solid mineral, oil and gas. Sources: Dicken and San Juan (2016) for Bureau of Land Management (BLM) 43 Code of Federal Regulations (CFR) 3809 data; Susan G. Summer Elliott, U.S. Forest Service (USFS), written commun., March 9, 2016, for USFS 36 CFR 228 Subpart A plans. The number of cases is for the complete Public Land Survey System (PLSS) section that includes a proposed withdrawal area. —, no data]

Type	Mineral type	Number of unique cases	Active	Authorized/ Approved	Pending/ Proposed	Closed	Cancelled	Expired	Rejected	Withdrawn
Mining claims	Locatable	20,097	2,464	—	—	17,633	—	—	—	—
Coal leases	Leasable	—	—	—	—	—	—	—	—	—
Geothermal leases	Leasable	29	—	—	—	29	—	—	—	—
Non-energy solid mineral leases	Leasable	8	—	—	—	8	—	—	—	—
Oil and gas leases	Leasable	135	—	—	—	135	—	—	—	—
Mineral materials sales sites	Salable	104	—	17	—	86	—	1	—	—
Surface-management plans	—	128	1	4	1	113	—	10	—	—

Table 11. Summary of active and closed mining claims for locatable minerals in Public Land Survey System (PLSS) sections that are in the proposed withdrawal area within the study area for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area, Nevada and Oregon.

[Source: Dicken and San Juan, 2016. The number of cases is for the complete PLSS section that includes a proposed withdrawal area]

Area	Active lode claims	Closed lode claims	Active placer claims	Closed placer claims	Active millsites	Closed millsites
Sections containing proposed withdrawal area	2,427	17,209	37	255	0	169

Table 12. Status and number of surface-management plans for locatable minerals in the proposed withdrawal area within the study area for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area, Nevada and Oregon.

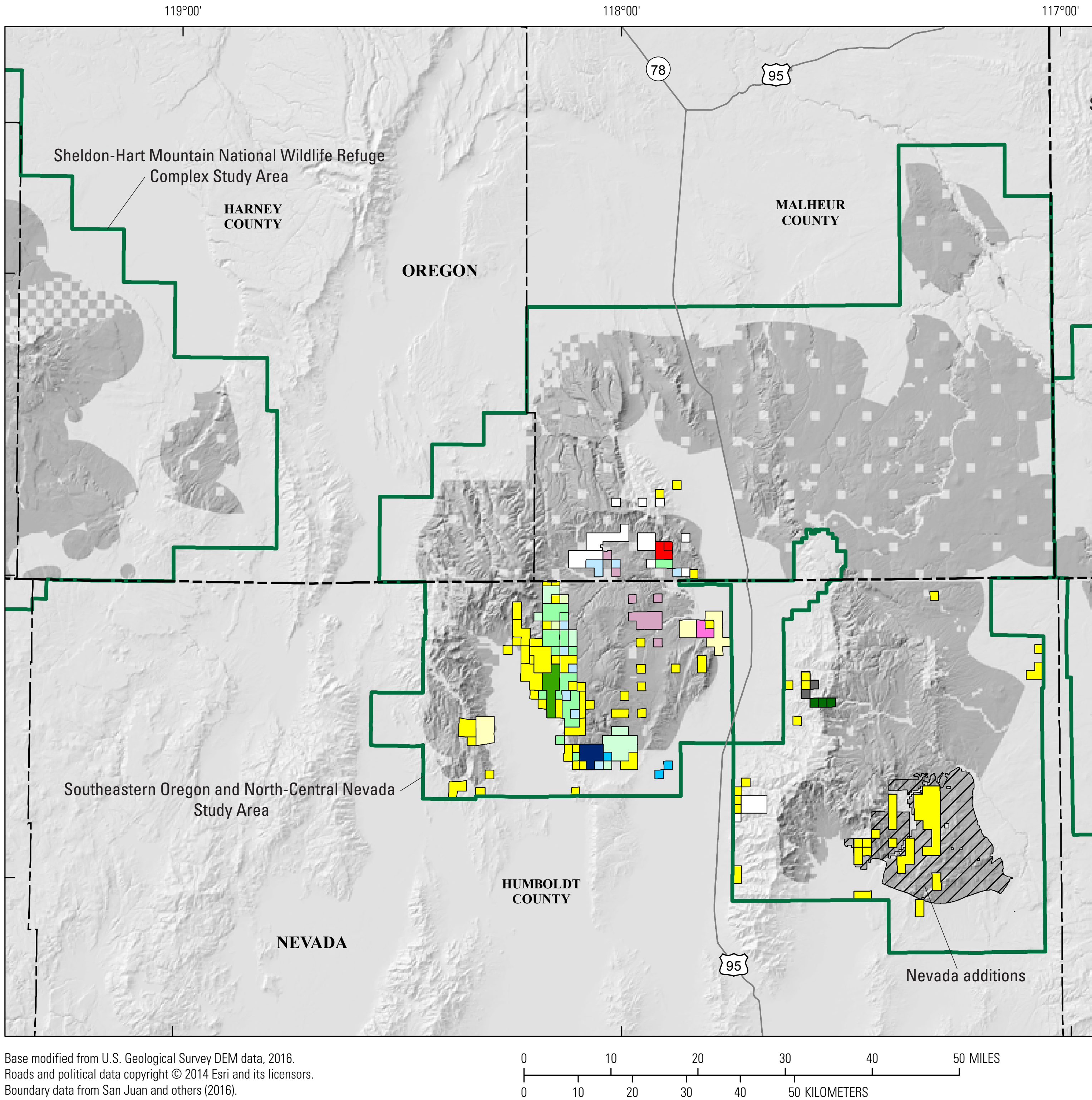
[Sources: Dicken and San Juan (2016) for Bureau of Land Management (BLM) 43 Code of Federal Regulations (CFR) 3809 plans; Susan G. Summer Elliott, U.S. Forest Service (USFS), written commun., March 9, 2016, for USFS 36 CFR 228 Subpart A plans. The number of cases is for the complete Public Land Survey System (PLSS) section that includes a proposed withdrawal area. —, no data]

Authorization type	Number of unique cases	Active	Authorized/ Approved	Pending/ Proposed	Closed	Cancelled	Expired	Rejected	Withdrawn
Plans of operations	13	1	2	—	10	—	—	—	—
Notice	115	—	1	1	103	—	10	—	—

Table 13. Status and number of active surface-management plans in the proposed withdrawal area within the study area for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area, Nevada and Oregon, summarized by locatable commodity.

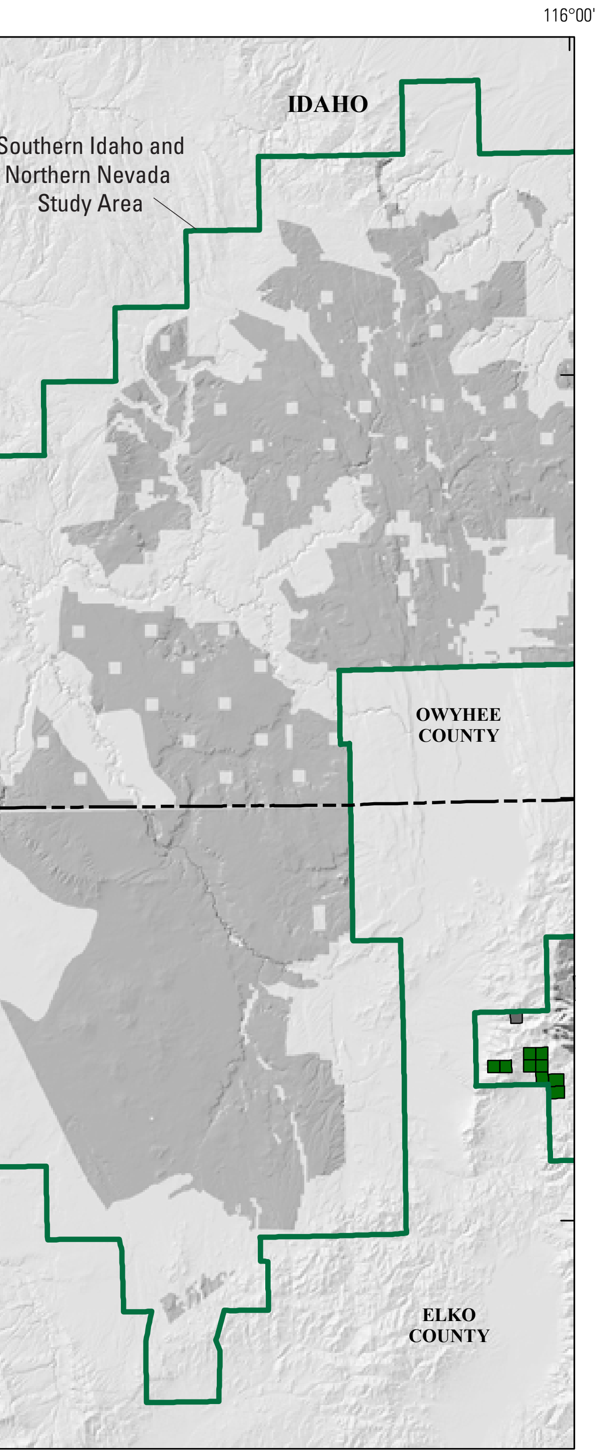
[Active includes active, authorized/approved, and pending/proposed from table 12. Sources: Dicken and San Juan (2016) for Bureau of Land Management (BLM) 43 Code of Federal Regulations (CFR) 3809 plans; Susan G. Summer Elliott, U.S. Forest Service (USFS), written commun., March 9, 2016, for USFS 36 CFR 228 Subpart A plans. The number of cases is for the complete Public Land Survey System (PLSS) section that includes a proposed withdrawal area]

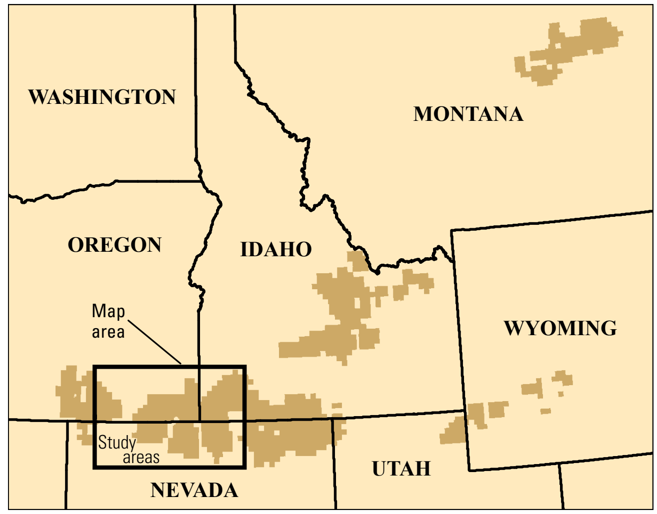
Commodity	Active notices	Active plans of operations
Gold and silver	0	1
Clay, common	1	0
Gemstone, semiprecious silica	1	0
Lithium	0	1
Uranium and other minerals	0	1



Base modified from U.S. Geological Survey DEM data, 2016.
Roads and political data copyright © 2014 Esri and its licensors.
Boundary data from San Juan and others (2016).
USA Contiguous Albers Equal Area Conic Projection.
Central meridian, 118° W., latitude of origin, 37.5° N.
North American Datum of 1983.

Figure 20. Map showing active and closed surface-management plans of operations and notices for locatable mineral commodities in the study area for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area, Oregon and Nevada, including data from the Bureau of Land Management (Dicken and San Juan, 2016, 43 Code of Federal Regulations [CFR] 3809 data) and the U.S. Forest Service (Susan G. Summer Elliott, U.S. Forest Service [USFS], written commun., March 9, 2016, for USFS 36 CFR 228 Subpart A plans). USGS, U.S. Geological Survey.





EXPLANATION

BLM—Locatable commodities: commodity; case disposition; case type

- Gold, gold lode, gold placer, copper; closed, expired, cancelled; surface management-notice
- Gold, gold lode; closed; surface management-plan
- Uranium and other minerals; authorized; surface management-plan
- Uranium, uranium and other minerals, uranium, (U_3O_8 content); closed; surface management-notice
- Uranium and other minerals; closed; surface management-plan-withdrawal-review
- Lithium; authorized; surface management-plan
- Lithium; authorized, pending; surface management-notice
- Lithium; closed; surface management-notice
- Mercury; closed; surface management-notice
- Rare earths; closed; surface management-notice
- Clay, bentonite; closed, expired; surface management-notice
- Other (all locatables, none, to be defined)

U.S. Forest Service—Management plans

- Active
- Inactive

Base data

- USGS study area boundary
- Proposed withdrawal areas
- Proposed withdrawal additions
- State boundaries
- County boundaries

Figure 20.—Continued

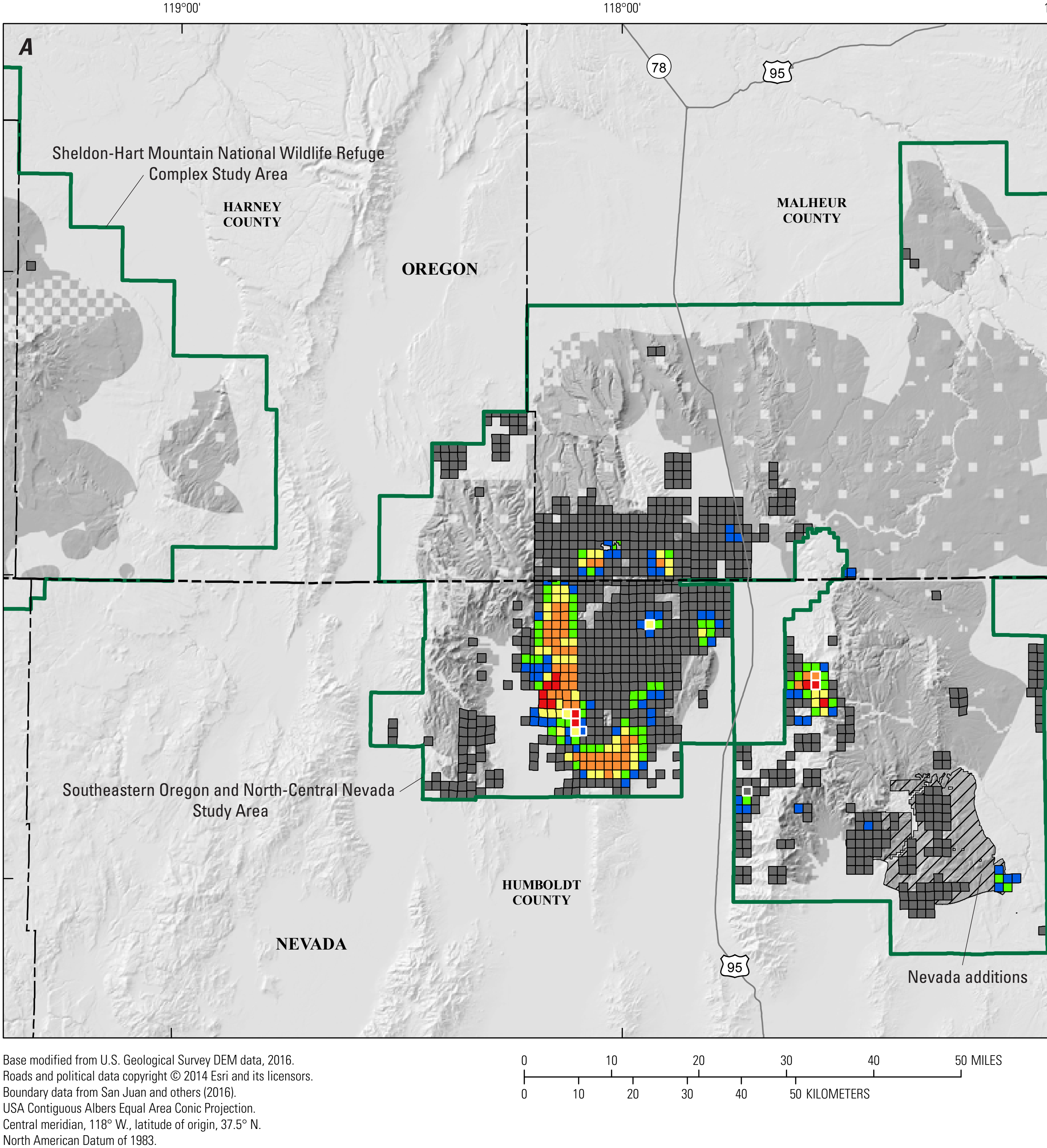


Figure 21. Maps showing mining claims by Public Land Survey System (PLSS) section in the study area for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area, Nevada and Oregon. *A*, Number of active lode claims and placer claims per section (Dicken and San Juan, 2016). *B*, Thirty-five year averages of the number of active lode claims by section for mining claims located between 1976 and 2010 (Causey, 2007, 2011).

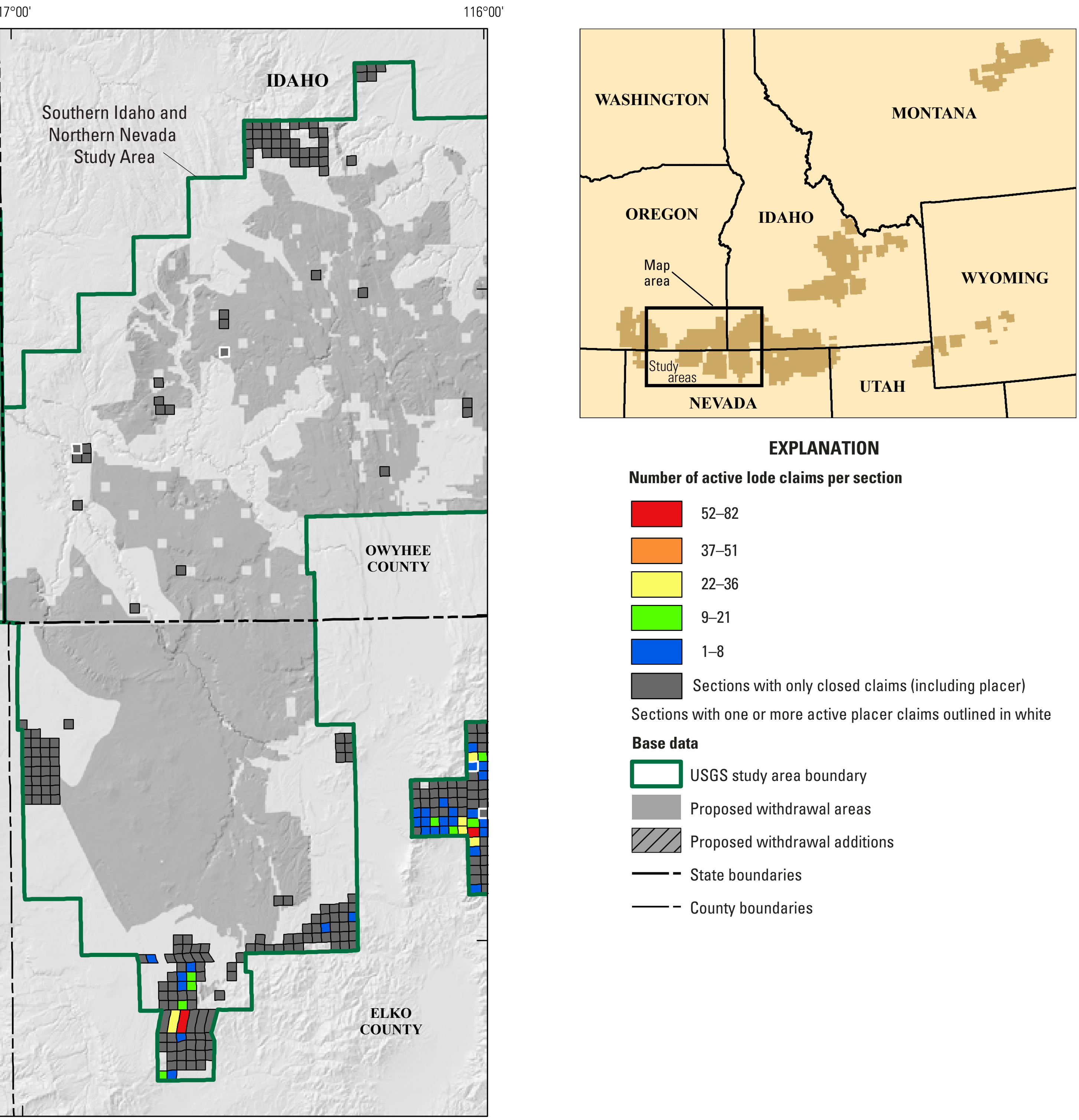


Figure 21.—Continued

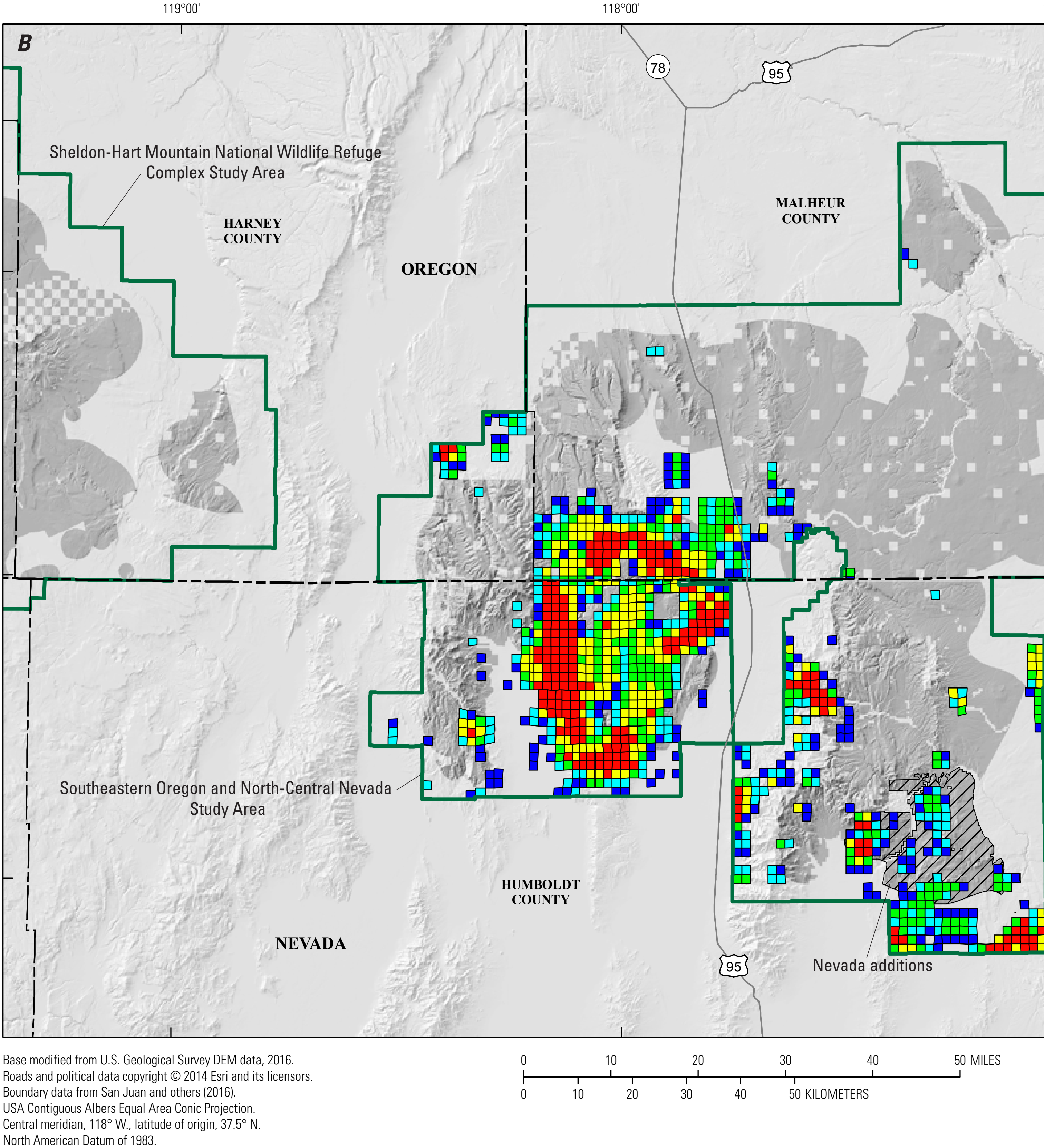


Figure 21. Maps showing mining claims by Public Land Survey System (PLSS) section in the study area for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area, Nevada and Oregon. *A*, Number of active lode claims and placer claims per section (Dicken and San Juan, 2016). *B*, Thirty-five year averages of the number of active lode claims by section for mining claims located between 1976 and 2010 (Causey, 2007, 2011).

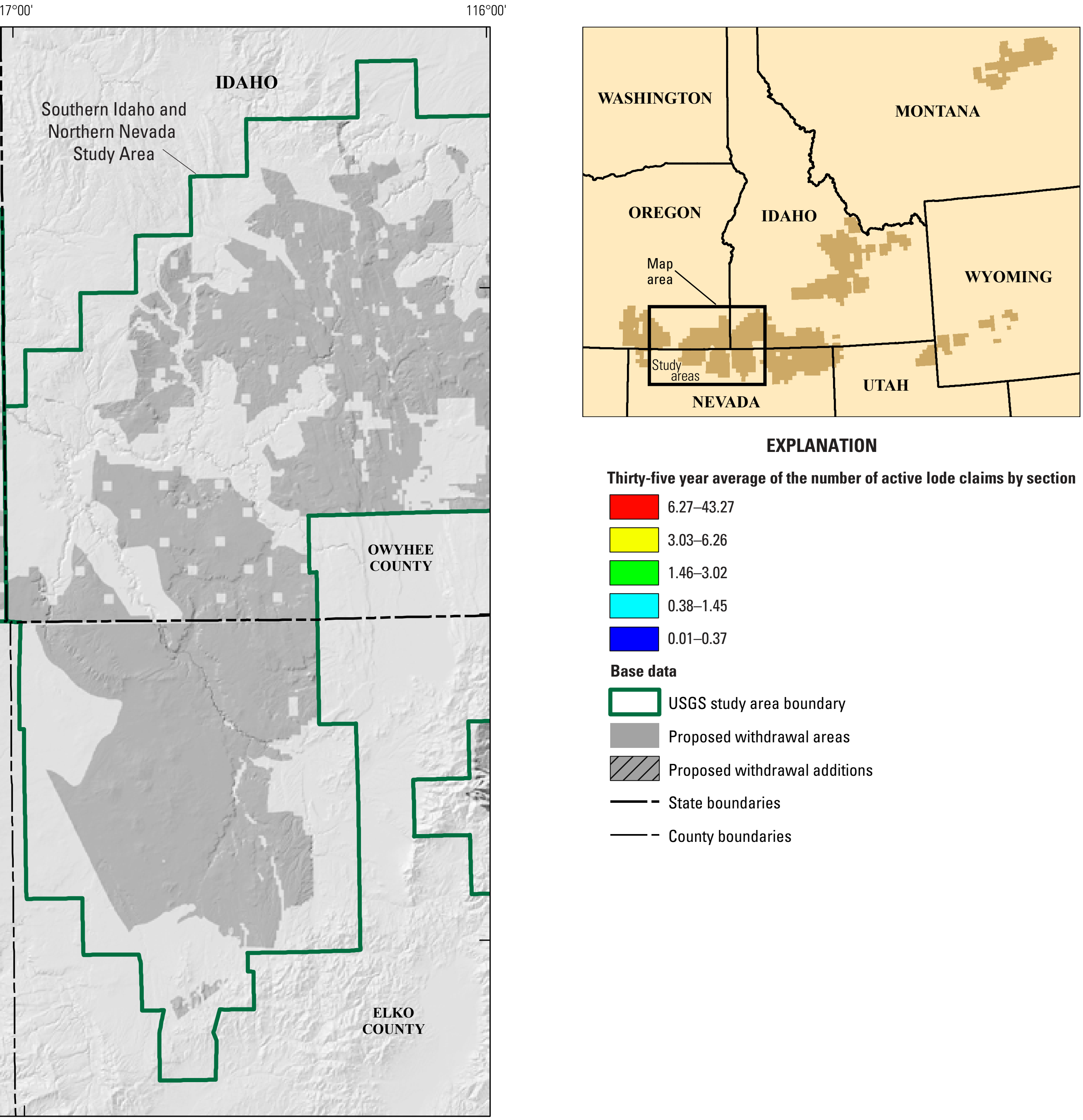
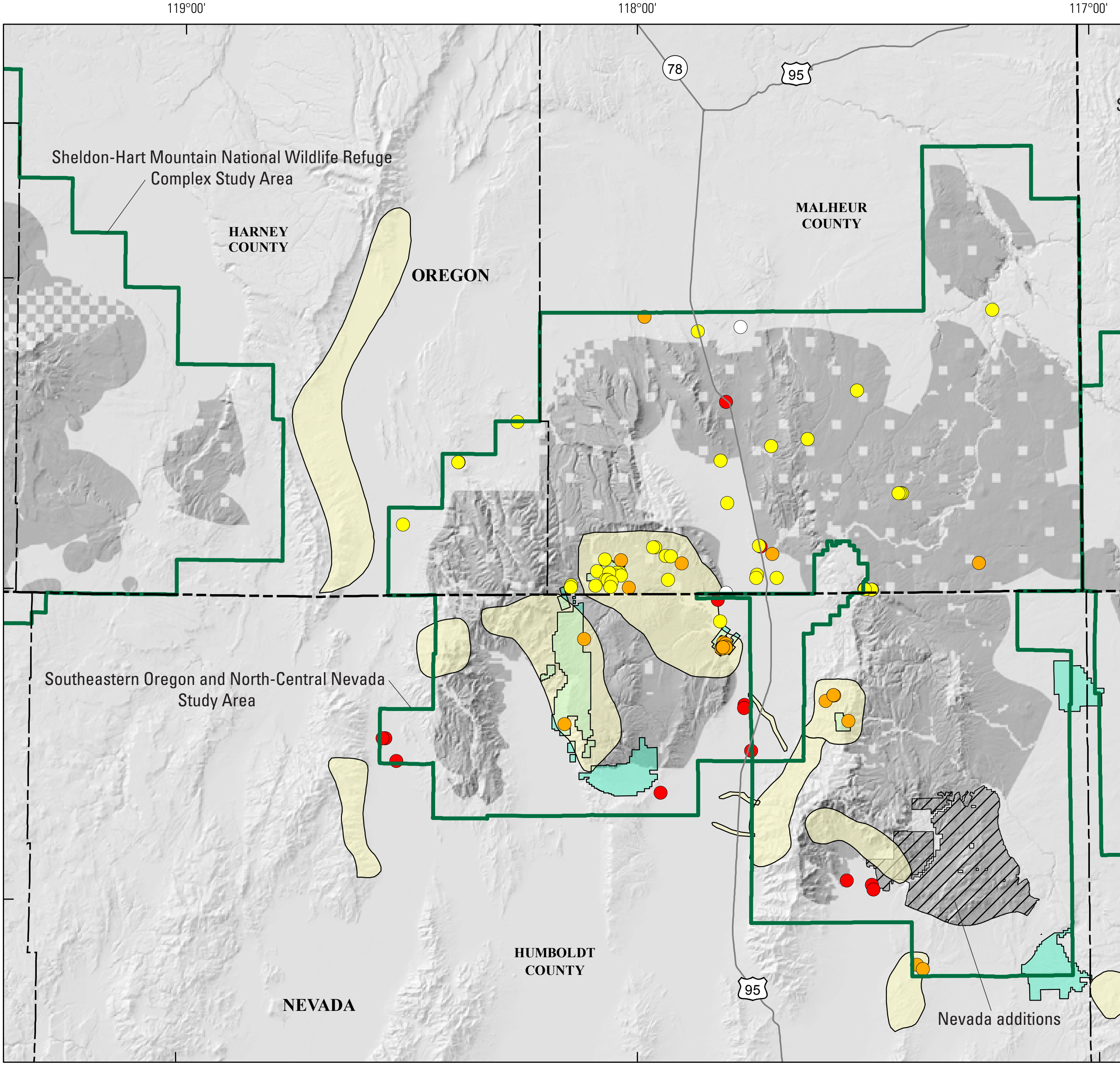


Figure 21.—Continued



Base modified from U.S. Geological Survey DEM data, 2016.
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Boundary data from San Juan and others (2016).
USA Contiguous Albers Equal Area Conic Projection.
Central meridian, 118° W., latitude of origin, 37.5° N.
North American Datum of 1983.

0 10 20 30 40 50 MILES
0 10 20 30 40 50 KILOMETERS

Figure 22. Map showing mining districts, mine status, and active exploration areas in or near the study area for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area, Nevada and Oregon (Fernette and others, 2016a,b). USGS, U.S. Geological Survey.

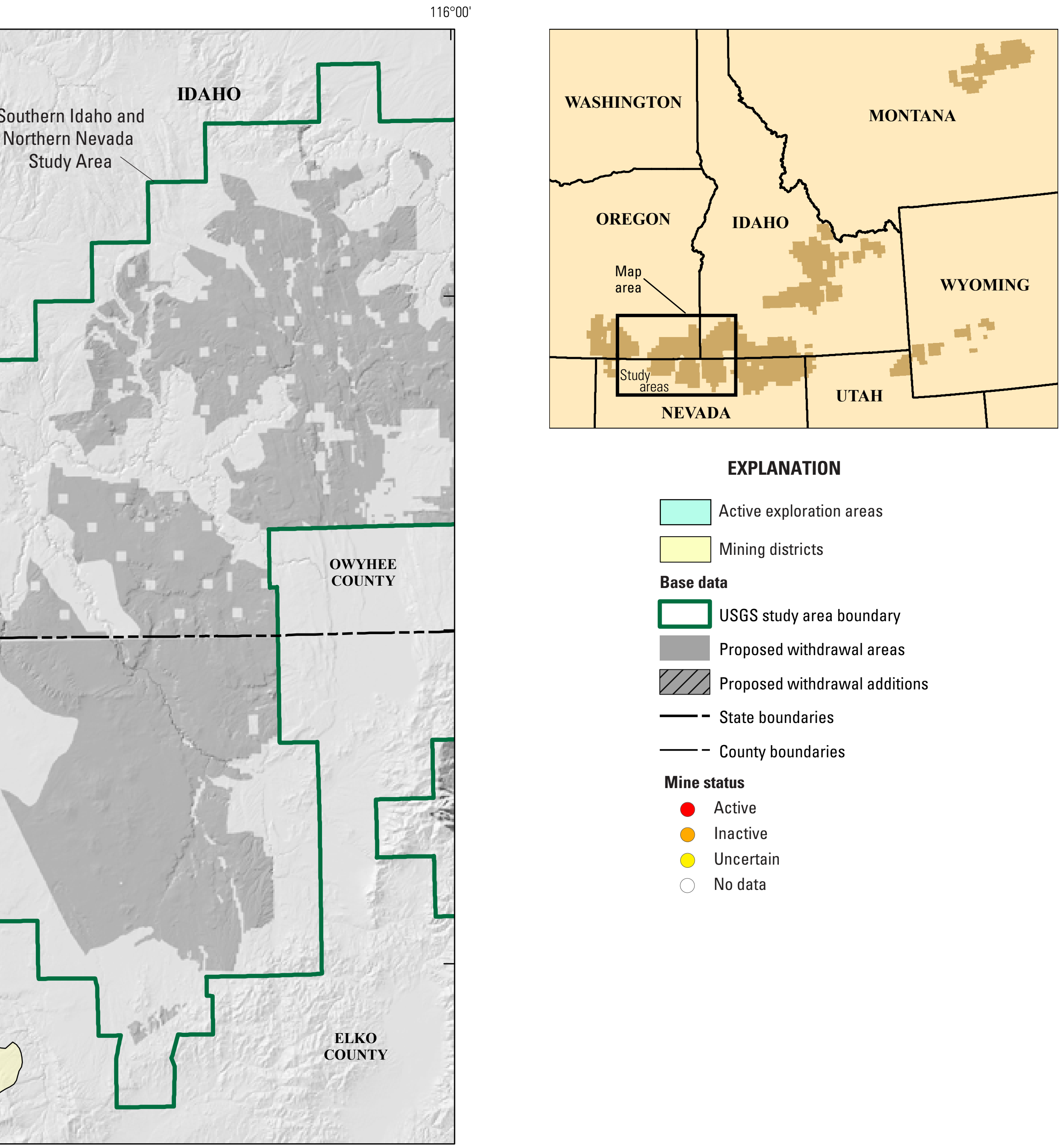


Figure 22.—Continued

Table 14. Mined deposits with production, and resources within and partly within the study area for the Southeastern Oregon and North-Central Nevada Focal Area.

[Data from technical reports, including NI 43-101 documents, are in Fernette and others, 2016a. Nevada mining districts are from Tingley (1992). One flask of mercury = 76 pounds of mercury; est., estimate; g/metric ton, grams per metric ton; kg, kilogram; lbs, pounds; M+I+I, measured plus indicated plus inferred; MST, million short tons; NV, Nevada; opt, troy ounce per short ton; OR, Oregon; oz, troy ounce; ppm, part per million; ST, short ton; U_3O_8, triuranium octoxide; @, at; %, weight percent; $, U.S. dollars; M, million]

Mine/Deposit name	Assessment tract name	Mining district	County, state	Commodity	Production years	Production	Resource	Notes; source
National Mine	ONEP03, Buckskin	National	Humboldt, NV	Gold and silver	1909–1929	175,502 oz gold; 457,190 oz silver	—	Vanderburg (1938)
Buckskin National Mine	ONEP03, Buckskin	National	Humboldt, NV	Gold and silver	1908–1941	24,000 oz gold; 300,000 oz silver	138,351 ST @ 0.363 opt gold; 3.37 opt silver	Fernette and others (2016a), Vikre (1985b)
McCormick/Paradise Mine	ONEP03, Buckskin	National	Humboldt, NV	Mercury	1930s	58 flasks mercury	Est. 2,000–3,000 flasks	Vanderburg (1938), Roberts (1940)
Silver Butte claims	ONEP04, Paradise Valley	Paradise Valley	Humboldt, NV	Silver and gold	1879/1935	Est. $1.5–3M	—	Vanderburg (1938)
Cordero	ONEP01, Cordero	Opalite	Humboldt, NV	Gold and silver	—	—	—	—
Cordero Mine	ONEP01, Cordero	Opalite	Humbolt, NV	Mercury	1941–43	105,636 flasks mercury	—	Yates (1942); Bailey and Phoenix (1944); Rytuba (1976); Speer (1977); NI 43-101 NV Cordero Gold Silver Project August 1, 2007 technical report; Fernette and others (2016a)
Cordero (McDermitt) Mine	ONEP01, Cordero	Opalite	Humbolt, NV	Mercury	1975–1986	269,580 flasks mercury	1,070,000 ST @ 7.25 lbs mercury/ST	
Bretz Mine	ONEP01, Cordero	Opalite	Malheur, OR	Mercury	1931–1968	14,807 flasks mercury	—	
Opalite Mine	ONEP01, Cordero	Opalite	Malheur, OR	Mercury	—	12,367 flasks mercury	—	
Ruja	ONEP01, Cordero	Opalite	Humbolt, NV	Mercury	—	6,000 flasks mercury	—	
Cordero (McDermitt) Mine	ONEP01, Cordero	Opalite	Humboldt, NV	Gallium	—	—	21,562,700 million metric tons @ 46.5 ppm gallium (M+I+I)	Carew (2008)
Moonlight Mine	ONVU01, Kings Valley	Opalite	Humboldt, NV	Uranium	—	600 kg (~1,320 lbs)	479,000 ST @ 0.108% U_3O_8	Castor and Henry (2000), Fernette and others (2016a)
Kings Valley South; Kings Valley North	ONVU01, Kings Valley	Opalite	Humboldt, NV	Uranium	—	—	2,499,000 ST @ 0.076% U_3O_8	NI 43-101 NV Kings Valley Project December 20, 2007 technical report; Eggleston and others (2007)
Aurora	ONVU01, Kings Valley	Opalite	Malheur, OR	Uranium	—	—	76,390,184 ST @ 248 ppm U_3O_8	https://aurorauraniumlimited.wordpress.com/projects/, accessed January 14, 2016; Meyers and Underhill (2005)
Kings Valley Lithium	ONVU01, Kings Valley	Opalite	Humboldt, NV	Lithium	—	—	823 MST @ 0.30% lithium	Tetra Tech (2014), Eggleston (2008)

Mineral Potential of Locatable Minerals

Potential for undiscovered deposits of locatable mineral commodities (metallic locatable minerals and nonmetallic locatable minerals) within this study area was evaluated for the locatable commodities gold, silver, mercury, gallium, uranium, gemstones, lithium, specialty clays, zeolites, and diatomite. These mineral commodities were selected for evaluation on the basis of deposits in this study area with production and (or) defined resources, prospects, hydrothermal alteration, stratigraphy and structure of host rocks, and other geological characteristics of deposit types for these commodities (Day and others, 2016; appendix 2; table 1). Records of active and historic mining claims and surface-management plans provided by the BLM and USFS were also used in the assessment process. Mineral-resource potential is represented by rated tracts; tracts consist of areas favorable for undiscovered deposits of one or more commodities that are enclosed by tract boundaries, assigned qualitative potential (high, moderate, or low/permissive), and assigned a level of potential certainty. The tract boundaries include a buffer of variable dimension that reflects spatial uncertainty of one or more of the characteristics used to delineate the tract. The qualitative mineral potential ratings are derived from a classification matrix that merges mineral potential and level of certainty (appendix 1).

Delineation and rating of tracts are based entirely on publications available from libraries and Web sites, and on technical reports, documents, and maps available from Web sites, downloaded from Web sites that are no longer maintained, and provided by companies with mineral rights on lands included in the proposed withdrawal area. The technical reports, documents, and maps that are not available on Web sites, and those provided by companies, can be accessed in a database that includes mineral deposits with production and resources, and mineral exploration sites within the study areas (Fernette and others, 2016a). All publications, technical reports, documents, and maps used to delineate and rate tracts are cited in tract descriptions, in tables of tract characteristics, and in tables of deposit production, resources, and mineral exploration sites. We did not perform field examinations, mapping, or analyses of the tracts, deposits, and resources described in this report section.

Mineral Potential Tracts for Epithermal Gold, Silver, Mercury, and Gallium Deposits

Four mineral potential tracts for epithermal gold, silver, mercury, and gallium deposits were delineated and rated in the study area: tract ONEP01, Cordero (mercury, gold, silver, and gallium); tract ONEP02, Lucky Boy (mercury); tract ONEP03, Buckskin (gold, silver, and mercury); and tract ONEP04, Paradise Valley (silver and gold).

Tract ONEP01, Cordero—A high potential (H), with certainty level D, for epithermal mercury, gold, silver, and gallium deposits is assigned to a tract delineated by the observed and inferred distribution of caldera-ring fractures and postcaldera intrusions in the McDermitt caldera, Humboldt County, Nevada, and Malheur County, Oregon (tract ONEP01, Cordero; fig. 23*A*; appendix 2; Rytuba, 1976). The distribution of postcaldera intrusions in the subsurface is reflected by aeromagnetic high anomalies that occur inboard of the caldera margin (U.S. Geological Survey, Department of Interior and the National Geophysical Data Center, NOAA, 2002). The tract includes the Opalite Mining District (Tingley, 1992) which contains the McDermitt, Cordero, Bretz, Opalite, and Ruja Mines that have a total production of 10,530 short tons of mercury (Yates, 1942; Bailey and Phoenix, 1944; Rytuba, 1976; table 14). The mercury deposits occur in tuffs and caldera-fill sediments that have been altered to an assemblage of adularia, quartz, opal, and clays in and adjacent to the ring fracture zone of the caldera (Rytuba and Glanzman, 1979). Mercury ore minerals are primarily cinnabar, corderoite, and elemental mercury in association with pyrite and the antimony minerals, stibnite, and stibiconite (Rytuba and others, 2003).

Other prospects within the caldera ring fracture zone, primarily the northwest part of the caldera, have been the focus of exploration and drilling for gold and silver, and active claims are present in the Albisu-Corral Canyon area. Extensive drilling has delineated a low-grade gold resource in stockwork veins that contain sulfide±quartz±calcite and occur in tuffs and basalt (Concordia Resources Corporation, 2011). The surface manifestations of these deposits are characterized by hydrothermal illite that has been mapped using ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) remote-sensing imagery (Rockwell and others, 2015).

Elevated concentrations of gallium occur in caldera-filling tuffs and flows located below the near-surface McDermitt mercury deposit. A measured and indicated NI 43-101-compliant resource consists of 14.97 million short tons at 47.7 ppm gallium, and anomalous gallium and light rare earth element (REE) concentrations, occur in a wide area outside the established resource (Carew, 2008). Gallium occurs in zones of alunite-kaolinite-quartz alteration developed along caldera ring fracture faults (Rytuba and others, 2003). Low-grade uranium is associated with the Bretz and Opalite mercury deposits (Roper and Wallace, 1981; Berry and others, 1982). Numerous active lode and placer claims are in the tract, as well as many closed lode claims (fig. 21; Causey, 2007, 2011).

Tract ONEP02, Lucky Boy—A moderate potential (M), with certainty level C, for epithermal mercury deposits is assigned to areas delineated by the observed and inferred distribution of caldera ring fracture of the Whitehorse caldera and postcaldera domes and intrusions, Harney and Malheur Counties, Oregon (tract ONEP02, Lucky Boy; fig. 23*A*; appendix 2; Rytuba and others, 1981). The western boundary of the caldera is coincident with an oval aeromagnetic low anomaly that extends beyond the caldera margin on the east side of the caldera. Hydrothermal alteration of the rhyolite domes consists of silicification and argillic alteration and presence of quartz and chalcedony veins (Rytuba and others, 1981). Two gold and silver prospects, Lucky Boy and Flagstaff Butte, without identified resources are present (Fernette and others, 2016a). Extensive drilling by several mining companies has occurred at the Flagstaff Butte prospect (Ferns and others, 1986; Hladky, 1993). Numerous active lode and placer

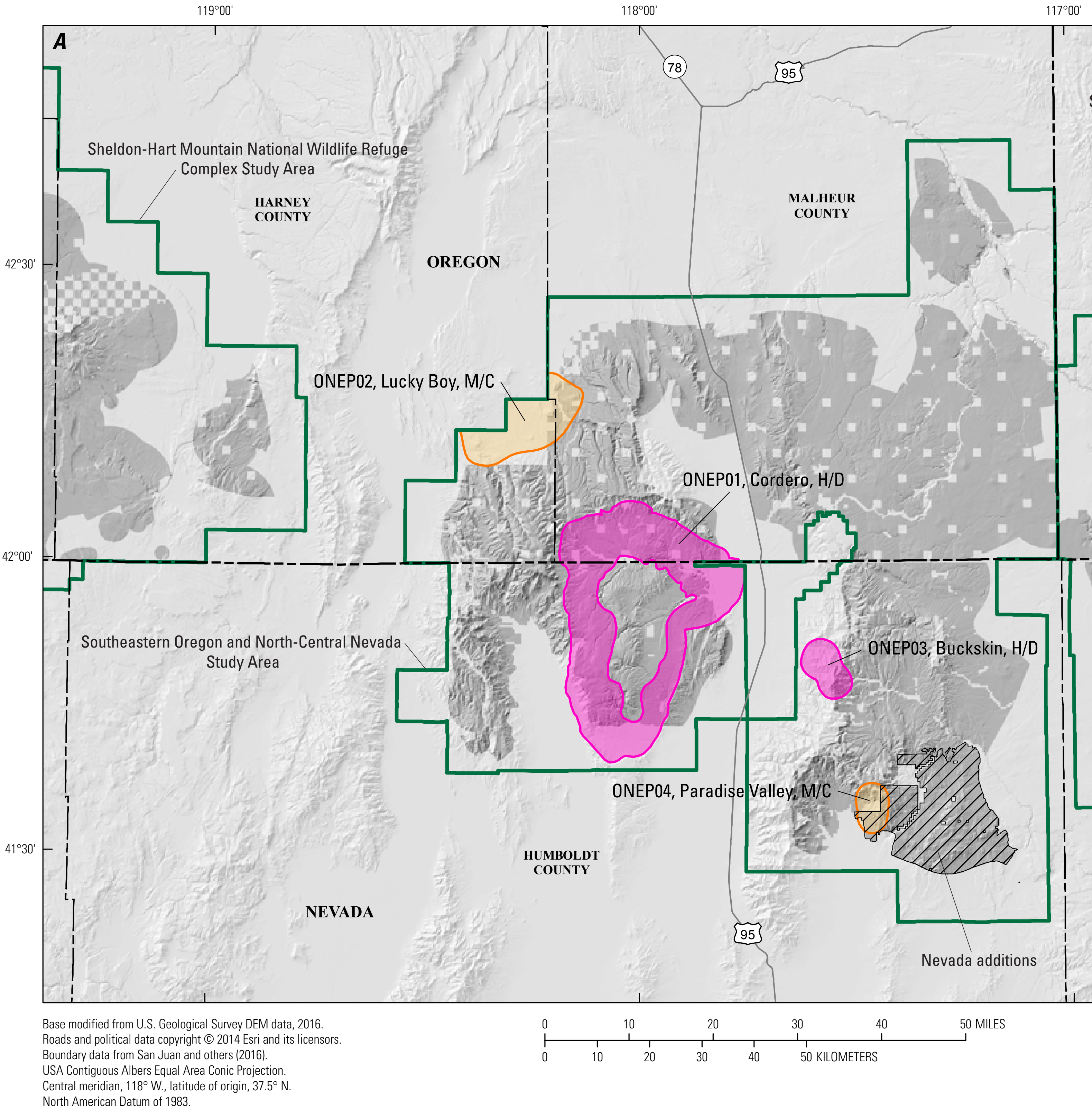
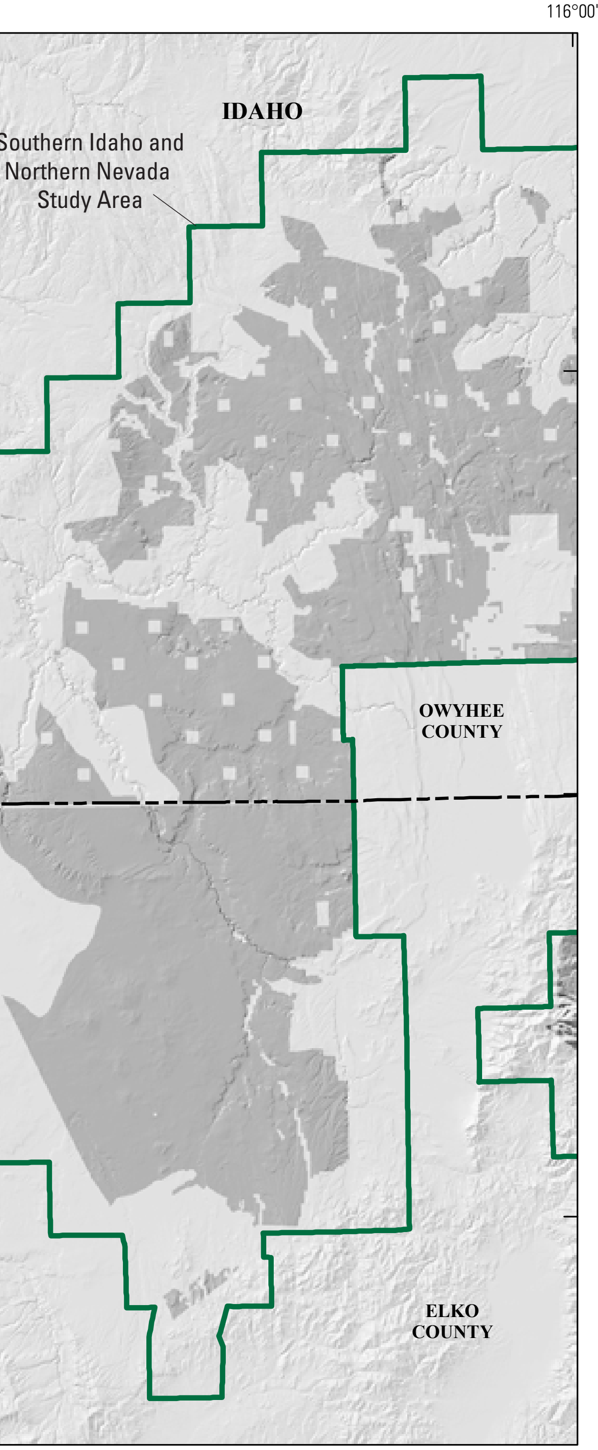
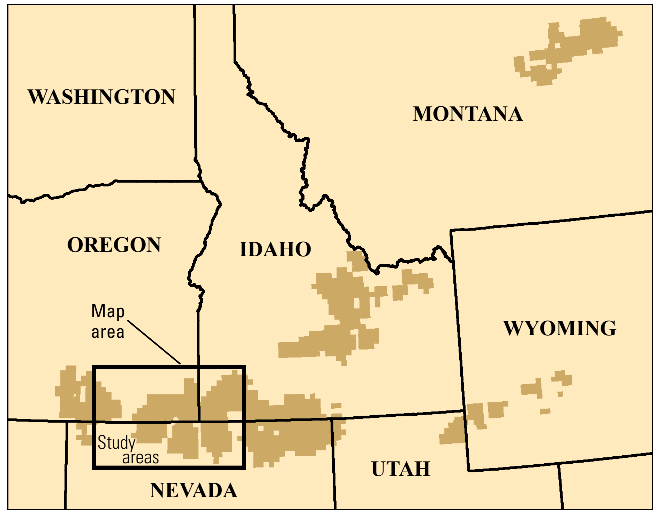


Figure 23. Maps showing assessment tracts and level of resource potential for metallic and nonmetallic locatable minerals in the study area for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area, Nevada and Oregon (San Juan and others, 2016); USGS, U.S. Geological Survey; *A*, Assessment tracts for epithermal gold-silver (mercury); *B*, Assessment tract for volcanogenic uranium; *C*, Assessment tract for orogenic low-sulfide gold-quartz veins; *D*, Assessment tract for specialty gemstone; *E*, Assessment tracts for hectorite (lithium-rich clay); *F*, Assessment tracts for specialty clay; *G*, Assessment tracts for zeolites; and *H*, Assessment tracts for lacustrine diatomite.





EXPLANATION

Assessment tract type—Epithermal gold-silver (mercury)

- High potential, high certainty
- Moderate potential, moderate certainty

Base data

- USGS study area boundary
- Proposed withdrawal areas
- Proposed withdrawal additions
- State boundaries
- County boundaries

Figure 23.—Continued

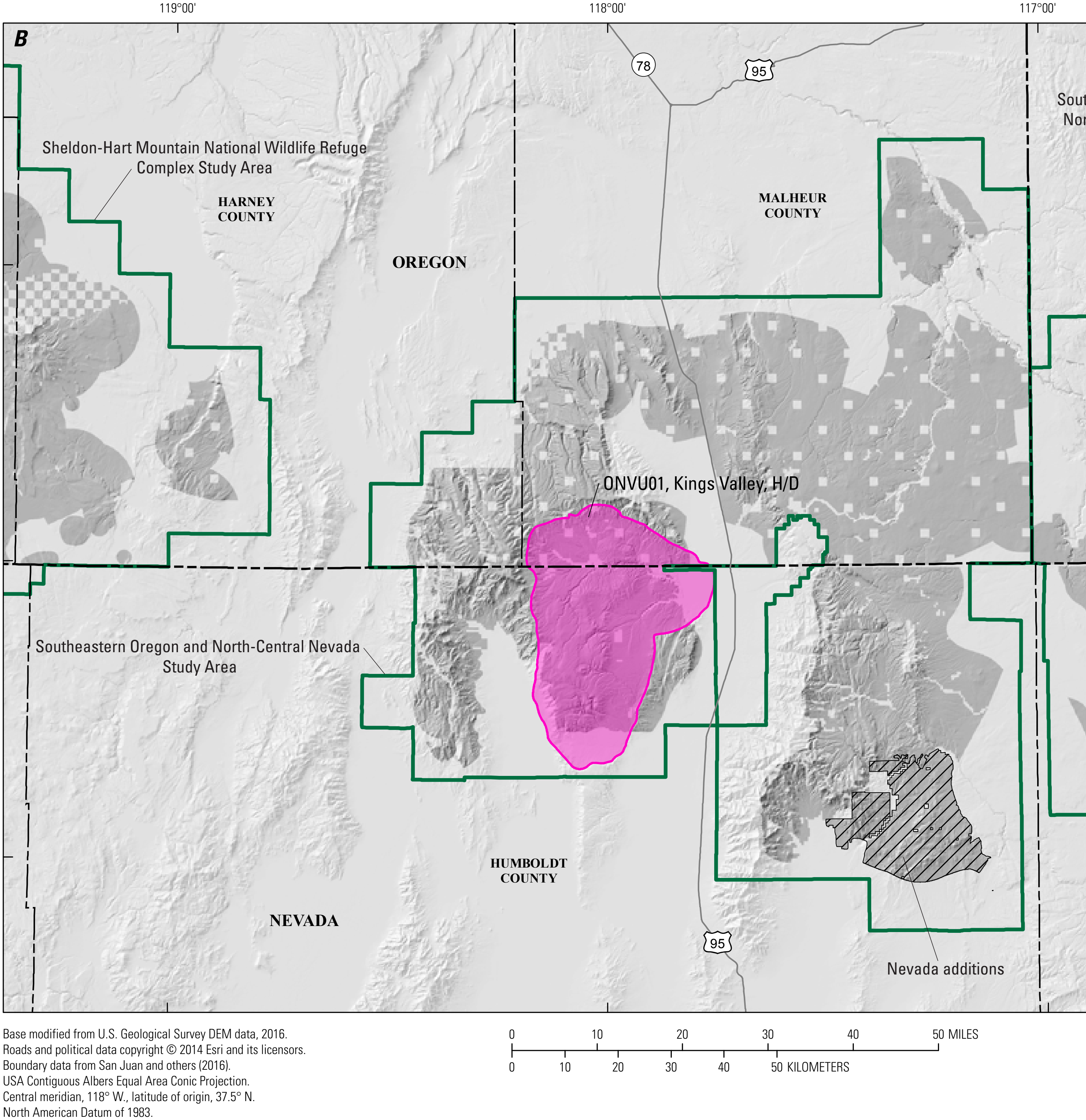
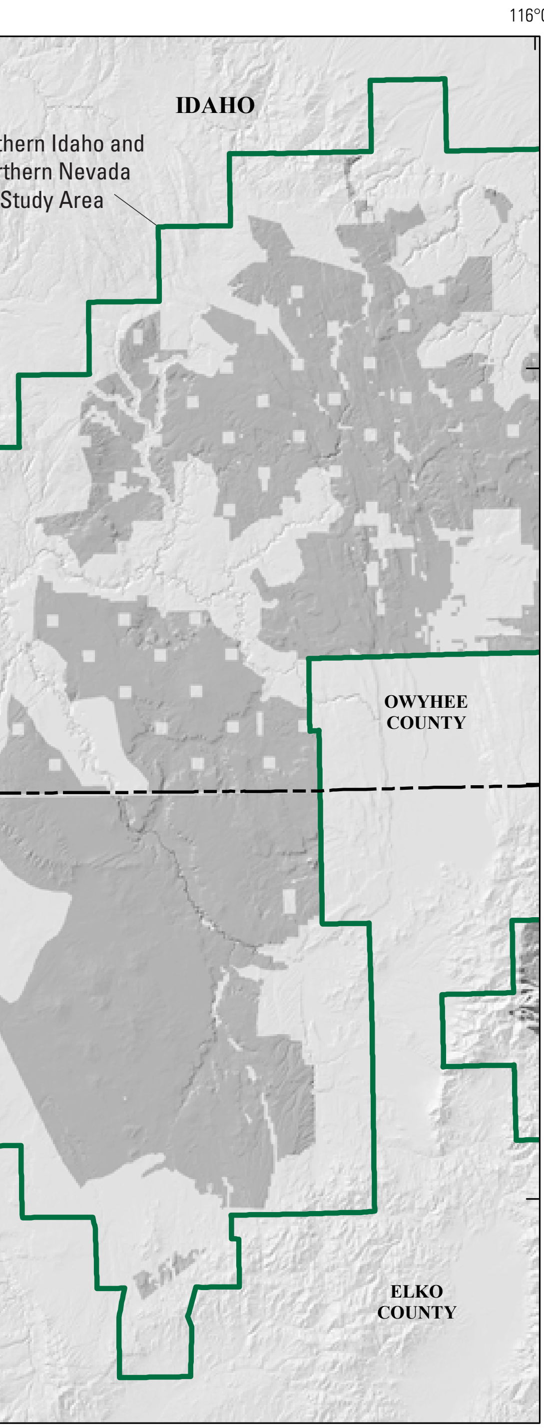
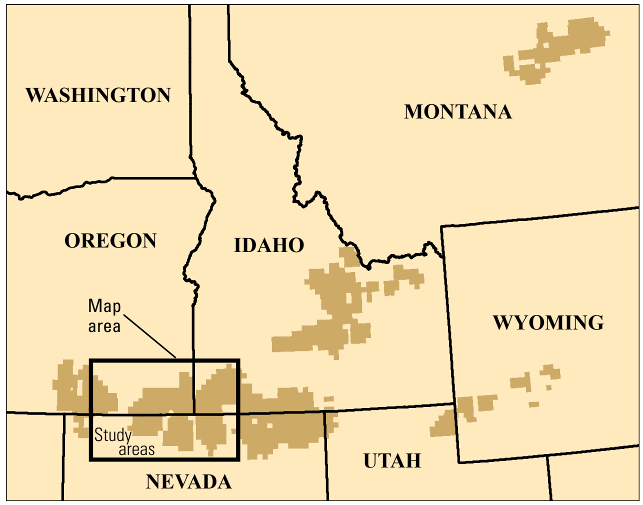


Figure 23. Maps showing assessment tracts and level of resource potential for metallic and nonmetallic locatable minerals in the study area for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area, Nevada and Oregon (San Juan and others, 2016); USGS, U.S. Geological Survey; *A*, Assessment tracts for epithermal gold-silver (mercury); *B*, Assessment tract for volcanogenic uranium; *C*, Assessment tract for orogenic low-sulfide gold-quartz veins; *D*, Assessment tract for specialty gemstone; *E*, Assessment tracts for hectorite (lithium-rich clay); *F*, Assessment tracts for specialty clay; *G*, Assessment tracts for zeolites; and *H*, Assessment tracts for lacustrine diatomite.





EXPLANATION

Assessment tract type—Volcanogenic uranium (Aurora and Kings River type)

High potential, high certainty

Base data

USGS study area boundary

Proposed withdrawal areas

Proposed withdrawal additions

State boundaries

County boundaries

Figure 23.—Continued

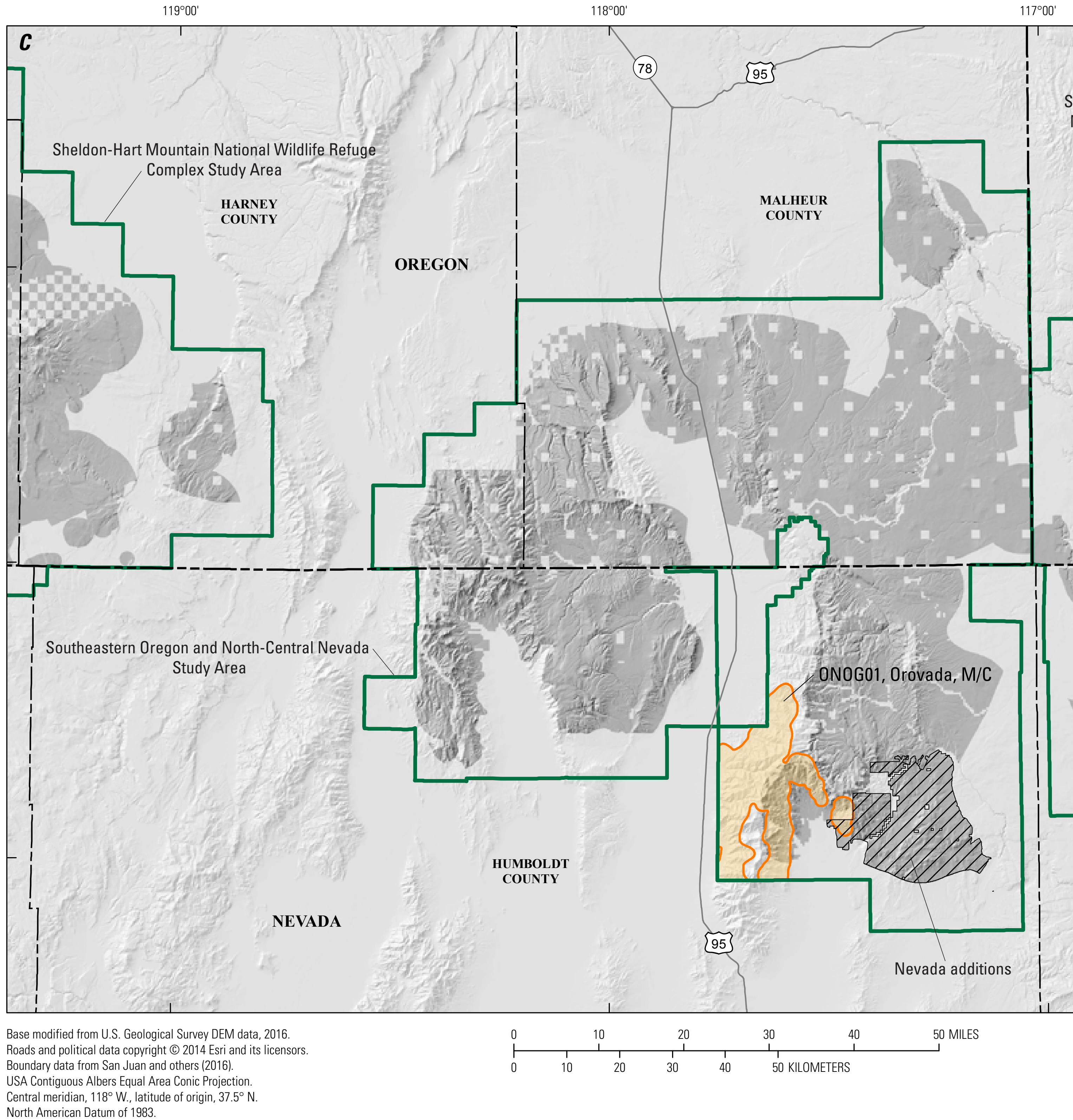
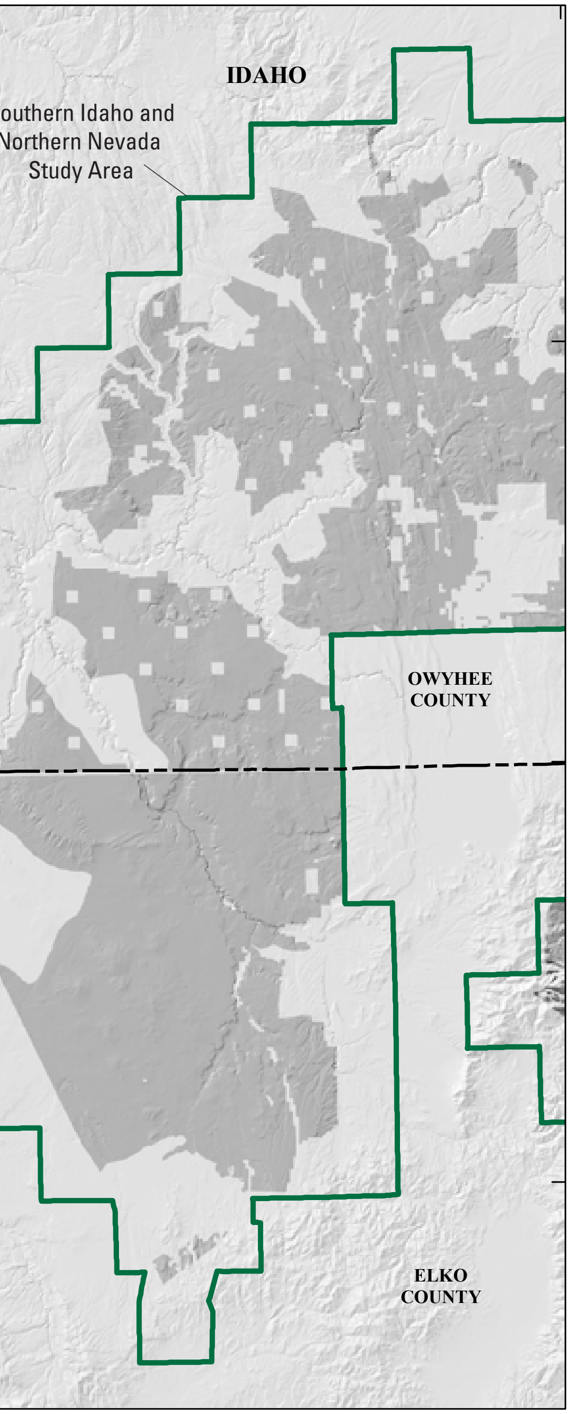
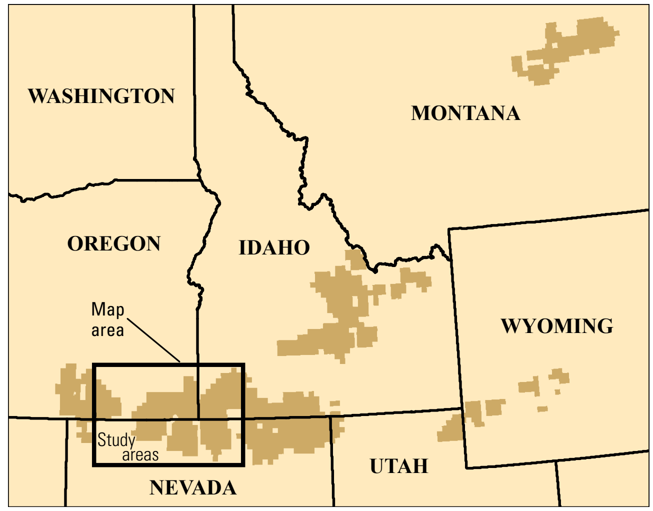


Figure 23. Maps showing assessment tracts and level of resource potential for metallic and nonmetallic locatable minerals in the study area for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area, Nevada and Oregon (San Juan and others, 2016); USGS, U.S. Geological Survey; *A*, Assessment tracts for epithermal gold-silver (mercury); *B*, Assessment tract for volcanogenic uranium; *C*, Assessment tract for orogenic low-sulfide gold-quartz veins; *D*, Assessment tract for specialty gemstone; *E*, Assessment tracts for hectorite (lithium-rich clay); *F*, Assessment tracts for specialty clay; *G*, Assessment tracts for zeolites; and *H*, Assessment tracts for lacustrine diatomite.





EXPLANATION

Assessment tract type—Orogenic low-sulfide gold-quartz vein

Moderate potential, moderate certainty

Base data

USGS study area boundary

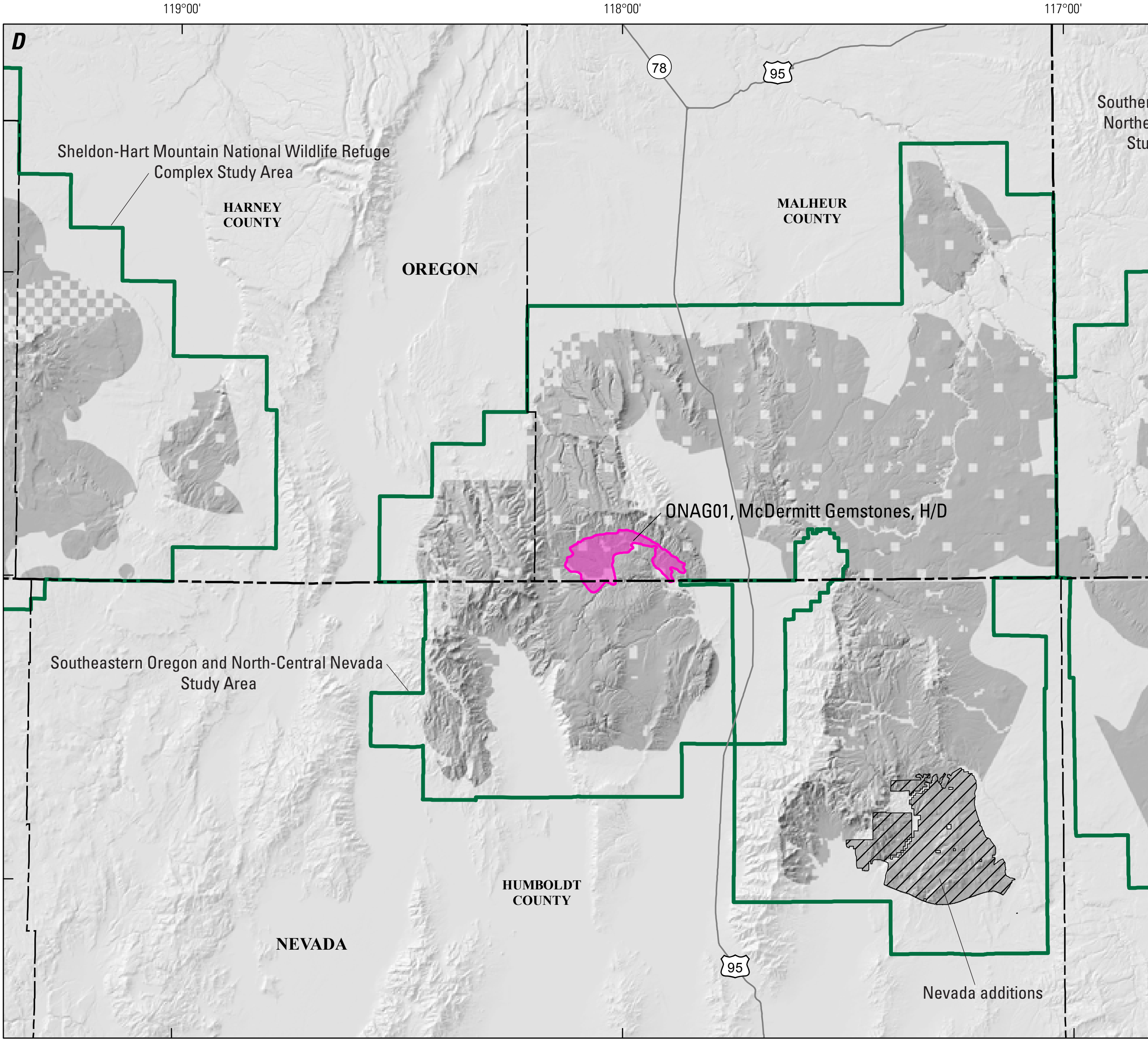
Proposed withdrawal areas

Proposed withdrawal additions

State boundaries

County boundaries

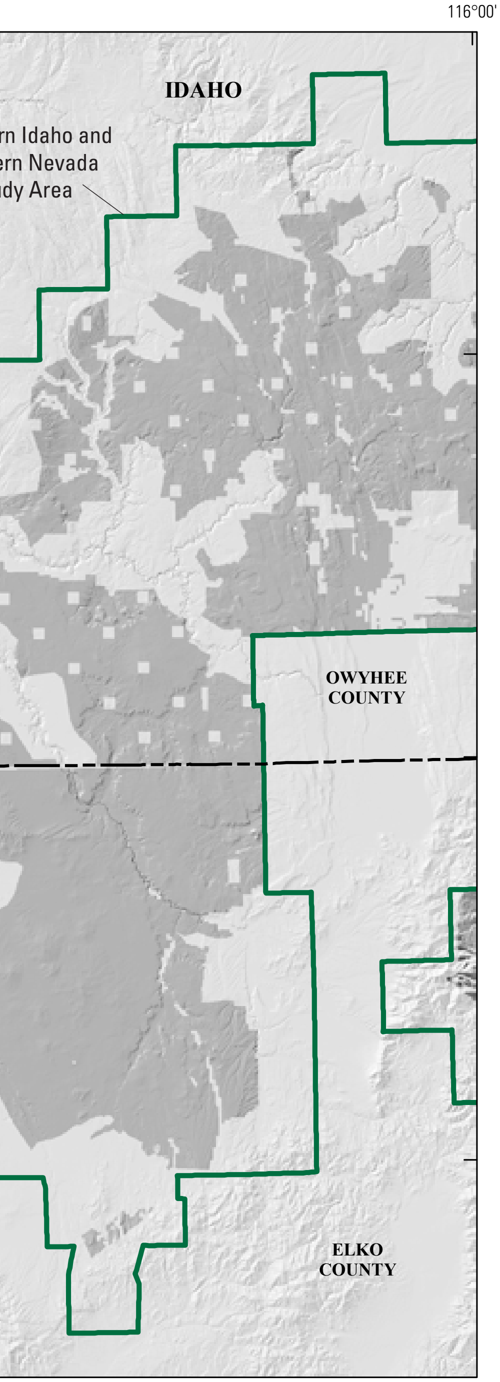
Figure 23.—Continued

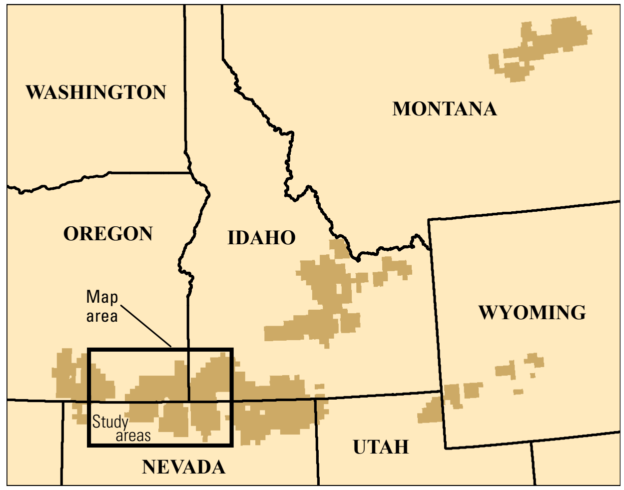


Base modified from U.S. Geological Survey DEM data, 2016.
Roads and political data copyright © 2014 Esri and its licensors.
Boundary data from San Juan and others (2016).
USA Contiguous Albers Equal Area Conic Projection.
Central meridian, 118° W., latitude of origin, 37.5° N.
North American Datum of 1983.

0 10 20 30 40 50 MILES
0 10 20 30 40 50 KILOMETERS

Figure 23. Maps showing assessment tracts and level of resource potential for metallic and nonmetallic locatable minerals in the study area for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area, Nevada and Oregon (San Juan and others, 2016); USGS, U.S. Geological Survey; *A*, Assessment tracts for epithermal gold-silver (mercury); *B*, Assessment tract for volcanogenic uranium; *C*, Assessment tract for orogenic low-sulfide gold-quartz veins; *D*, Assessment tract for specialty gemstone; *E*, Assessment tracts for hectorite (lithium-rich clay); *F*, Assessment tracts for specialty clay; *G*, Assessment tracts for zeolites; and *H*, Assessment tracts for lacustrine diatomite.





EXPLANATION

Assessment tract type—Specialty gemstone

High potential, high certainty

Base data

USGS study area boundary

Proposed withdrawal areas

Proposed withdrawal additions

State boundaries

County boundaries

Figure 23.—Continued

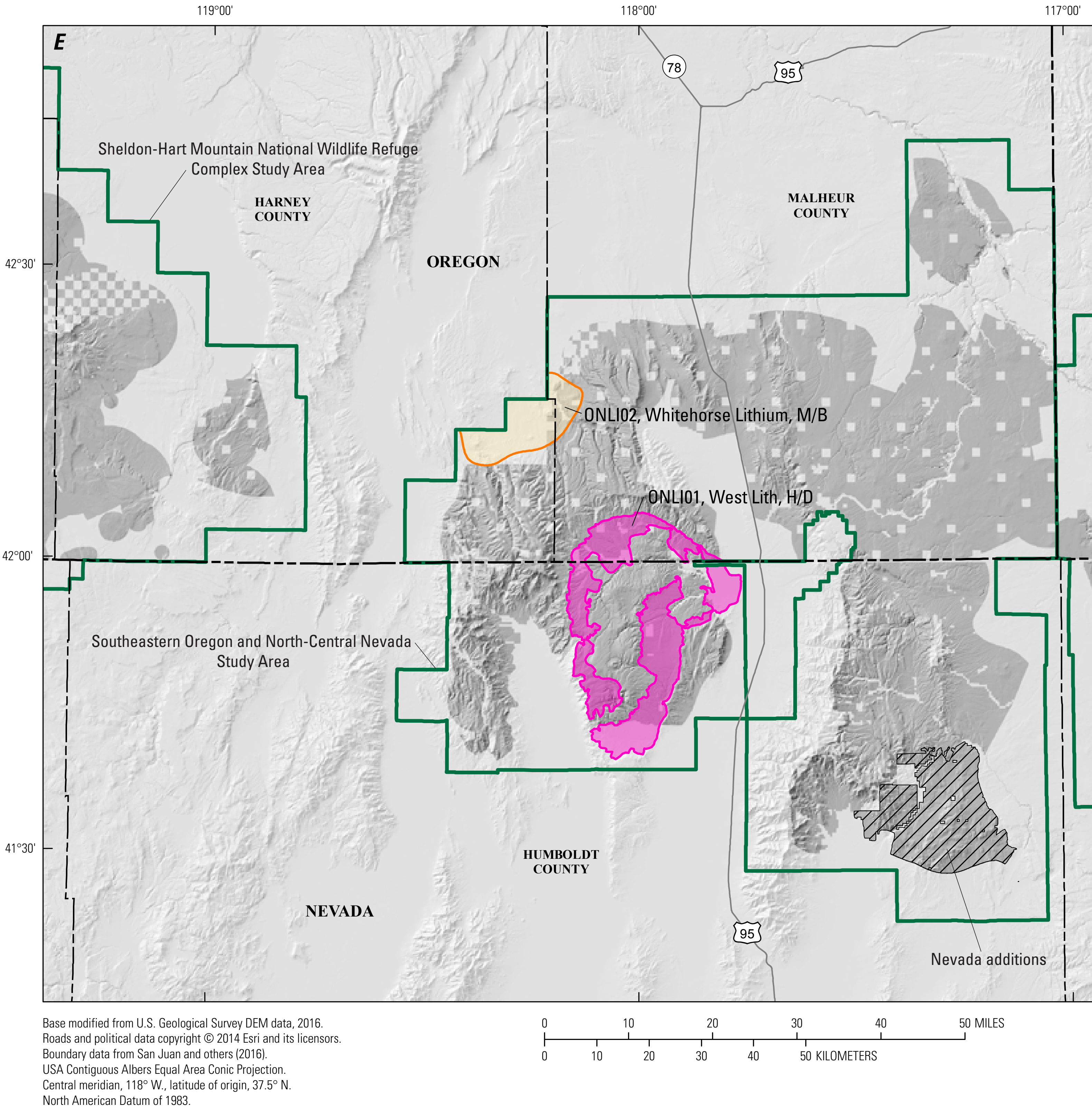


Figure 23. Maps showing assessment tracts and level of resource potential for metallic and nonmetallic locatable minerals in the study area for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area, Nevada and Oregon (San Juan and others, 2016); USGS, U.S. Geological Survey; *A*, Assessment tracts for epithermal gold-silver (mercury); *B*, Assessment tract for volcanogenic uranium; *C*, Assessment tract for orogenic low-sulfide gold-quartz veins; *D*, Assessment tract for specialty gemstone; *E*, Assessment tracts for hectorite (lithium-rich clay); *F*, Assessment tracts for specialty clay; *G*, Assessment tracts for zeolites; and *H*, Assessment tracts for lacustrine diatomite.

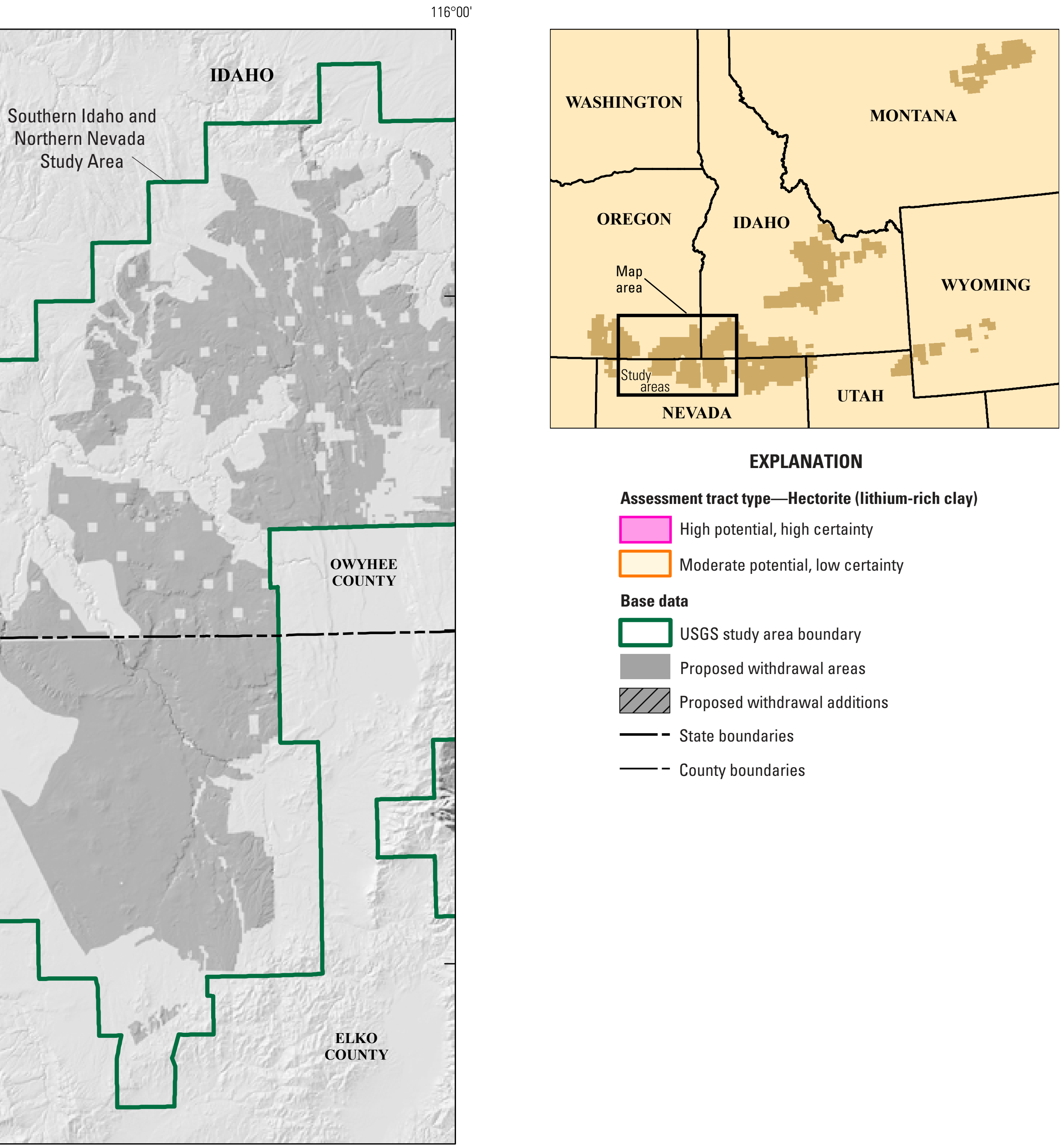
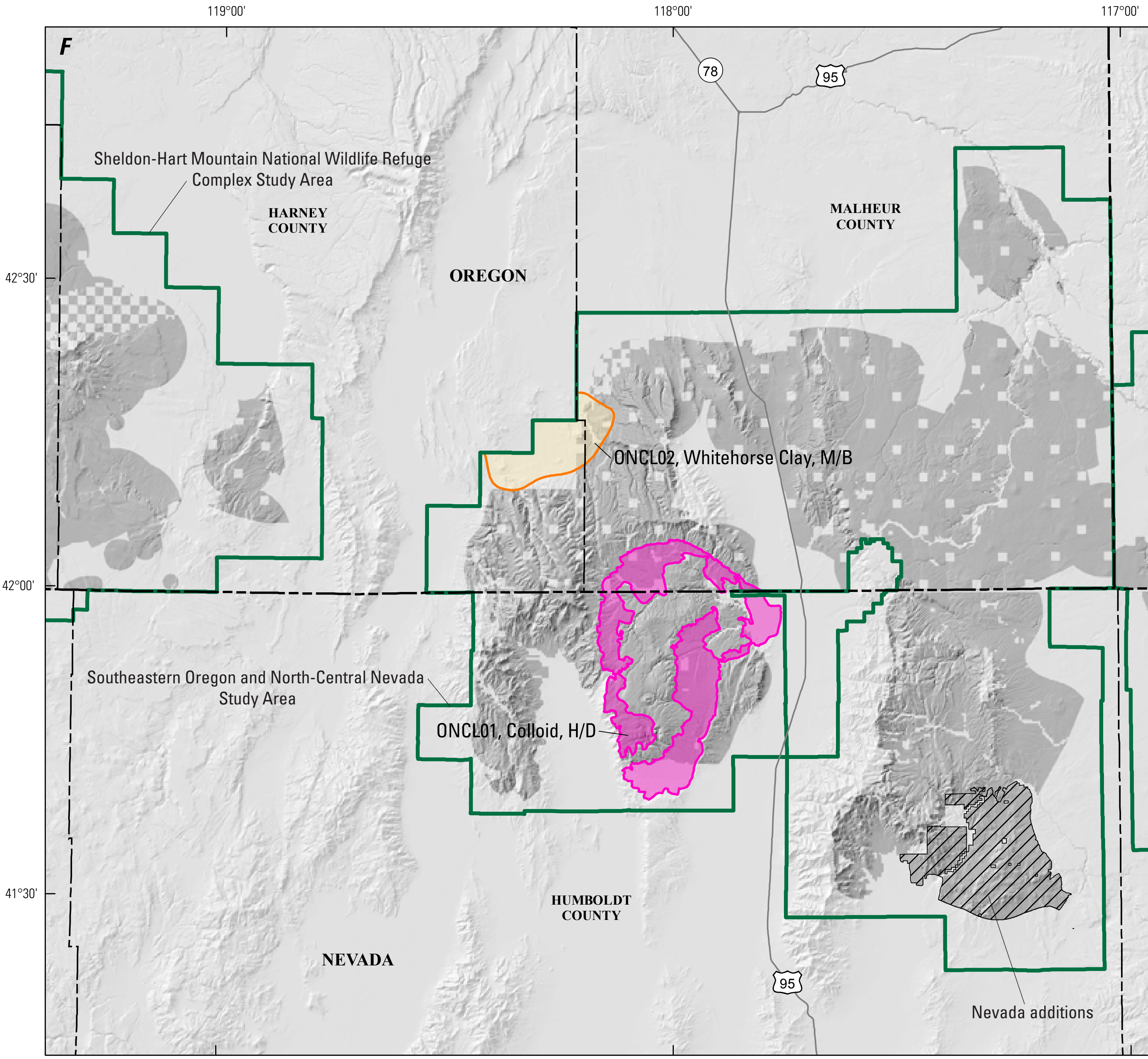


Figure 23.—Continued



Base modified from U.S. Geological Survey DEM data, 2016.
Roads and political data copyright © 2014 Esri and its licensors.
Boundary data from San Juan and others (2016).
USA Contiguous Albers Equal Area Conic Projection.
Central meridian, 118° W., latitude of origin, 37.5° N.
North American Datum of 1983.

0 10 20 30 40 50 MILES
0 10 20 30 40 50 KILOMETERS

Figure 23. Maps showing assessment tracts and level of resource potential for metallic and nonmetallic locatable minerals in the study area for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area, Nevada and Oregon (San Juan and others, 2016); USGS, U.S. Geological Survey; *A*, Assessment tracts for epithermal gold-silver (mercury); *B*, Assessment tract for volcanogenic uranium; *C*, Assessment tract for orogenic low-sulfide gold-quartz veins; *D*, Assessment tract for specialty gemstone; *E*, Assessment tracts for hectorite (lithium-rich clay); *F*, Assessment tracts for specialty clay; *G*, Assessment tracts for zeolites; and *H*, Assessment tracts for lacustrine diatomite.

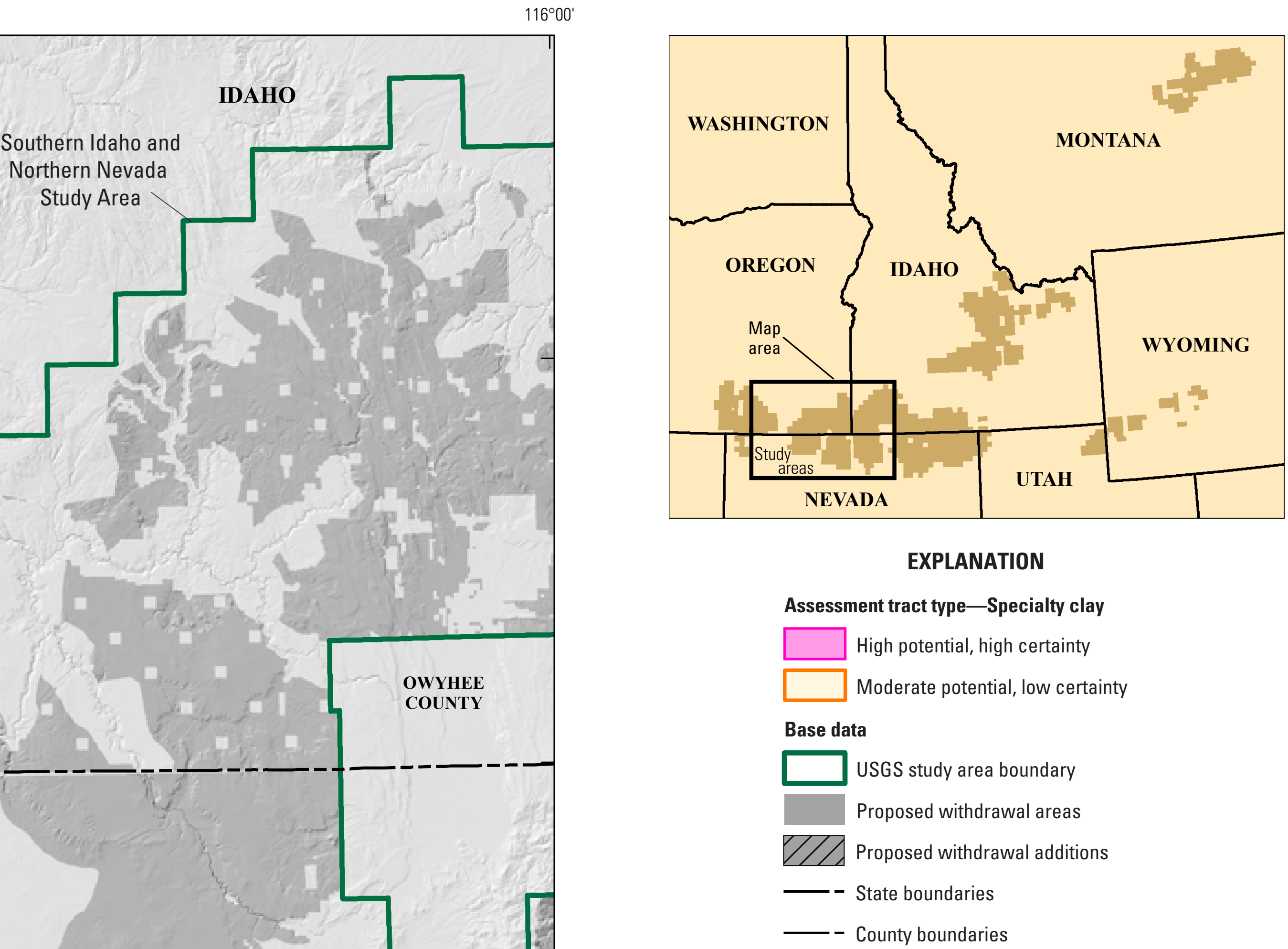


Figure 23.—Continued

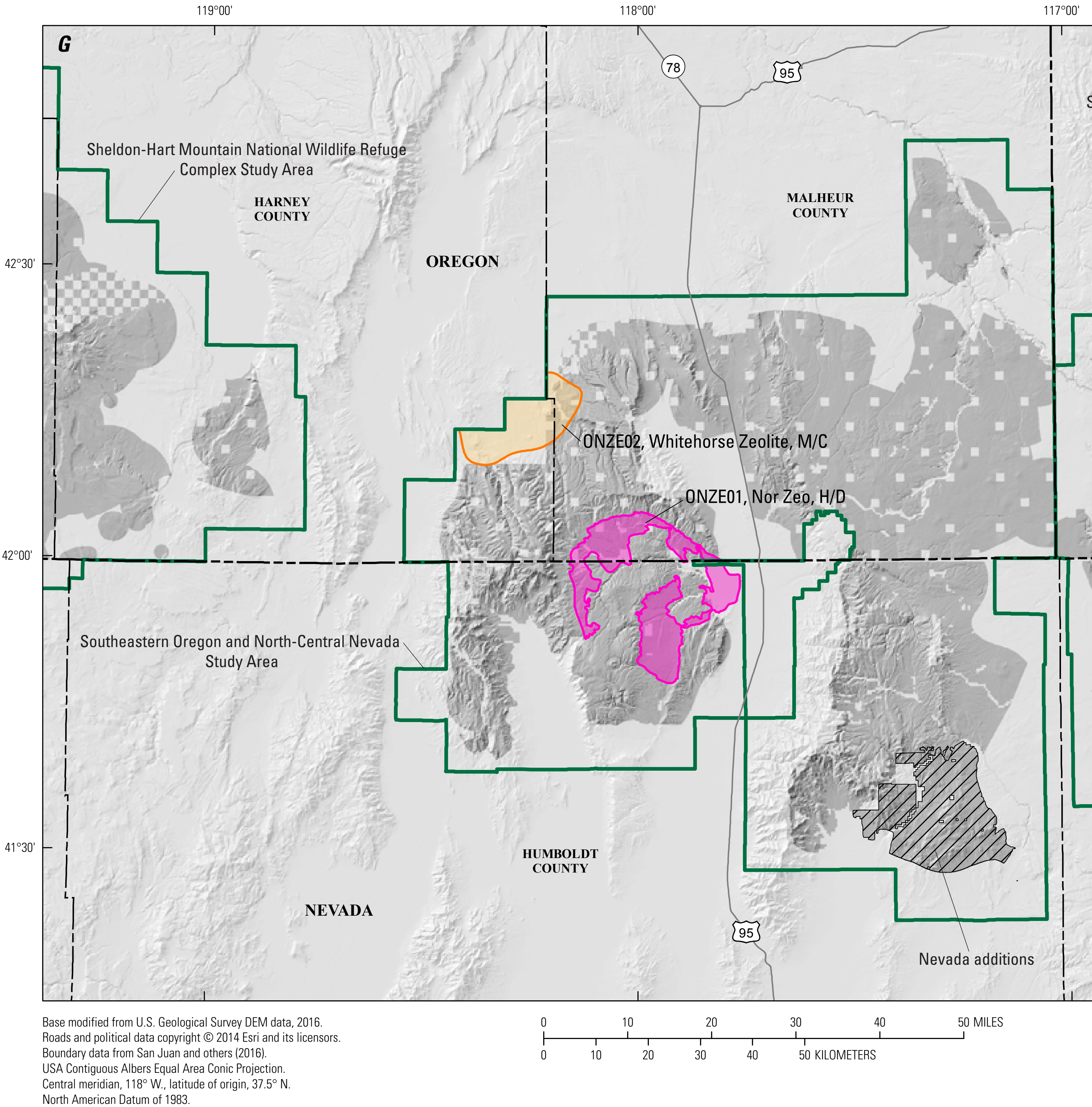
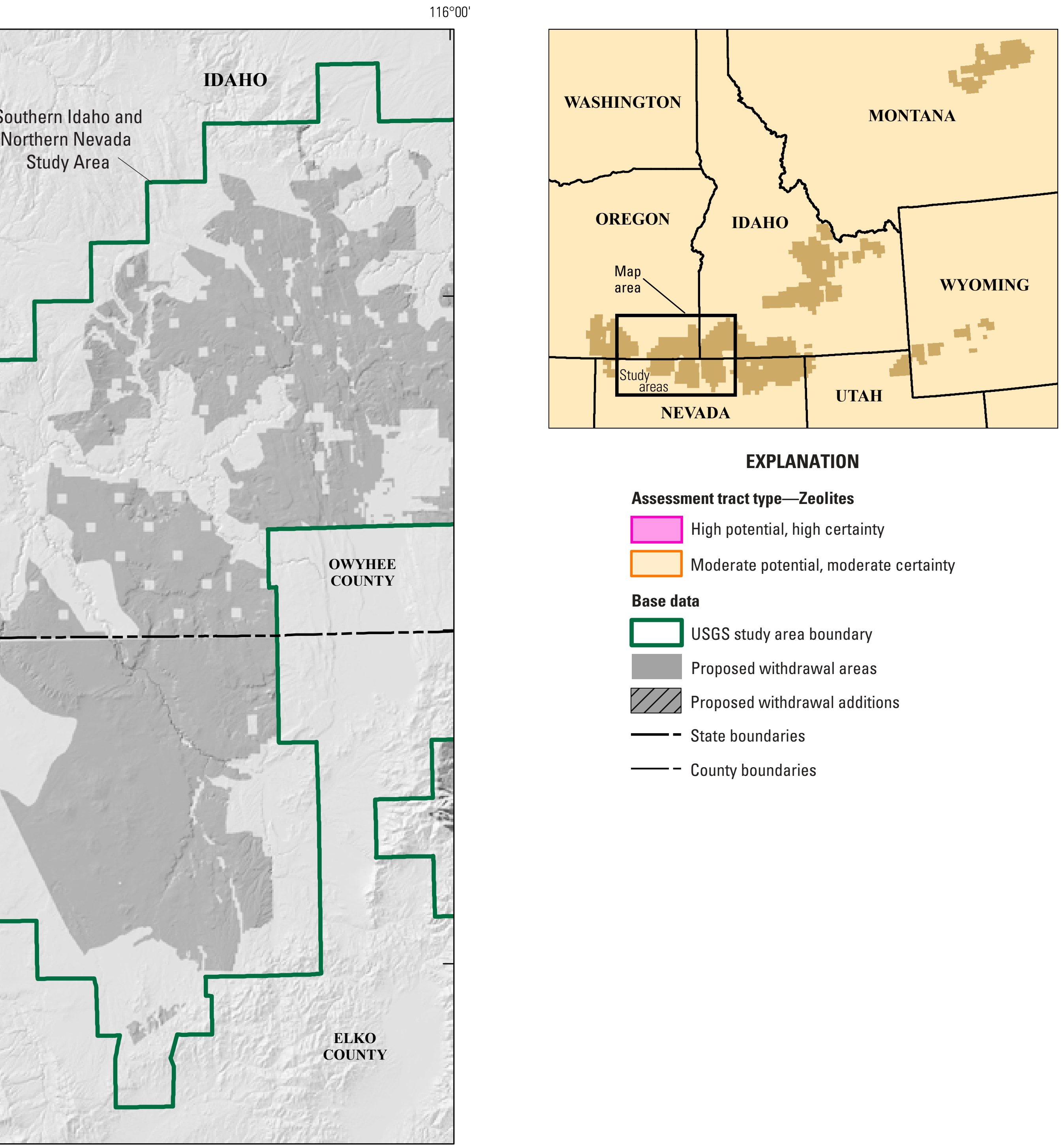


Figure 23. Maps showing assessment tracts and level of resource potential for metallic and nonmetallic locatable minerals in the study area for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area, Nevada and Oregon (San Juan and others, 2016); USGS, U.S. Geological Survey; *A*, Assessment tracts for epithermal gold-silver (mercury); *B*, Assessment tract for volcanogenic uranium; *C*, Assessment tract for orogenic low-sulfide gold-quartz veins; *D*, Assessment tract for specialty gemstone; *E*, Assessment tracts for hectorite (lithium-rich clay); *F*, Assessment tracts for specialty clay; *G*, Assessment tracts for zeolites; and *H*, Assessment tracts for lacustrine diatomite.



EXPLANATION

Assessment tract type—Zeolites

High potential, high certainty

Moderate potential, moderate certainty

Base data

USGS study area boundary

Proposed withdrawal areas

Proposed withdrawal additions

State boundaries

County boundaries

Figure 23.—Continued

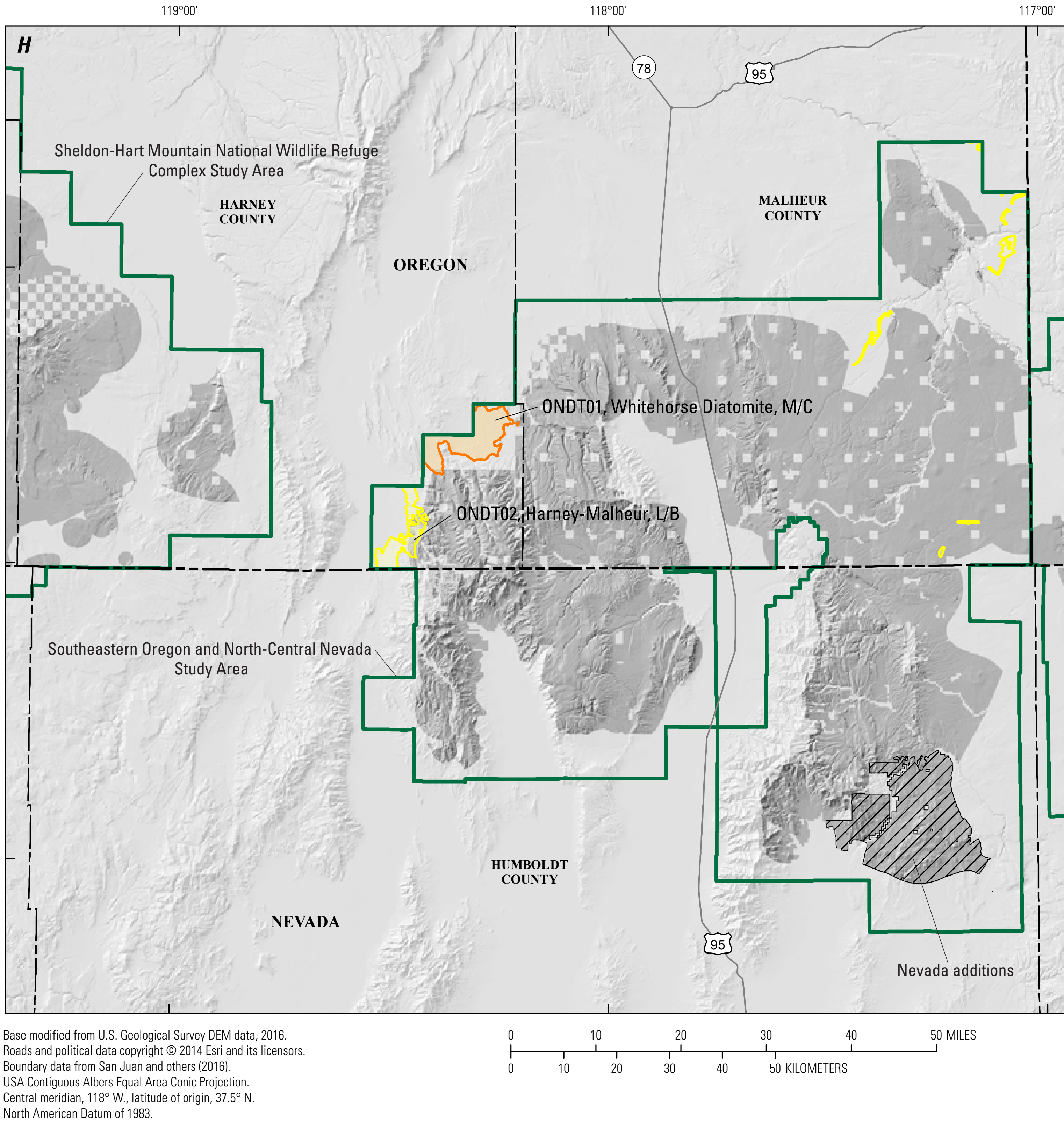


Figure 23. Maps showing assessment tracts and level of resource potential for metallic and nonmetallic locatable minerals in the study area for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area, Nevada and Oregon (San Juan and others, 2016); USGS, U.S. Geological Survey; *A*, Assessment tracts for epithermal gold-silver (mercury); *B*, Assessment tract for volcanogenic uranium; *C*, Assessment tract for orogenic low-sulfide gold-quartz veins; *D*, Assessment tract for specialty gemstone; *E*, Assessment tracts for hectorite (lithium-rich clay); *F*, Assessment tracts for specialty clay; *G*, Assessment tracts for zeolites; and *H*, Assessment tracts for lacustrine diatomite.

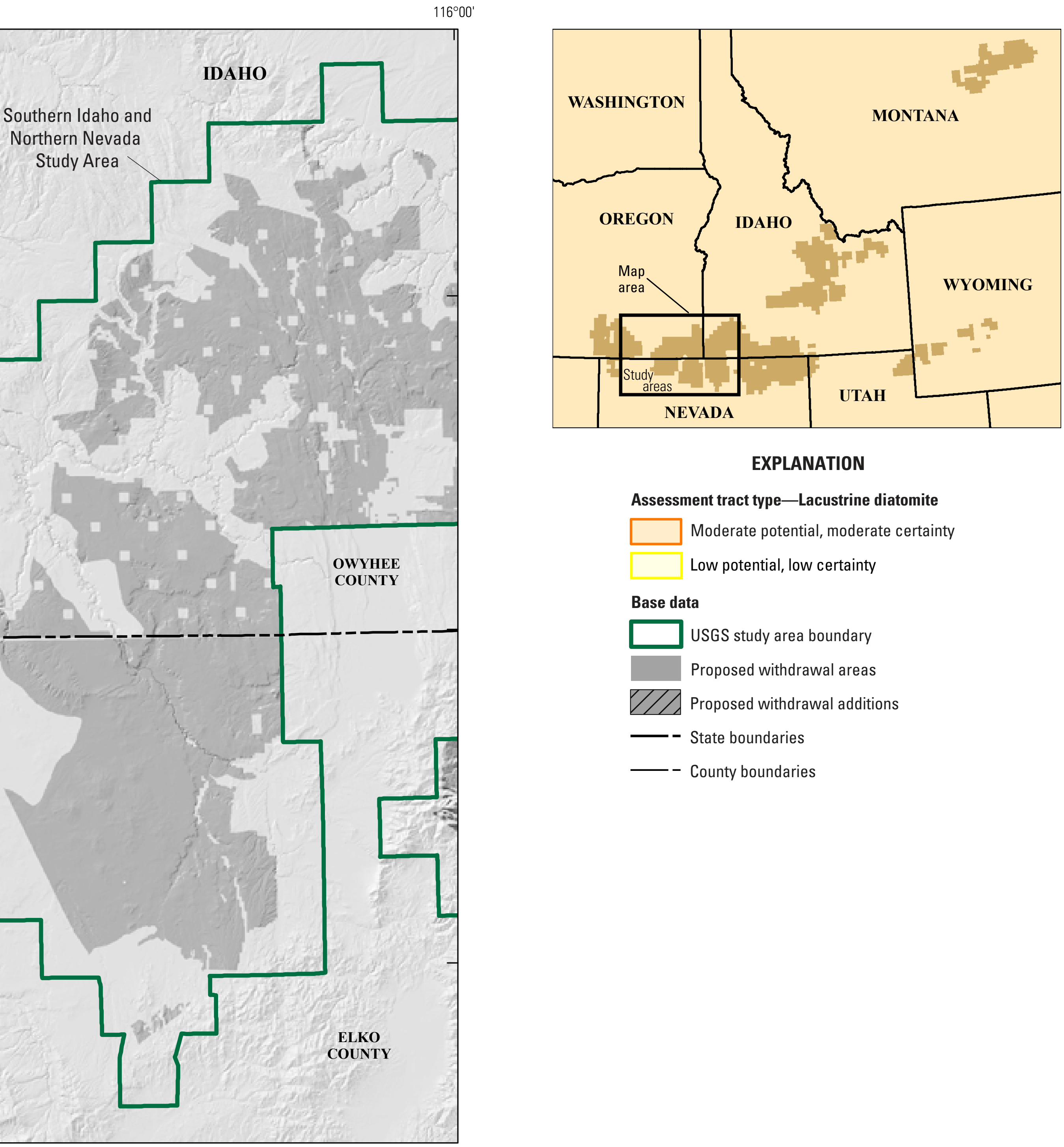


Figure 23.—Continued

claims are in the tract, as well as many closed lode claims (fig. 21; Causey, 2007, 2011).

Tract ONEP03, Buckskin—A high potential (H), at certainty level D, for epithermal gold, silver, and hot spring mercury deposits is assigned to an area around Buckskin Mountain in the northern Santa Rosa Range, Humboldt County, Nevada (tract ONEP03, Buckskin; fig.23*A*; appendix 2). This area, which is within the National district (Tingley, 1992), includes a middle Miocene eruptive center that consists of a rhyolite flow dome complex and volcaniclastic sedimentary rocks overlying intermediate lava flows and breccias (Vikre, 1985a,b, 2007). The eruptive center is related to the early Yellowstone Hot Spot magmatism (Brueseke and others, 2007). The Miocene rocks were deposited on Jurassic-Triassic metasedimentary rocks of the Auld Lang Syne Group that were intruded by Late Cretaceous granitic plutons (Vikre, 1985b). Surficial hydrothermal deposits that form a mineralized hot spring system, including pool sinter and silicified sediments, cap Buckskin Mountain and are related to the rhyolite dome complex (Vikre, 2007). At deeper levels, this hydrothermal system formed epithermal quartz veins along north-striking high-angle faults. Mining of the Bell vein on the east flank of Buckskin Mountain produced 24,000 oz gold and 300,000 oz silver from 1906 to 1941, and mining of other middle Miocene epithermal veins in the National district produced 177,538 oz gold and 471,541 oz silver during 1909–1936. Small amounts of mercury were produced from sinter and silicified clastic sedimentary rocks near the top of Buckskin Mountain (Roberts, 1940; Vikre, 1985b).

The tract was delineated using a 3-km buffer around deposits and prospects. Geologic mapping (Vikre, 1985a, 2007; Weiss and others, 2015) and interpreted ASTER remote-sensing imagery (Rockwell and others, 2015) were the basis for delineating strong argillic and advanced argillic alteration at Buckskin Mountain that underlie surficial hot spring deposits and overlie epithermal veins; the tract encompasses this alteration. Stream-sediment samples from the tract locally have anomalous concentrations of gold, arsenic, and copper. The tract contains numerous active lode claims, an active plan of operations, and closed notices and lode claims (figs. 20, 21; Causey, 2007, 2011).

Tract ONEP04, Paradise Valley—A moderate potential (M), at certainty level C, for epithermal silver and gold deposits is assigned to the Red Hills at the northeast end of Paradise Valley, Humboldt County, Nevada (tract ONEP04, Paradise Valley; fig. 23*A*; appendix 2). This area includes Jurassic-Triassic metasedimentary rocks of the Auld Lang Syne Group that are intruded by a Cretaceous granitic pluton and overlain by a middle Miocene rhyolite dome complex and associated rhyolite lava flows (Willden, 1964; Crafford, 2007). Miocene mafic lava flows overlie hydrothermally altered rhyolites on the east side of the area. Some silver-rich quartz veins in the metasedimentary rocks are associated with clay-altered rhyolite porphyry dikes in the Paradise Valley district (Silver Butte Mine; Vanderburg, 1938; Bonham and others, 1985; Tingley, 1992), and were mined on a small scale in the late 19th century.

The tract was delineated using a 3-km buffer around small quartz vein deposits in Mesozoic metasedimentary rocks. The eastern part of the tract includes extensive areas of advanced argillic, argillic, and sericite-smectite alteration in Miocene rhyolite that is delineated by interpreted ASTER remote-sensing imagery (Rockwell and others, 2015). Stream-sediment samples have anomalous concentrations of silver, arsenic, and lead, and composite hydrothermal mineralization geochemical anomalies (Ludington and others, 2006). An aeromagnetic low coincides with the altered rhyolites. Several active lode claims are in the area, as well as numerous closed lode claims and closed notices that indicate recent exploration activity (fig. 21; Causey, 2007, 2011).

Buffering Epithermal Mercury, Gold, Silver, and Gallium Tracts

The epithermal gold, silver, mercury, and gallium tracts described above were delineated from characteristics of epithermal gold, silver, and mercury deposits on the basis of the deposit model, which was assembled from characteristics of well-documented epithermal gold, silver, and mercury deposits and the magmatic-hydrothermal systems that formed the deposits (Day and others, 2016; appendix 2; gallium is not included in the deposit model because of the rarity of gallium deposits). Some of these characteristics may be concealed (for example, altered rocks covered by younger rocks; drill-defined gold and silver resources; deposits identified by drill-hole intercepts with elevated gold and silver values) and do not appear on published maps (geologic; topographic) or in other publications. Gold and silver occurrences on published maps and in other publications were the first criterion used to delineate possible concealed and unmapped epithermal gold and silver deposits. Other criteria used include the alteration and geochemical signatures of the magmatic-hydrothermal systems that form epithermal gold and silver deposits. The approximate diameters of footprints (surface exposures) of well-exposed epithermal gold and silver systems, based primarily on mapped gold and silver occurrences, alteration, and geochemistry, range from several hundred meters to about 10 km, and are mostly 10–20 km^2 in the study areas for the Sagebrush Focal Areas (appendix 5). If the areas of well-exposed systems are geometrically represented by circles concentric to mapped or published gold and silver occurrences, then circles enclosing systems that formed epithermal gold and silver deposits in the study areas have radii of 1.8–2.6 km. Based on the distribution and spatial density of gold and silver occurrences in the study areas, a circle with radius of 3 km centered on occurrences was used to delineate tracts. Tract boundaries represent the merged circumferences of circles concentric to all gold and silver occurrences within the tract.

Mineral Potential Tract for Volcanogenic Uranium Deposits

One mineral potential tract for volcanogenic uranium deposits was delineated and rated in this study area: tract ONVU01, Kings Valley.

Tract ONVU01, Kings Valley—A high potential (H), with certainty level D, for volcanogenic uranium deposits (Aurora-type and Moonlight-King River-type) is assigned to areas within the McDermitt caldera (tract ONVU01, Kings Valley; fig. 23*B*; appendix 2). The Kings Valley tract is delineated by the mapped McDermitt caldera margin buffered by 1 km to include uncertainty of the caldera margin. The tract includes uranium deposits, mapped and inferred subsurface flows and rhyolite caldera ring intrusions and domes, and caldera-fill sediments within the caldera that host uranium deposits. The McDermitt caldera is among the most highly mineralized calderas in the world and contains significant deposits of uranium. The potential for Aurora-type uranium mineralization is based on characteristics of the Aurora uranium deposit which occurs in intermediate composition iron-rich lavas that fill the moat of the caldera. The Aurora deposit has a measured resource of 18.9 million pounds (Mlbs) triuranium octoxide U_3O_8 with a cutoff grade of 0.025 percent (Myers and Underhill, 2005). The uranium minerals uraninite, coffinite, and uranyl phosphates and uranium silicate have precipitated in the vesicles of lava flows (icelandites) and in flow breccias and fractures (Roper and Wallace, 1981). Alteration minerals include pyrite, fluorite, potassium feldspar, and chalcedony and opal. Other elements enriched in the deposit include arsenic, barium, mercury, molybdenum, antimony, and tungsten (Castor and Henry, 2000). The lavas are covered by caldera lake sedimentary rocks and are exposed in limited areas. On the eastside of the caldera a geochemical anomaly of uranium, arsenic, and molybdenum in stream sediments indicates the potential for Aurora-type uranium mineralization in lava flows inferred to be present below caldera lake sediments in this area of the caldera.

The Moonlight-Kings River-type volcanogenic uranium deposits occur adjacent to rhyolite intrusions emplaced along the caldera ring fracture zone. The rhyolite intrusions are associated with a continuous series of aeromagnetic high anomalies that are inboard of the caldera margin and are interpreted to reflect rhyolite intrusions permissive for uranium deposits. The Moonlight Mine produced about 600 kg of U_3O_8 at an average grade of 0.13 percent (Castor and Henry, 2000). Drilling along the western caldera ring fracture north of the Moonlight Mine has delineated a number of uranium deposits that are related to subsurface rhyolite intrusions. This mineralized zone has a measured resource of 4.838 Mlbs of U_3O_8 with a cutoff grade of 0.035 percent for the North Zone and a cutoff grade of 0.050 percent for the South Zone and Moonlight Mine area (Eggleston and others, 2007). The uranium minerals include uraninite, coffinite, and uraniferous zircon, and the deposits are enriched in arsenic, gold, silver, molybdenum, and antimony (Castor and Henry, 2000).

Stratabound uranium deposits with a grade of 0.02 percent uranium occurs in a 2-m thick zone of silicified caldera-fill sedimentary rocks northwest of the Aurora uranium deposit, and drilling has documented this mineralized zone over a 3-km^2 area (Roper and Wallace, 1981). This type of uranium mineralization is permissive throughout the area of the caldera where caldera-fill sediments are present.

A large low-grade resource of uranium occurs in altered tuffs and flow breccias associated with rhyolite domes in the southwest of part of the McDermitt caldera (Castor and Henry, 2000). The rhyolite domes are interpreted to be the extrusive equivalent of subvolcanic rhyolite intrusions associated with Moonlight-Kings River-type uranium deposits.

Favorable Stratigraphy for Uranium Deposits

Outside delineated tracts in the study area for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area, it is conceivable that additional uranium deposits may be identified. Scattered occurrences, geochemical and surface radiometric anomalies, identification of permissive strata, and delineation of permissive tracts in past assessments support low potential throughout the study area for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area.

The Paradise Valley/Capitol Peak area is approximately 15 km east of the McDermitt Caldera and was identified during the U.S. Department of Energy National Uranium Resource Evaluation program as favorable for uranium deposits based on radiometric and geochemical anomalies associated with a thick pile of permissive silicic volcanic rocks (Garside, 1982). However, no uranium occurrences or geochemical anomalies were confirmed by more recent geochemical and mineral deposit compilations, and a tract was not delineated (U.S. Geological Survey, 2005; Fernette and others, 2016a; Smith and others, 2016).

Mineral Potential Tract for Orogenic Low-Sulfide Gold-Quartz Vein Deposits

One mineral potential tract for orogenic low-sulfide gold-quartz vein deposits was delineated and rated in this study area: tract ONOG01, Orovada.

Tract ONOG01, Orovada—A moderate potential (M), with certainty level C, for orogenic gold deposits is assigned to metamorphosed siliciclastic rocks of the Triassic Auld Lang Syne Group in the study area for the Southern Oregon and North-Central Nevada Sagebrush Focal Area (tract ONOG01, Orovada; fig. 23*C*; appendix 2). The tract includes the Orovada active exploration project (Fernette and others, 2016a) and extends into the proposed withdrawal area and the Nevada additions study area.

Orogenic gold veins form during metamorphic dewatering of siliciclastic sequences where ascending fluids cool and decompress in dilatant structures (Groves and others, 1998; Phillips and Powell, 2010). Such veins are present in metamorphosed Auld Lang Syne Group, part of the Jungo terrane, which was emplaced along the Fencemaker thrust fault and heated by Cretaceous granitic intrusions (Cheong and others, 2000). The tract consists of map units that comprise the Jungo terrane (Trs; fig. 19) and includes a 1-km-wide buffer to account for cover and uncertainty of mapped contacts.

Production of gold or other commodities was not recorded in the tract; 19 prospects and occurrences in the tract contain variable amounts of gold, silver, antimony, and base metals (Cheong and others, 2000; U.S. Geological

Survey, 2005; Johnston and others, 2015; Fernette and others, 2016a). Placer gold, possibly derived from orogenic gold veins, is reported in two drainages on the west side of this tract (Fernette and others, 2016a). Anomalous concentrations of gold and arsenic are present in stream sediments (Day and others, 2016; Smith and others 2016). The tract includes active lode claims, closed plans of operations and notices (fig. 20; tables 10, 11, 12, 13), and historic claims (fig. 21; Causey, 2007, 2011).

Market Analyses of Gold, Silver, Mercury, Gallium, and Uranium

Market analyses of gold, silver, mercury, gallium, and uranium are provided in appendix 5 and section I of Day and others (2016).

Mineral Potential Tract for Gemstone Deposits

One mineral potential tract for gemstone deposits was delineated and rated in the study area: tract ONAG01, McDermitt Gemstones.

Tract ONAG01, McDermitt Gemstones—A high potential (H), with certainty level D, for semiprecious gemstone deposits is assigned to caldera-fill sediments in the northern part of the McDermitt caldera (tract ONAG01, McDermitt Gemstones; fig. 23*D*; appendix 2). Eight occurrences of agate, picture stone, wonderstone (decorative and ornamental rocks), petrified wood, and geodes have historical production, and seven prospects are in the study area. The agate is termed and marketed as Purple Cow agate. Green jasper in petrified wood has been marketed as larsonite. McDermitt picture stone is marketed in slabs and in jewelry. Detailed descriptions of the mine sites that have historical production and continue to produce semiprecious gemstones, picture rock, and petrified wood are provided by Kappele (2011).

Mineral Potential Tracts for Hectorite (Lithium-Rich Clay) Deposits

Two mineral potential tracts for hectorite (lithium-rich clay) deposits were delineated and rated in the study area: tract ONLI01, West Lith; and tract ONLI02, Whitehorse Lithium.

Tract ONLI01, West Lith—A high potential (H), with certainty level D, for deposits of lithium-bearing hectorite clay is in the West Lithium tract, defined by the distribution of sedimentary rocks and water-laid tuffs that fill the moat of the McDermitt Caldera (tract ONLI01, West Lith; fig. 23*E*; appendix 2). The McDermitt caldera is among the world's most highly mineralized calderas and contains significant deposits of lithium in hectorite and illite clays. This lithium resource is potentially critical to the United States development of clean energy economy as defined in the American Recovery and Reinvestment Act (The White House, 2016). The stratiform lithium deposits and lithium-mineralized sedimentary rocks occur in caldera-fill sedimentary rocks that have been altered to zeolites and adularia (Glanzman and others, 1977; Glanzman and Rytuba, 1979; Eggleston, 2008). The highest concentrations of lithium occur in trioctahedral illite clays, and lower lithium concentrations occur in overlying trioctahedral and dioctahedral smectite clays (Glanzman and Rytuba, 1979; Stillings, 2012). Observed factors that contribute to the high potential designation include the presence of five distinct lithium deposits that have been discovered in the past decade by Western Lithium. One deposit has been proposed for development; it contains 234 million short tons at a grade of 0.665 percent lithium (570 kilotons lithium carbonate equivalent, Eggleston, 2008; Tetra Tech, 2014). More than 40 drill holes throughout the caldera have encountered lithium-mineralized rocks in caldera-fill sedimentary rocks at grades that are potentially economic (Tetra Tech, 2014). In addition, geochemical anomalies and mineralogical studies reported by Glanzman and others (1977), Rytuba and Glanzman (1979), and Stillings (2012) demonstrate that there are occurrences of lithium-mineralized rocks throughout the caldera-fill sedimentary rocks. The cumulative lithium resource in the caldera is comparable to the similar Sonora Lithium clay deposit in Mexico being developed by Bacanora and Rare Earth Minerals. Production from this deposit has recently been contracted by Tesla Motors to supply lithium for its lithium battery gigafactory in Reno, Nevada (The Northern Miner, 2015).

Tract ONLI02, Whitehorse Lithium—The caldera-fill sediments in the Whitehorse caldera have moderate potential (M), with certainty level B, for deposits of lithium-bearing hectorite clay (tract ONLI02, Whitehorse Lithium; fig. 23*E*; appendix 2). The tract boundary is defined mainly by the Whitehorse caldera margin, but extends beyond the southwest caldera margin to include sedimentary rocks (Tts) deposited within a structural basin that may represent an older caldera (Rytuba and others, 1981; Rytuba and others, 1982b; Barrow, 1983). The tract includes sedimentary rocks, water-laid tuffs, and diatomite of the Trout Creek Formation of Smith, 1927 (his unit Ttc) within the caldera and areas where the rocks are covered by younger basalt flows and alluvium (Rytuba and others, 1982a,b,c,d,e,f).

The Whitehorse caldera has similar geochemistry to the nearby McDermitt caldera that contains a large resource of lithium-rich hectorite clay. Evidence for lithium resources in Whitehorse caldera stratigraphy includes limited surface geochemical samples that are anomalous in lithium and clays within the caldera-fill sedimentary rocks that have been documented by X-ray diffraction and scanning electron microscope studies of two drill holes (Rytuba and others, 1981).

Mineral Potential Tracts for Specialty Clay Deposits

Two mineral potential tracts for specialty clay deposits were delineated and rated in the study area: tract ONCL01, Colloid; and tract ONCL02, Whitehorse Clay.

Tract ONCL01, Colloid—There is high potential (H), with certainty level D, for deposits of specialty clay, used primarily in cosmetics, in the Colloid tract, which is defined by the distribution of sedimentary and volcanic rocks that fill the moat of the McDermitt Caldera (tract ONCL01, Colloid; fig. 23*F*; appendix 2). This tract is spatially coincident with tract ONLI01, West Lith. Observed factors that contribute to the high potential designation include the presence of two clay mines that operate intermittently. J.M. Huber Corporation mines clays for specialty use and American Colloid has mined hectorite clay in the area known as the Huber open pit for the past 25 years (Odom, 1992; Tetra Tech, 2014). In addition, X-ray diffraction studies (Rytuba and others, 2003) demonstrate the widespread occurrence of clay minerals in the caldera-filling sedimentary rocks.

Tract ONCL02, Whitehorse Clay—The caldera-fill sedimentary rocks of the Whitehorse caldera have moderate potential (M) with certainty level B for deposits of specialty clay (tract ONCL02, Whitehorse Clay; fig. 23*F*; appendix 2). Delineation of tract boundaries and tract geology are described in report section “Tract ONLI02, Whitehorse Lithium.”

The Whitehorse caldera contains sedimentary rocks similar to sedimentary rocks in the nearby McDermitt caldera that contains a large resource of specialty clay (tract ONCL01, Colloid, above). Evidence for specialty clay resources in Whitehorse caldera stratigraphy includes clays within the caldera-fill sedimentary rocks that are documented by X-ray diffraction and scanning electron microscope studies of two drill holes (Rytuba and others, 1981).

Mineral Potential Tracts for Zeolite Deposits

Two mineral potential tracts for zeolite deposits were delineated and rated in the study area: tract ONZE01, Nor Zeo; and tract ONZE02, Whitehorse Zeolite.

Tract ONZE01, Nor Zeo—There is high potential (H), with certainty level D, for zeolite deposits in caldera-fill sediments that occur in the northern part of the McDermitt Caldera (tract ONZE01, Nor Zeo; fig. 23*F*; appendix 2). Zeolites are present throughout the northern part of the caldera-fill sedimentary rocks. The distribution of zeolites that consist of clinoptilolite, mordenite, and analcime was studied by X-ray diffraction methods and was delineated by Glanzman and Rytuba (1979) and Rytuba and others (2003). The zeolites formed by hydrothermal and diagenetic alteration of the caldera-fill sediments. In the southwestern part of the caldera, the sedimentary rocks are altered to alkali feldspar rather than zeolites. The area of caldera-fill sedimentary rocks that contains feldspar instead of zeolites was delineated by the X-ray diffraction studies reported by Rytuba and others (2003) and these areas were excluded from the tract. The boundary between potassium-rich and potassium-poor sedimentary rocks is also demonstrated with geochemical studies and by a radiometric survey (U.S. Geological Survey, 1982).

Tract ONZE02, Whitehorse Zeolite—The caldera-fill sedimentary rocks of the Whitehorse Caldera have moderate potential (M), with certainty level C, for zeolite deposits (tract ONZE02, Whitehorse Zeolite; fig. 23*G*; appendix 2). Delineation of tract boundaries and tract geology are described in report section “Tract ONLI02, Whitehorse Lithium.”

The Whitehorse caldera contains sedimentary rocks similar to those in the nearby McDermitt caldera that are altered to zeolites. The zeolites formed from the alteration of water-laid tuffs. X-ray diffraction and scanning electron microscope studies of two drill holes in the Whitehorse caldera demonstrate the presence of anomalous amounts of the zeolites clinoptilolite, phillipsite, and erionite in caldera-fill sedimentary rocks (Rytuba and others, 1981). Clays are associated with the zeolites (see report section “Tract ONCL02, Whitehorse Clay”).

Mineral Potential Tracts for Lacustrine Diatomite Deposits

Two mineral potential tracts for lacustrine diatomite deposits were delineated and rated in the study area: tract ONDT01, Whitehorse Diatomite; and tract ONDT02, Harney-Malheur, which is based on favorable stratigraphy.

Tract ONDT01, Whitehorse Diatomite—This tract has moderate potential (M) for lacustrine diatomite deposits at certainty level C (tract ONDT01, Whitehorse Diatomite; fig. 23*H*; appendix 2). The tract is located in eastern Harney County, Oregon, where it is delineated by the mapped extent of the Trout Creek Formation (Barrow, 1983), a lacustrine basin-fill unit generally within the Whitehorse caldera, a feature recognized by negative gravity and aeromagnetic anomalies (Rytuba and others, 1981). The host unit is delineated as the composited map extent of the Trout Creek Formation of Smith (1927; his unit Ttc, undivided) and subunits Ttcb (basalt unit), Ttcd (diatomaceous unit), and Ttct (tuffaceous unit), and was generated from the scanned, georeferenced, and digitized map of Barrow (1983). The unit spatially corresponds in part to unit Tts from the Oregon state map (Miller and others, 2002; geology from Walker and MacLeod, 1991) and unit Tts (Walker and Repenning, 1965) that includes the Trout Creek Formation and Virgin Valley Beds.

The diatomite potential from a previous mineral assessment conducted in the vicinity of the tract was moderate with B certainty (U.S. Geological Survey and U.S. Bureau of Mines, 1989). Although current and past production was not recorded, two point locations within the tract are noted as the "Trout Creek Diatomite Occurrence" and the "Trout Creek West Deposit" (U.S. Geological Survey, 2016a). Total thickness of the Trout Creek Formation in the caldera is about 183 m, with diatomaceous earth being the upper 37 m (Rytuba and others, 1981; Bawiec and others, 1989).

Tract ONDT02, Harney-Malheur—This tract has low potential (L) for lacustrine diatomite deposits at certainty level B (tract ONDT02, Harney-Malheur; fig. 23*H*; appendix 2). It is in eastern Harney and Malheur Counties, Oregon, and consists of Pliocene and Miocene stratigraphic units Ts and Ts? (Walker and MacLeod, 1991) on the Oregon state map (Miller and others, 2002); these units include diatomite as a minor or incidental lithology among sedimentary units associated with volcanic strata.

More specifically, the geologic units represented by unit Ts in Oregon are semiconsolidated to well-consolidated, mostly lacustrine tuffaceous sandstone, and siltstone, mudstone, concretionary claystone, pumicite, diatomite, air-fall and water-deposited vitric ash, palagonitic tuff, and tuff breccia, and fluvial sandstone and conglomerate (Walker and MacLeod, 1991). The Harney County portion of the tract was deposited in the Pueblo caldera in which the lower part of the caldera fill consists of thin beds of diatomaceous earth interstratified with tuffaceous sedimentary rocks and thin pyroclastic flows (Bawiec and others, 1989). Elsewhere in Harney and Malheur Counties, Walker and Repenning (1965; 1966) show additional mapped units Pleistocene to Pliocene unit QTs, Pliocene unit Tst, and Miocene unit Tts as tuffaceous lacustrine sediments containing "ashy diatomite," although the Oregon state map (Miller and others, 2002) does not mention diatomite in this unit. These units were not included in the tract because of their implied impure nature.

The diatomite potential from a previous mineral assessment conducted in the vicinity of the Harney County portion of the tract was low and of B certainty (U.S. Geological Survey and U.S. Bureau of Mines, 1989). No current or past mines, no identified prospects or occurrences, and no active claims, plans of operations, or notices are within the tract.

Market Analyses of Lithium, Zeolites, and Diatomite

Market analyses of lithium, zeolite, and diatomite are provided in appendix 5 and section I of Day and others (2016).

Occurrence of Leasable Minerals

Leasable mineral commodities (leasable solid and fluid minerals) include oil and gas, geothermal, coal, and non-energy solid minerals, including phosphate and potash. These commodities were not evaluated for assessment, but were qualitatively appraised for exploration and mining activity, lease status, and potential for deposits within the study area for the Southern Oregon and North-Central Nevada Sagebrush Focal Area. No production of leasable solid minerals (coal, phosphate, and potash) or production of leasable fluid minerals (oil and gas, and geothermal) has occurred in the study area. Favorable stratigraphy for coal and phosphate is not exposed, has not been recognized, or is concealed within the study area. Based on comparison to deposits of these commodities elsewhere in the western United States with past or present production (including oil and gas fields, and geothermal fields), and current market conditions, neither concealed or exposed deposits of these commodities are likely to be explored for, or produced, in coming decades, with the possible exceptions of geothermal and potash.

Although no oil and gas, geothermal, and potash have been produced, these commodities occur, and have been explored for under leases in the study area for the Southern Oregon and North-Central Nevada Sagebrush Focal Area. Although all leases are closed, they indicate that exploration for these leasable commodities has occurred in recent years (table 10).

Oil and Gas

There are 135 closed oil and gas leases in the study area for the Southern Oregon and North-Central Nevada Sagebrush Focal Area (table 10). One dry well is within the USGS study area boundary but external to the proposed withdrawal area (fig. 24). Oil and gas exploration, assessment, and potential in the four study areas are described in report section "Introduction; Leasable Minerals."

Geothermal

There are 29 closed geothermal leases in the study area for the Southern Oregon and North-Central Nevada Sagebrush Focal Area (fig. 24; table 10). Geothermal exploration, assessment, and potential in the four study areas are described in report section "Introduction; Leasable Minerals."

Potash

No potash occurrences are in the study area for the Southern Oregon and North-Central Nevada Sagebrush Focal Area. However, 8 leases for non-energy, solid mineral commodities were recorded by the BLM; all are closed (table 10). The leases are situated near the former Lake Lahonton high-stand shoreline (fig. 24), suggesting that lacustrine basin brine containing potassium salts may have been the commodity sought. An important source of potash salt production in the western United States is brine in intracontinental, closed basins (Orris, 2011). Closed basins have restricted surface water inflow and outflow. Lowland basins and adjacent mountain ranges in the Basin and Range Province comprise physiography in which closed-basin lakes could form and brines could subsequently evolve. During the Pleistocene, at least two large, closed-basin lakes, Lake Bonneville and Lake Lahontan, formed in the Basin and Range. As Lake Bonneville water levels steadily declined from the high stand at about 15,000 years before present to the Holocene, lake water salinity and potash salt concentrations increased.

Near Wendover, Utah, south of the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, groundwater that is a remnant of Lake Bonneville is pumped from shallow groundwater wells and evaporated in solar evaporation ponds; precipitates are processed to recover potash and other salts. No producing closed-basin brine potash occurrences are known in the study areas to the west that are partially cospatial with former Lake Lahonton. South of the study area for the Sheldon-Hart Mountain National Wildlife Refuge Complex Sagebrush Focal Area, closed basin potash brine occurrences in Churchill County, Nevada (Dixie and North Sand Springs Marshes), in part coincide with the former extent Lake Lahontan (Papke, 1976). A potash tract was delineated that coincides with former Lake Bonneville, but a potash tract was not delineated for former Lake Lahontan (Orris and others, 2014).

Occurrence of Salable Minerals

Salable mineral commodities, mainly sand and gravel, and aggregate, have been produced at numerous sites in the study area for the Southern Oregon and North-Central Nevada study area. There are 104 salable commodity sites (mineral materials sales sites) in the study area, 17 of which are authorized (approved) and pending, and 87 of which are closed or expired (fig. 25; table 10). There are 7 approved (authorized) sites that are sand and gravel, 2 are soil/topsoil, 4 are crushed stone, 2 are specialty stone, and 2 are weathered granite (table 15).

Table 15. Active mineral material sales sites in the proposed withdrawal area within the study area for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area, Nevada and Oregon.

[Source: Dicken and San Juan, 2016. The number of cases is for the complete Public Land Survey System (PLSS) section that includes a proposed withdrawal area]

Commodity	Number of approved sites	Number of pending sites
Sand and gravel	7	0
Soil/other, topsoil	2	0
Stone, crushed and broken	4	0
Stone, specialty	2	0
Stone, weathered granite	2	0

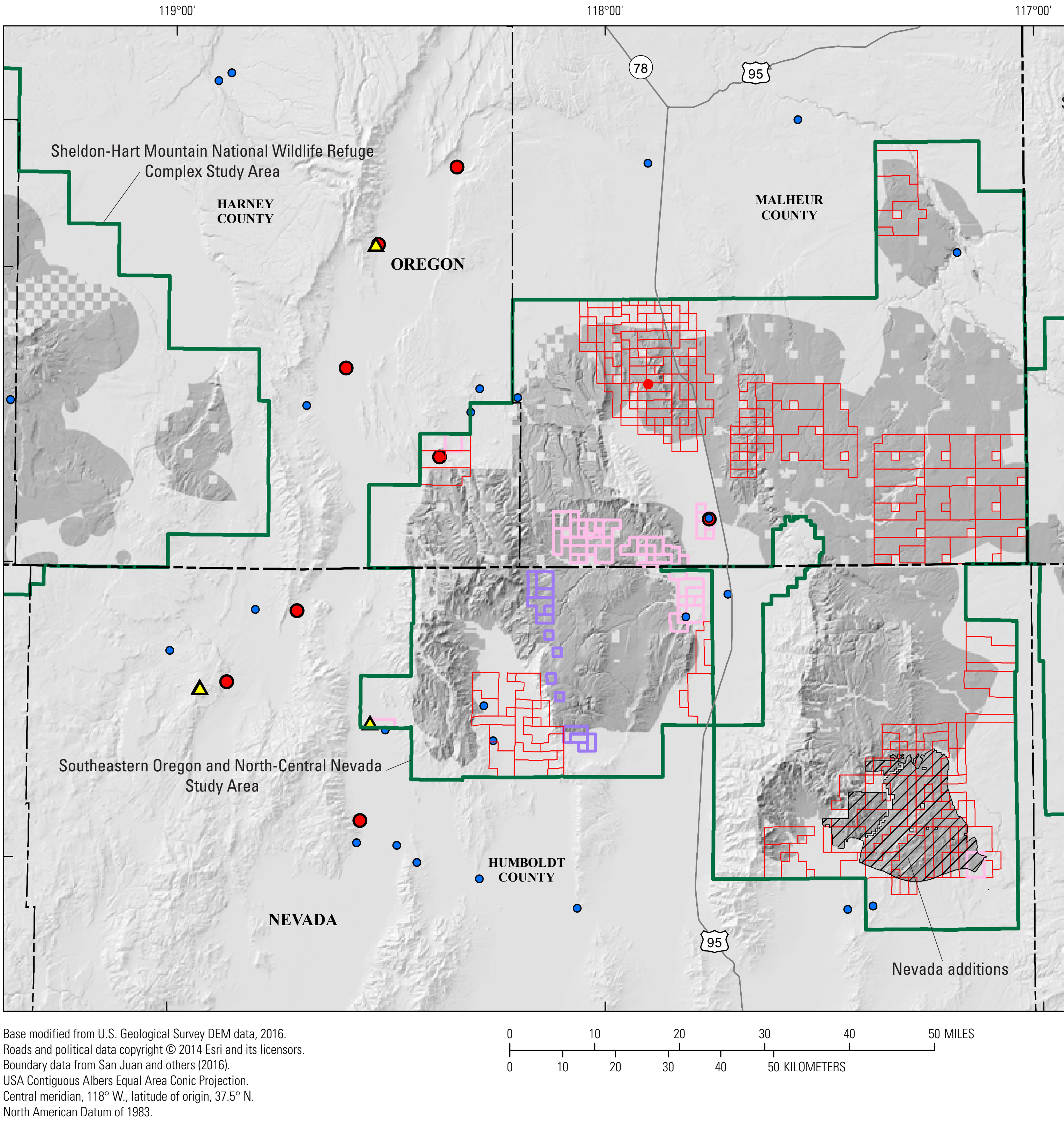


Figure 24. Map showing Bureau of Land Management (BLM) oil and gas, geothermal, and potash leases; oil and gas exploration (dry); and geothermal sites in the study area for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area, Nevada and Oregon (Williams and others, 2008a,b; Dicken and San Juan, 2016; Gunther and others 2016a,b; IHS Energy Group, 2016). USGS, U.S. Geological Survey.

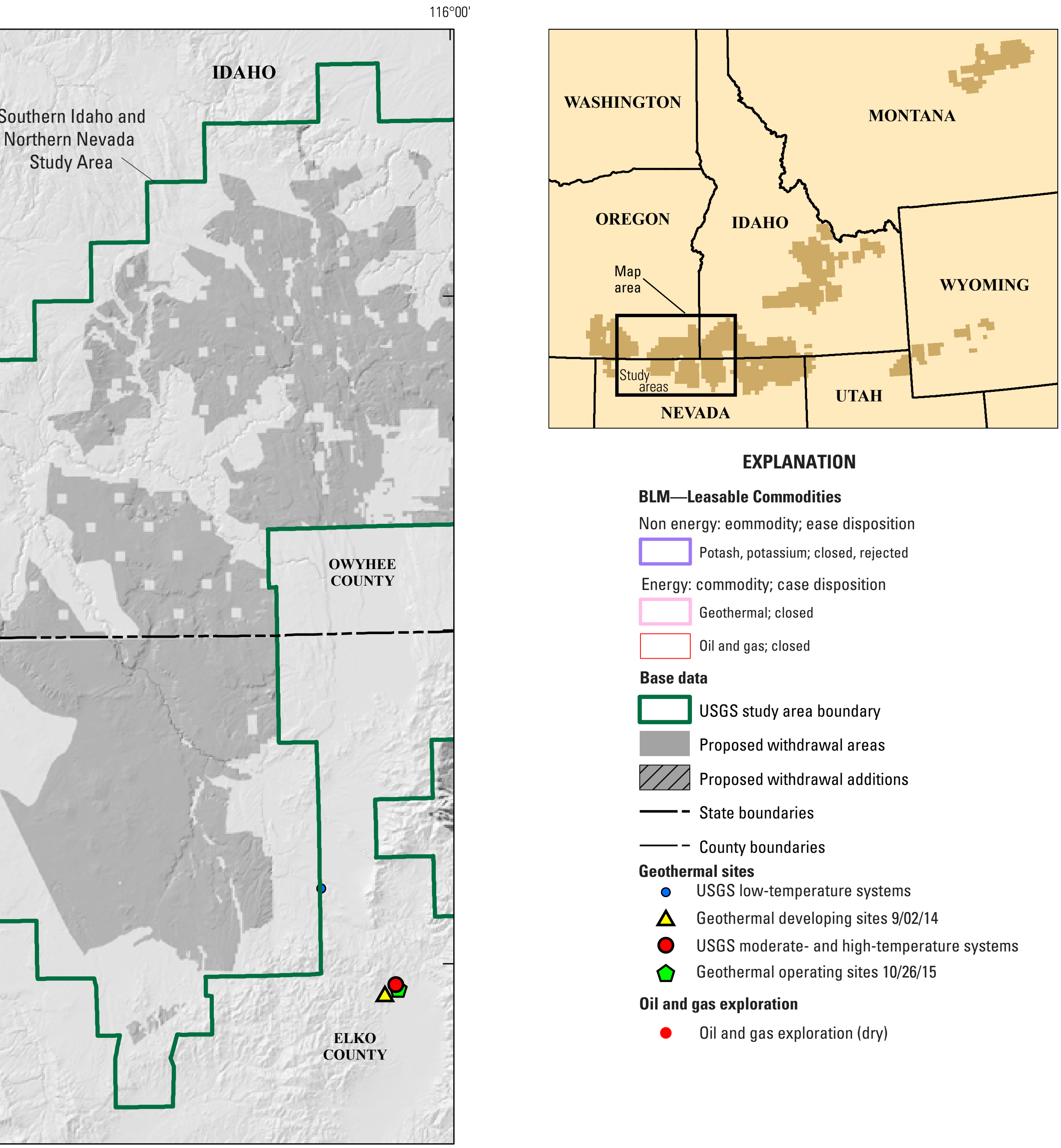
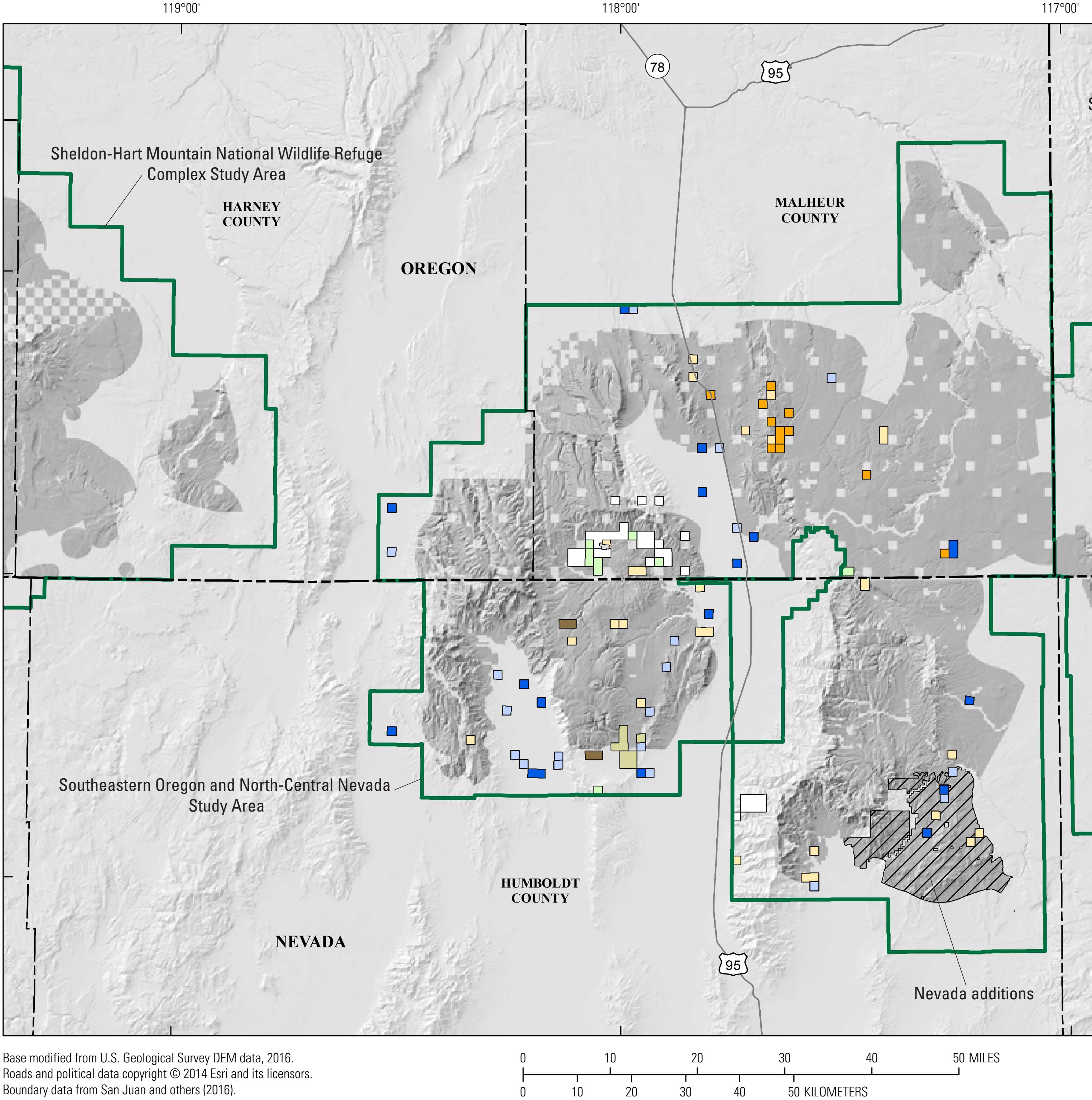
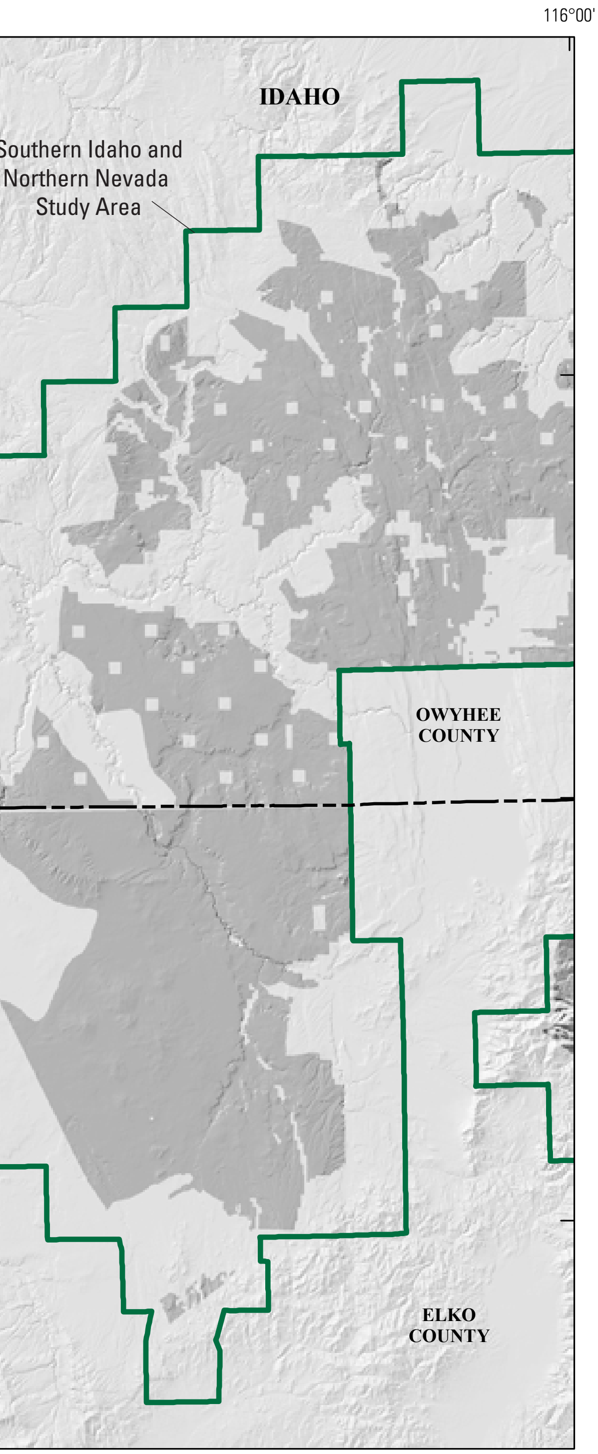


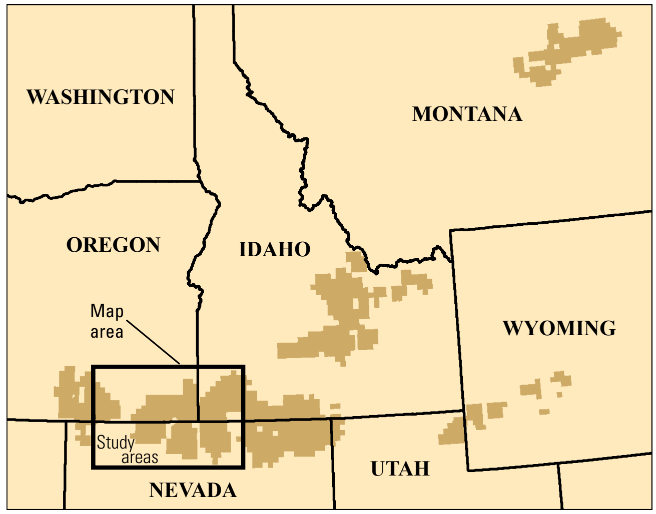
Figure 24.—Continued



Base modified from U.S. Geological Survey DEM data, 2016.
Roads and political data copyright © 2014 Esri and its licensors.
Boundary data from San Juan and others (2016).
USA Contiguous Albers Equal Area Conic Projection.
Central meridian, 118° W., latitude of origin, 37.5° N.
North American Datum of 1983.

Figure 25. Map showing Bureau of Land Management (BLM) salable mineral commodity sites in the study area for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area, Nevada and Oregon (Dicken and San Juan, 2016). USGS, U.S. Geological Survey.





EXPLANATION

BLM—Salable mineral commodities: commodity; case disposition

- Stone (specialty, weathered, riprap, crushed, dimension); authorized
- Stone (specialty, weathered, riprap, crushed, dimension); closed, expired
- Clay, common; authorized
- Clay, common; closed
- Gemstone; authorized, closed expired, pending, withdrawn
- Sand and gravel; authorized, pending
- Sand and gravel; closed, expired, rejected
- To be defined, none; closed

Base data

- USGS study area boundary
- Proposed withdrawal areas
- Proposed withdrawal additions
- State boundaries
- County boundaries

Figure 25.—Continued

Mineral-Resource Potential of the Study Area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, Nevada, Idaho, and Utah

Introduction

The study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area spans the borders of Idaho, Nevada, and Utah, and includes parts of Cassia, Owyhee, and Twin Falls Counties, Idaho; Elko County, Nevada; and Box Elder County, Utah (fig. 26). This report section describes the mineral potential of the proposed withdrawal area within the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, which includes parts of the proposed withdrawal area described in report section "Introduction." The proposed withdrawal area within this study area encompasses 3,734,263 acres (~15,112 km^2; 5,835 mi^2), of which, the Bureau of Land Management (BLM) manages 3,343,220 acres and the U.S. Forest Service manages 390,933 acres.

Description of Geology

Archean, Neoproterozoic, Paleozoic, Mesozoic, Tertiary, and Quaternary rocks are exposed within the proposed withdrawal area within the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, Idaho, Nevada, and Utah, and the USGS study area boundary (fig. 27). Most pre-Tertiary rocks within the USGS study area boundary are in Nevada and Utah, whereas the USGS study area boundary in Idaho nearly entirely encloses Tertiary strata. Archean, Neoproterozoic, and Paleozoic rocks include metamorphosed igneous and sedimentary rocks. Paleozoic sedimentary rocks (Cambrian to Permian) comprise the Roberts Mountains and Golconda allochthons. These allochthons have been intruded by granitic rocks, mostly plutons (Jurassic, Cretaceous, and Tertiary). Tertiary strata are predominantly volcanic lava flows and tuffs, and sedimentary rocks (Eocene, Miocene, and Pliocene). Quaternary strata include volcanic rocks and surficial deposits. In Nevada and Utah, the two allochthons have been juxtaposed by compressional tectonism during the Mesozoic. The allochthons and Tertiary volcanic strata have been laterally displaced by late Tertiary extensional tectonism which produced the modern landforms of alternating, north-south oriented mountain ranges separated by broad, relatively flat valleys (Basin and Range topography). In Idaho, exposed Miocene and Pliocene strata are part of a sequence of mostly rhyolite, basalt, and lacustrine rocks that fill a large, arcuate depression, the Snake River Plain, which spans the southern part of Idaho, southeastern Oregon, and northwestern Wyoming. These Tertiary strata form broad volcanic uplands across the northern and western parts of the study area.

More complete descriptions of these strata, and their tectonic evolution, are in report section "Introduction; Description of Geology."

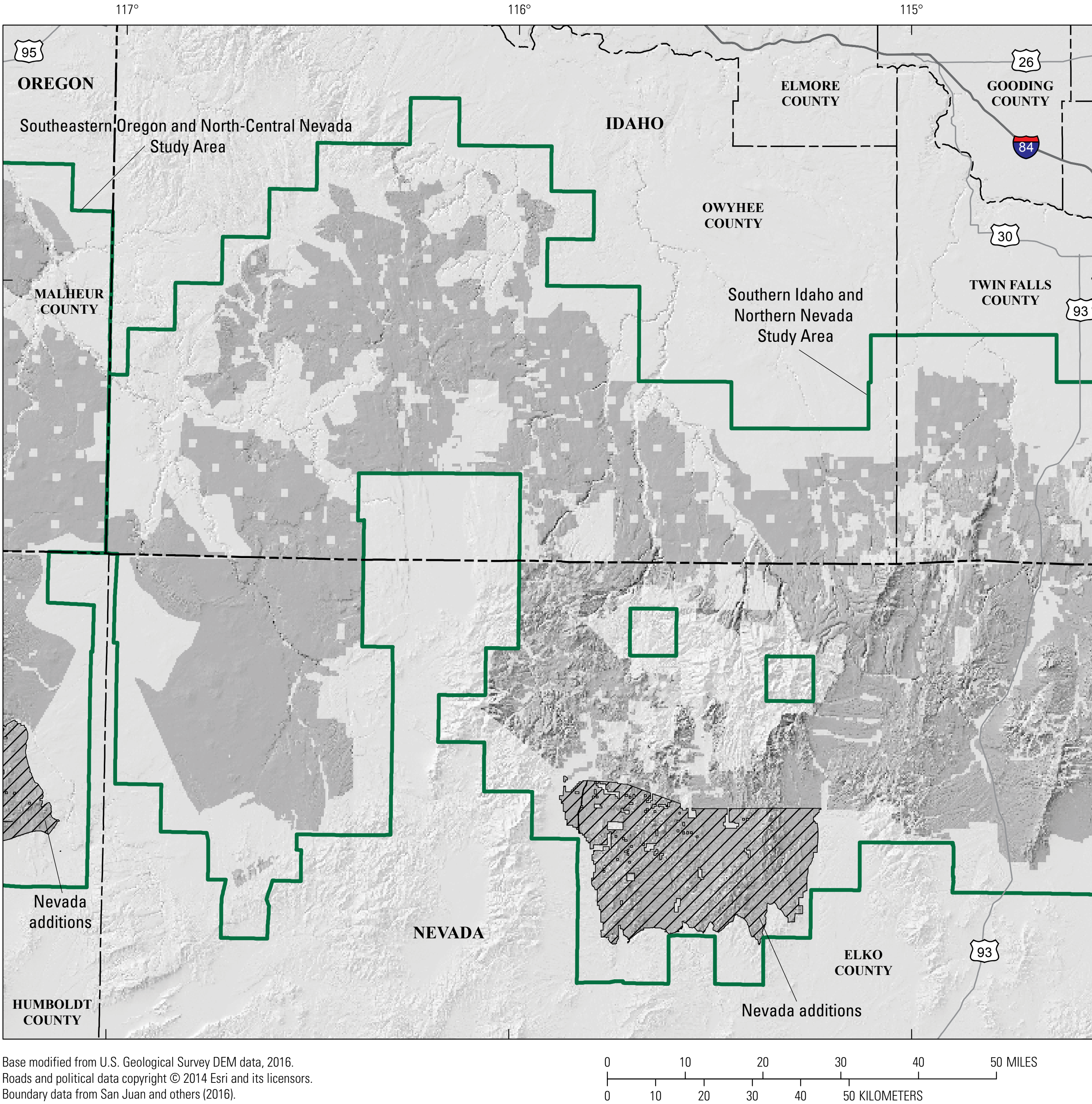
Mineral-Resource Potential

Mineral Deposit Types

Characteristics of metallic and nonmetallic locatable mineral deposits, prospects, and host rocks in the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, Idaho, Nevada, and Utah (appendix 2), are compatible with classification of these deposits as numerous deposit types, including epithermal gold and silver deposits, hydroallogenic uranium deposits, various intrusion-related deposits, volcanogenic massive sulfide (VMS) deposits, Carlin-type gold deposits, lacustrine diatomite deposits, and bedded barite deposits. Within the study area there is also favorable or permissive stratigraphy for several of these deposit types (volcanogenic massive sulfide, Carlin-type gold, lacustrine diatomite, and bedded barite deposits) and for black shale vanadium deposits, sedimentary exhalative (SEDEX) zinc-lead-silver-gold deposits, and Mississippi Valley-type (MVT) lead and zinc deposits (Day and others, 2016).

Epithermal gold, silver, and mercury deposits are shallowly formed vein, stockwork, disseminated, and replacement deposits that are mined primarily for gold and silver. Hot-spring-type mercury deposits are often the near-surface expression of gold and silver deposits that occur at deeper levels below mercury-enriched sinter and volcaniclastic strata. Epithermal gold, silver, and mercury deposits in the western United States occur largely in Eocene-Miocene volcanic fields and have been mined primarily for gold and silver, and lesser mercury (on the basis of mass and value).

Hydroallogenic uranium deposits are localized primarily by permeability and paleohydrology. They occur in a wide variety of rock types, including granitic and sedimentary rocks. Uranium in these largely Tertiary deposits is derived from low-temperature fluid leaching of volcanic rocks, often proximal to deposits, and is concentrated by fluid reduction in faults, shear zones, joints, and permeable strata.



Base modified from U.S. Geological Survey DEM data, 2016.
Roads and political data copyright © 2014 Esri and its licensors.
Boundary data from San Juan and others (2016).
USA Contiguous Albers Equal Area Conic Projection.
Central meridian, 115° W., latitude of origin, 37.5° N.
North American Datum of 1983.

Figure 26. Map showing proposed withdrawal areas that comprise the Southern Idaho and Northern Nevada Sagebrush Focal Area, Nevada, Idaho, and Utah, and boundary of the U.S. Geological Survey (USGS) study area. The study area boundary corresponds to townships that enclose the proposed withdrawal areas.

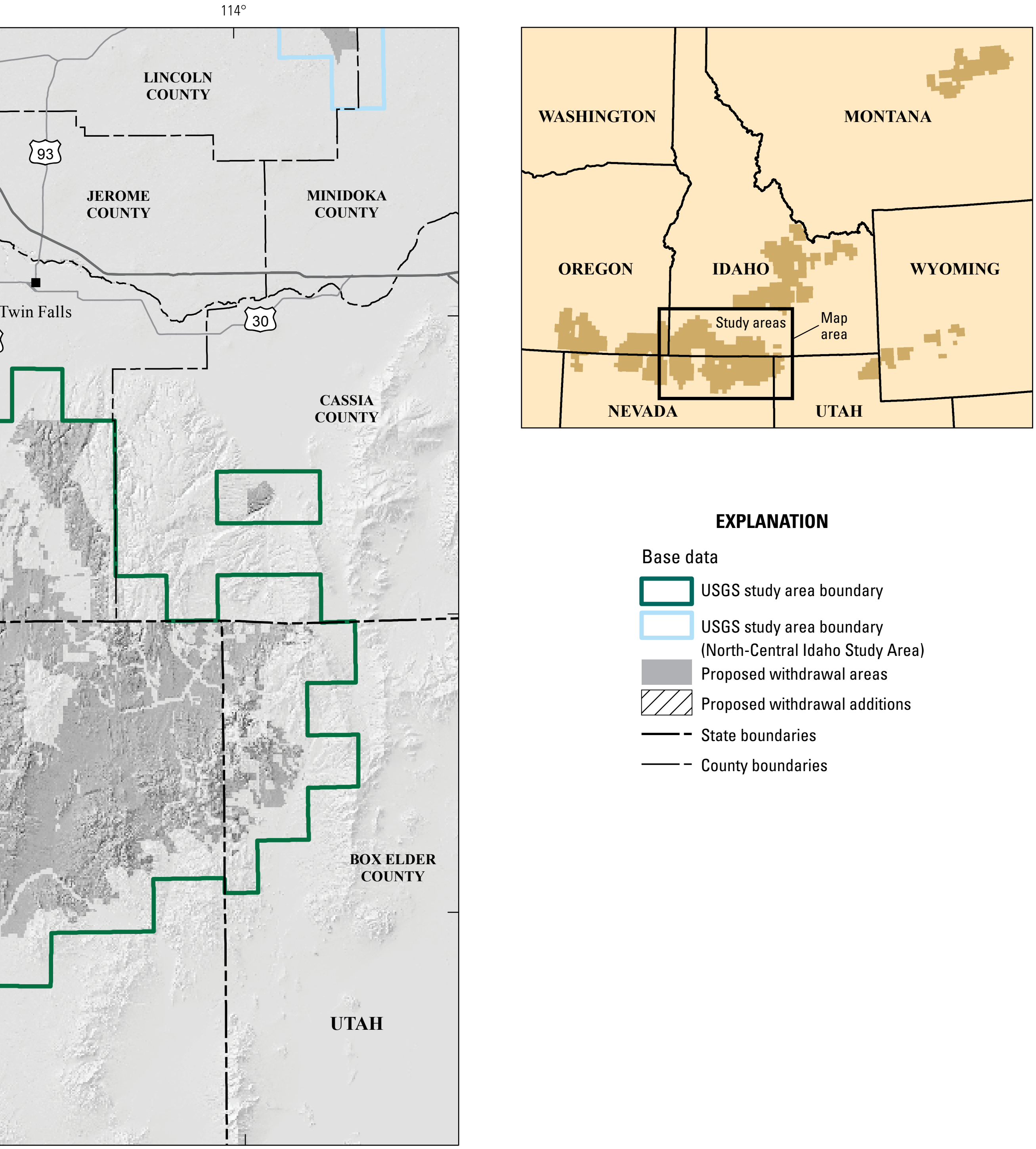


Figure 26.—Continued

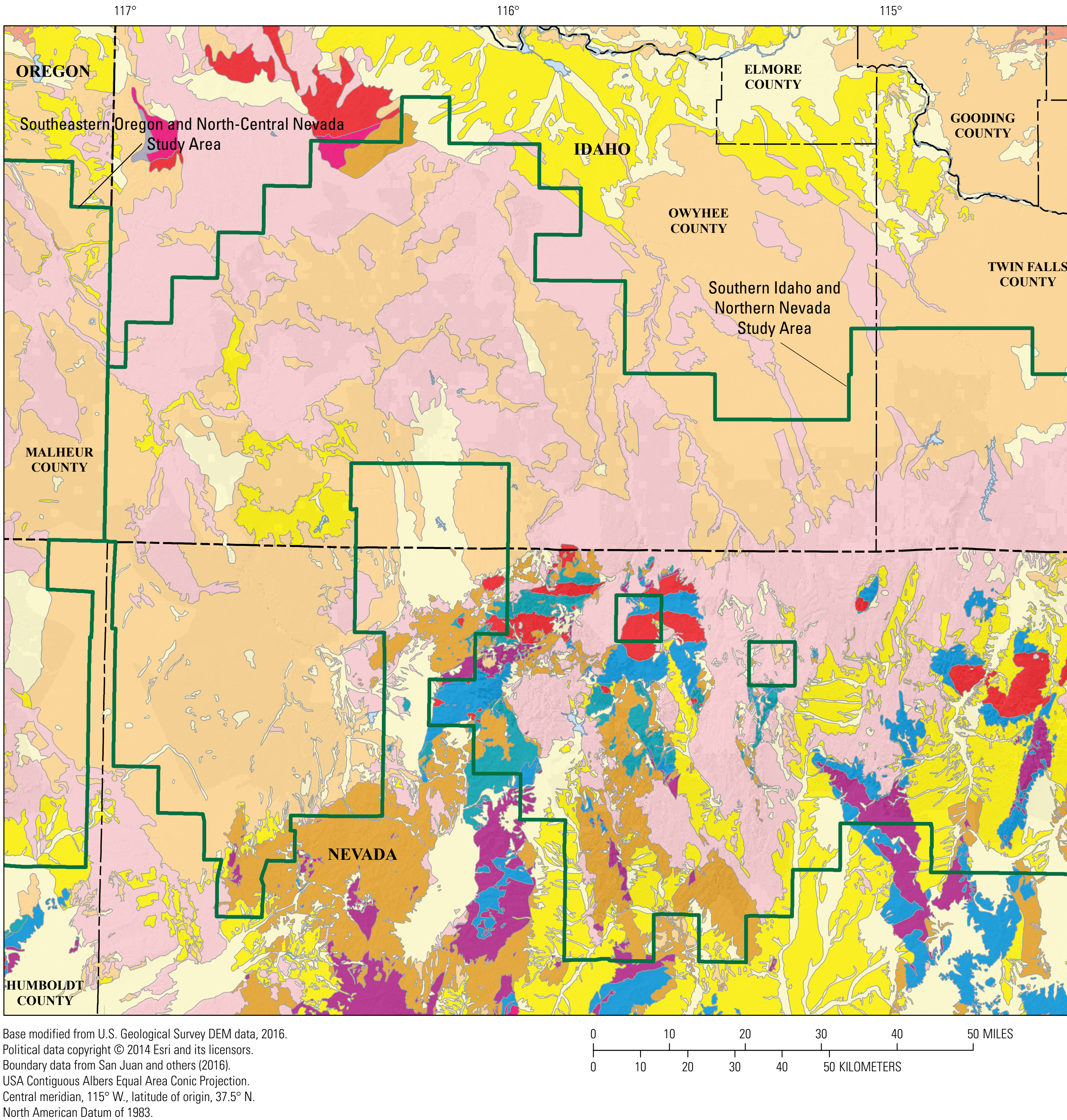


Figure 27. Simplified geologic map of the study areas for the Southern Idaho and Northern Nevada Sagebrush Focal Area, Nevada, Idaho, and Utah; and the Nevada additions. Synthesized from Hintze and others (2000), Crafford (2007), and Lewis and others (2012). USGS, U.S. Geological Survey.

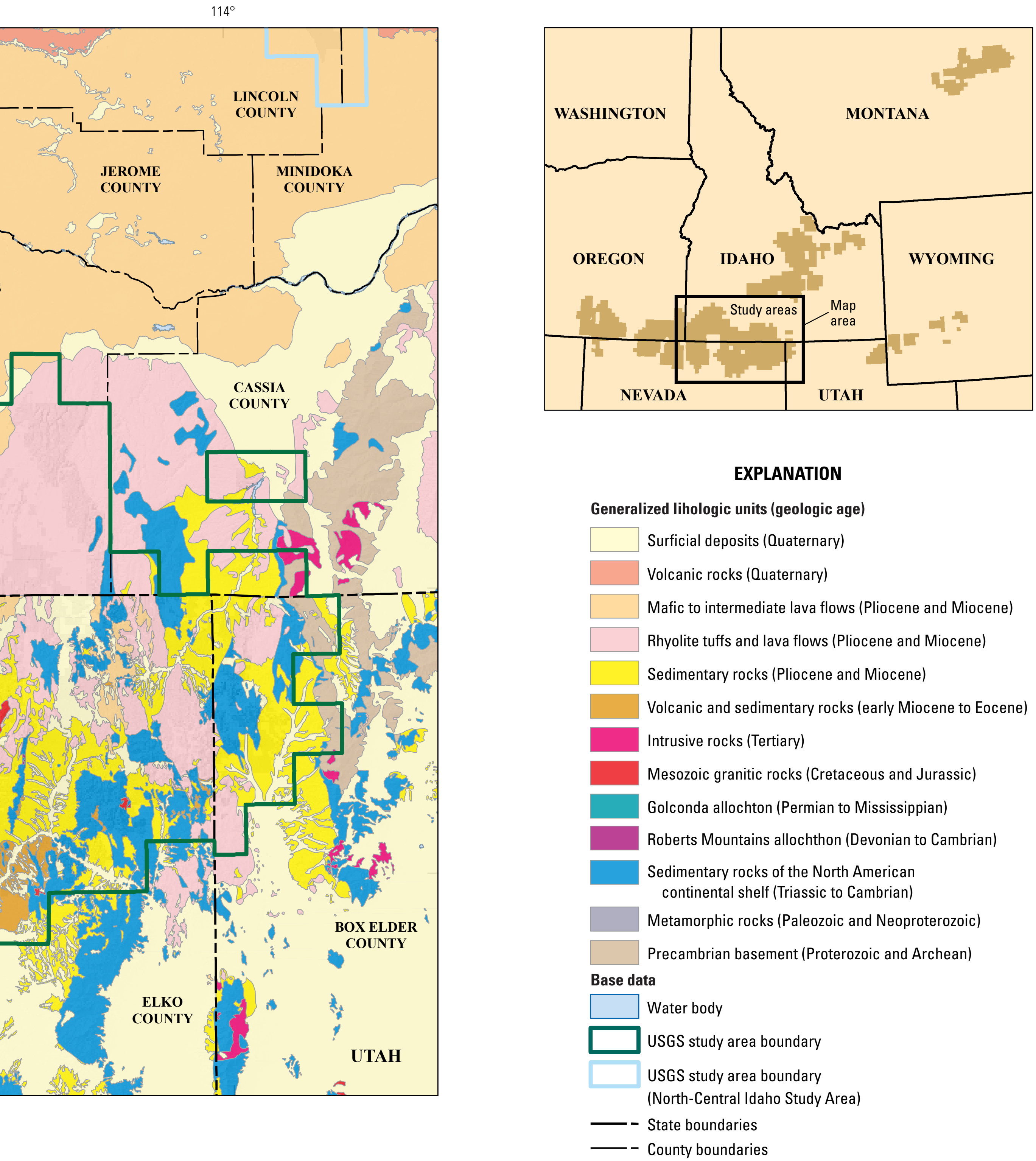


Figure 27.—Continued

Numerous intrusion-related deposit types are represented in the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, including porphyry copper, porphyry molybdenum, copper skarn, tungsten skarn, lead-zinc skarn, polymetallic replacement, polymetallic vein, and distal disseminated silver-gold deposits. Porphyry copper and molybdenum deposits consist of copper minerals (mainly chalcopyrite) and molybdenite that are disseminated in highly altered, granitic and porphyritic, mostly felsic intrusions, and occur in veins and breccias in and adjacent to these intrusions. Most deposits are Mesozoic and Cenozoic, and many deposits, because of the large scale of mining, produce annually, in addition to copper and molybdenum, hundreds of thousands to millions of ounces of gold and silver. Copper, tungsten, and lead-zinc skarn and polymetallic replacement and vein deposits consist of copper, tungsten, lead, zinc, silver, gold, and numerous silicate, carbonate, oxide, sulfide, and sulfate minerals that have replaced, or comprise veins in, carbonate and lesser siliciclastic rocks adjacent to, proximal to, and distal to granitic and porphyritic, mostly felsic intrusions. In addition to copper, tungsten, lead, and zinc, silver and gold commonly have been recovered from these deposits, may have been the main commodity recovered, or, because of high unit value, may have enabled recovery of other metals. Some skarn, replacement, and vein deposits are adjacent to intrusions containing porphyry copper and molybdenum deposits. Distal disseminated silver-gold deposits occur mainly in carbonate and clastic sedimentary rocks distal to porphyry copper, skarn, and polymetallic vein deposits, and have been mined nearly entirely for silver and gold.

Volcanogenic massive sulfide (VMS) deposits, from which copper and lesser zinc and silver are produced, consist of stratabound concentrations of sulfide minerals that were precipitated from hydrothermal fluids in extensional seafloor environments. These mostly Paleozoic and Mesozoic deposits are interbedded with basaltic to andesitic sills and flows, and siliciclastic rocks.

Carlin-type gold deposits consist of gold-bearing pyrite disseminated in Paleozoic marine, carbonaceous, calcareous, and (or) dolomitic sedimentary rocks which were deposited on slopes of the carbonate platform margin, or in marginal basin, shelf, foreland basin, and overlap sequences. These mostly Eocene deposits predominantly occur in the Great Basin of Nevada and compose a major crustal supply of gold.

Lacustrine diatomite deposits consist of chalklike, earthy siliceous sedimentary strata composed of diatoms. In volcanic terranes, diatomaceous lake sediments typically occur within sequences of volcanic and sedimentary rocks. Lacustrine diatomite deposits in the western United States occur primarily in high-silica sequences of middle Miocene flows and tuffs.

Bedded barite deposits are meters-thick, stratiform masses of barite and barite-rich strata that have lateral dimensions of as large as several kilometers. They form by precipitation from fluids vented in submarine basins and form beds or lenses within carbonate and siliciclastic sequences. In the Great Basin of the western United States, bedded barite deposits occur in middle to late Paleozoic rocks.

Geology and Occurrence of Mineral Deposit Types

The southeastern and eastern parts of the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, Idaho, Nevada, and Utah, are underlain by Paleozoic and Mesozoic sedimentary and granitic rocks, and lower Paleozoic, Neoproterozoic, and older Precambrian siliciclastic and metamorphic rocks. These rocks are covered, in part, by Tertiary and Quaternary volcanic and sedimentary rocks. The Mesozoic granitic rocks have intruded Paleozoic and Mesozoic carbonate and siliciclastic strata of the North American continental shelf, the Roberts Mountains allochthon, and Precambrian rocks. The northern and western parts of the study area are underlain nearly entirely by Tertiary and Quaternary volcanic and sedimentary rocks (fig. 27).

Epithermal gold and silver deposits and lacustrine diatomite deposits occur in Tertiary volcanic flows, intrusions, tuffs, and associated epiclastic sedimentary strata in Elko County, Nevada, and Owyhee and Cassia Counties, Idaho. Most epithermal gold and silver deposits are in Elko County, Nevada, in the southeastern part of the study area. Hydroallogenic uranium deposits, intrusion-related deposits, VMS deposits, Carlin-type gold deposits, and bedded barite deposits occur mainly in pre-Tertiary sedimentary and igneous rocks and nearly all deposits are in in Elko County, Nevada, in the southeastern part of the study area. Favorable pre-Tertiary stratigraphy for volcanogenic massive sulfide deposits, Carlin-type gold deposits, bedded barite deposits, black shale vanadium deposits, SEDEX zinc-lead-silver-gold deposits, and MVT lead and zinc deposits is also exposed primarily in the southeastern part of the study area. Favorable stratigraphy for lacustrine diatomite deposits spans most of the study area.

Exploration and Mining Activity for Locatable Minerals

Metallic and nonmetal locatable mineral commodities that have been mined and explored for in the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area include gold, silver, copper, lead, zinc, uranium, antimony, tungsten, diatomite, and barite. Large numbers (thousands) of lode and placer claims have been staked in the study area (fig. 28, 29, 30; tables 16, 17); there are 30 authorized, pending, approved, and proposed plans of operations and notices for gold, silver, tungsten, diatomite, and an unspecified commodity, and 101 closed and expired plans of operations and notices in the study area, indicative of current and recent mineral exploration (fig. 28; tables 18, 19). In addition, numerous claims were staked and filed in the study area from 1976 to 2007 (Causey, 2007, 2011; fig. 29).

Several epithermal gold and silver deposits, various types of intrusion-related deposits, several hydroallogenic uranium deposits, one VMS deposit, and bedded barite deposits with recorded production exist within, or partially within the study area (table 20). Production from epithermal gold and silver deposits in the Jarbidge district (Elko County, Nevada) was about 0.36 million troy ounces (Moz) of gold and 1.67 Moz of silver. Production from epithermal gold and silver deposits in the Good Hope and Cornucopia districts (Elko County, Nevada) was about 0.10 Moz of gold and 0.76 Moz of silver. Gold and silver produced from intrusion-related, polymetallic deposits in the six largest districts in the study area (Island Mountain, Edgemont, Delano, Mountain City, Contact, and Charleston districts, Elko County, Nevada) total 64,390 troy ounces (oz) of gold and 5,840,616 oz of silver. The Carlin-type gold deposit at the Big Springs Mine produced about 0.4 Moz of gold. Total gold and silver production from these districts is about 0.53 Moz and 8.2 Moz, respectively. Other metals produced from these districts include 104,954 short tons of copper, 12,232 short tons of lead, 746 short tons of zinc, 27 short tons of antimony, and 971 units of tungsten trioxide (WO_3). Uranium mines in the Mountain City district cumulatively produced about 20,876 pounds (lbs) of triuranium octoxide (U_3O_8) (table 20).

Mining districts and exploration projects with gold and silver resources that are within or partially within the study area include Island Mountain (Elko County, Nevada; 26.3 million short tons at 0.019 troy ounce per short ton gold), Doby George (Elko County, Nevada; 27.1 million short tons at 0.028 opt gold), Aura (Elko County, Nevada; 2 million short tons at 0.01 opt gold, 2.2 opt silver), White Rock (Elko County, Nevada and Box Elder County, Utah; 9 million short tons at 0.018 opt gold), Gravel Creek (Elko County, Nevada; 16.9 million short tons at 0.08 opt gold, 1.2 opt silver), Wood Gulch (Elko County, Nevada; 0.8 million short tons at 0.12 opt gold), Big Springs (Elko County, Nevada; 14.8 million metric tons at 0.05 opt gold), and Blue Hill Creek (Cassia County, Oregon; 14.4 million short tons at 0.016 opt gold). These resources contain about 3.5 Moz of gold and about 25 Moz of silver (table 20).

Uranium resources include Race Track, Rim Rock, and South Fork-Pixley (Elko County, Nevada; cumulative resources are 1.1 million pounds [Mlbs] U_3O_8). Copper resources occur at Contact (Elko County, Nevada; 473 million short tons at 0.19 percent copper). Tungsten resources occur at Indian Springs (Elko County, Nevada; 18.9 million short tons at 0.17 percent WO_3) and in the Alder district (Elko County, Nevada; 0.75 million short tons at 0.43 percent WO_3; table 20).

Although numerous lode and placer claims have been staked in the study area in the vicinity of diatomite and barite deposits (tables 16, 17, 18), there is only one active plan of operations specifically for diatomite (fig. 28; table 19). No diatomite production was recorded within the study area. Barite has been mined from a number of deposits in the Snake Mountains (Elko County, Nevada), and barite has been produced in the Jarbidge district (Elko County, Nevada). Cumulative barite production in the study area is about 1.01 million short tons (table 20).

A qualitative estimate of past mining activity for locatable metallic (and nonmetallic) mineral commodities was made by counting mining-related symbols on USGS topographic maps that cover the study area (Fernette and others, 2016b). There are 2,402 mine symbols shown on USGS 7.5-minute topographic maps, 350 of which are adits, shafts, or open-pit mines, and 1,869 are prospect pits. These symbols are commonly associated with mining and exploration of locatable minerals and provide a broad indication of the extent of past mining activity in the area. Other mine symbols include borrow pits, gravel pits, and cinder pits, which are commonly associated with production of salable minerals.

A second qualitative estimate of past mining activity was made by extracting mines and deposits with the statuses "producer" and "past producer" from the USGS Mineral Resources Data System (MRDS). The MRDS database contains 434 records of "producer" and (or) "past producer." These producers include 365 deposits mined for metallic minerals, 13 deposits mined for industrial minerals, 4 deposits mined for uranium, and 42 deposits mined mostly for stone, sand, and gravel (U.S. Geological Survey, 2005). However, some MRDS records may be duplicates.

Table 16. Type, number, and status of mining claims, leases, mineral material sales sites for salable mineral commodities, and surface-management plans in the proposed withdrawal area within the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, Idaho, Nevada, and Utah.

[Leasable mineral commodities include coal, geothermal, non-energy solid mineral, oil and gas. Sources: Dicken and San Juan (2016) for Bureau of Land Management (BLM) 43 Code of Federal Regulations (CFR) 3809 data; Susan G. Summer Elliott, U.S. Forest Service (USFS), written commun., March 9, 2016, for USFS 36 CFR 228 Subpart A plans. The number of cases is for the complete Public Land Survey System (PLSS) section that includes a proposed withdrawal area. —, no data]

Type	Mineral type	Number of unique cases	Active	Authorized/ Approved	Pending/ Proposed	Closed	Cancelled	Expired	Rejected	Withdrawn
Mining claims	Locatable	29,165	3,221	—	—	25,944	—	—	—	—
Coal leases	Leasable	—	—	—	—	—	—	—	—	—
Geothermal leases	Leasable	7	—	—	2	5	—	—	—	—
Non-energy solid mineral leases	Leasable	—	—	—	—	—	—	—	—	—
Oil and gas leases	Leasable	1,029	—	8	2	1,019	—	—	—	—
Mineral materials sales sites	Salable	131	—	17	1	111	—	2	—	—
Surface-management plans	—	131	9	26	4	93	—	8	—	—

Table 17. Summary of active and closed mining claims for locatable minerals in Public Land Survey System (PLSS) sections that include the proposed withdrawal area within the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, Idaho, Nevada, and Utah.

[Source: Dicken and San Juan, 2016. The number of cases is for the complete PLSS section that includes a proposed withdrawal area]

Area	Active lode claims	Closed lode claims	Active placer claims	Closed placer claims	Active millsites	Closed millsites
Sections containing proposed withdrawal area	3,148	24,906	43	869	30	167

Table 18. Status and number of surface-management plans for locatable minerals in the proposed withdrawal area within the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, Idaho, Nevada, and Utah.

[Sources: Dicken and San Juan (2016) for Bureau of Land Management (BLM) 43 Code of Federal Regulations (CFR) 3809 plans; Susan G. Summer Elliott, U.S. Forest Service (USFS), written commun., March 9, 2016, for USFS 36 CFR 228 Subpart A plans. The number of cases is for the complete Public Land Survey System (PLSS) section that includes a proposed withdrawal area. —, no data]

Authorization type	Number of unique cases	Active	Authorized/ Approved	Pending/ Proposed	Closed	Cancelled	Expired	Rejected	Withdrawn
Plans of operations	33	9	2	1	21	—	—	—	—
Notice	98	—	5	—	85	—	8	—	—

Table 19. Status and number of active surface-management plans in the proposed withdrawal area within the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, Idaho, Nevada, and Utah, summarized by locatable commodity.

[Active includes active, authorized/approved, and pending/proposed from Table 18. Sources: Dicken and San Juan (2016) for Bureau of Land Management (BLM) 43 Code of Federal Regulations (CFR) 3809 plans; Susan G. Summer Elliott, U.S. Forest Service (USFS), written commun., March 9, 2016, for USFS 36 CFR 228 Subpart A plans. The number of cases is for the complete Public Land Survey System (PLSS) section that includes a proposed withdrawal area. —, no data]

Commodity	Active notices	Active plans of operations
Gold and silver	—	9
Gold	2	0
Gold, lode	3	1
Soil/other, diatomite	0	1
Tungsten, lode and placer	0	1

Table 20. Mined deposits with production and resources within, and partially within, the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, Idaho, Nevada, and Utah.

[Data from technical reports, including NI 43-101 documents, are in Fernette and others, 2016a,b. Nevada mining districts are from Tingley (1992). One unit of tungsten = 20 pounds of tungsten trioxide (WO_3) or 15.86 pounds of tungsten (W); est., estimate; g/metric ton, grams per metric ton; ID, Idaho; lbs, pounds; M+I+I, measured plus indicated plus inferred; MST, million short tons; NV, Nevada; opt, troy ounce per short ton; oz, troy ounce; ST, short ton; UT, Utah; @, at; %, weight percent; $, U.S. dollars]

Mine/Deposit name	Assessment tract name	Mining district	County, state	Commodity	Production years	Production	Resource	Notes; source
Jarbidge	INEP04, Jarbidge	Jarbidge	Elko, NV	Gold and silver	1910–1950	355,707 oz gold; 1,666,222 oz silver	—	LaPointe and others (1991)
Alpha Mine				Gold and silver	1923–26	$12,512	—	Couch and Carpenter (1943)
Bluster				Gold and silver	1916–1929	$74,374	—	Couch and Carpenter (1943)
Wildcat				Barite	1955–58	2,727 ST	—	LaPointe and others (1991)
Coon Creek				Tungsten	1943–1956	608 units WO_3	—	Stager and Tingley (1988)
Buckeye and Ohio	INEP10, Good Hope	Good Hope	Elko, NV	Gold and silver	1880–82; 1921	District: $100,000; ~91,000 oz gold	—	Emmons (1910), Knox (1970), LaPointe and others (1991)
				Antimony	1950	“several thousand pounds”	—	Lawrence (1963), LaPointe and others (1991)
	INEP02, Cornucopia	Cornucopia	Elko, NV	Silver and gold	Late 1800s	760,000 oz silver; 13,000 oz gold	—	Emmons (1910)
Diamond Jim, Rosebud, Gribble	INPR06, Island Mountain	Island Mountain	Elko, NV	Gold, silver, lead, zinc, copper, antimony, tungsten	1918–1982	District: 1,520 oz gold; 120,671 oz silver; 822 ST lead; 42 ST zinc; 5 ST copper; 11 ST antimony; 15 units tungsten	26,300,000 ST @ 0.019 opt gold	LaPointe and others (1991), Fernette and others (2016a)
Doby George	INCT06, Doby George 1	Island Mountain	Elko, NV	Gold	—	—	27,100,000 ST @ 0.028 opt gold	Davis and others (2006); Western Exploration and Development, Ltd. (2008)
Big Springs	INCT04, Big Springs 1	Independence Mountains	Elko, NV	Gold	1987–1993	386,000 oz gold	14.8 million metric tons @ 2 g/metric ton gold	Anova Metals Limited (2016)
Bull Run, Lucky Girl	—	Edgemont	Elko, NV	Gold, silver, lead, zinc, copper, tungsten	1902–1971	District: 39,121 oz gold; 90,649 oz silver; 100 ST lead; 2 ST zinc; 1 ST copper; 3 units tungsten	—	LaPointe and others (1991)
Burns	—	Edgemont	Elko, NV	Tungsten	1953	3 units WO_3	—	Stager and Tingley (1988)
White Rock	INEP06, Angel Wing	—	Elko, NV; Box Elder, UT	Gold	2009	—	9,000,000 ST @ 0.018 opt gold; ~150,000 oz gold	Goodall (2003), Kehmeier (2009)

Table 20. Mined deposits with production and resources within, and partially within, the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, Idaho, Nevada, and Utah.—Continued

Mine/Deposit name	Assessment tract name	Mining district	County, state	Commodity	Production years	Production	Resource	Notes; source
Gravel Creek	INEP03, Wood Gulch	—	Elko, NV	Gold and silver	—	—	16,940,000 ST @ 0.08 opt gold; 1.2 opt silver	Inventory; Fernette and others (2016a)
Wood Gulch	INEP03, Wood Gulch	—	Elko, NV	Gold	1988–1990	34,782 oz gold	Est. 780,000 ST @ 0.12 opt gold	NV NI 43-101 Doby George-Wood Gulch-IL Ranch Properties April 24, 2008 technical report
Blue Hill Creek	INE07, Oakley	—	Cassia, ID	Gold	—	—	14,400,000 ST @ 0.016 opt gold	Fernette and others (2016a)
Cleveland, Delano	INPR10, Delano	Delano	—	Gold, silver, lead, zinc, copper	1918–1980	District: 333 oz gold; 1,499,973 oz silver; 11,069 ST lead; 693 ST zinc; 84 ST copper; 384 units tungsten	—	LaPointe and others (1991)
Indian Springs	INPR10, Delano	Delano	Elko, NV	Tungsten	—	—	18,900,000 ST @ 0.17% WO_3	Stager and Tingley (1988), LaPointe and others (1991)
Blue Ribbon-Boyce	—	Aurum	Elko, NV	Antimony	1940	7 ST antimony	—	Lawrence (1963)
Rio Tinto, Mountain Laurel, Silver King	INPR02, Mountain City; INMS03, Rio Tinto 2	Mountain City	Elko, NV	Copper, gold, silver, lead	1869–1982	District: 101,984 ST copper; 20,557 oz gold; 559,561 oz silver; 54 ST lead; <1 ST zinc	—	LaPointe and others (1991)
Race Track, Rim Rock, South Fork-Pixley	INHU01, Racetrack	Mountain City		Uranium	1950s/1960s	20,876 lbs U_3O_8	1,100,000 lbs U_3O_8	Drilled resource 1967–1983; Bayswater Uranium Corporation (2007); Proffitt and others (1982)
Blue Jacket	INPR04, Blue Jacket	Aura	Elko, NV	Gold, silver, copper, lead, zinc	—	—	2 MST @ 0.01 opt gold; 2.2 opt silver; 0.25% copper; 2% lead; 1.8% zinc	Long and others (1998)
Contact	INPR09, Contact	Contact	Elko, NV	Copper, gold, silver, lead, tungsten	1908–1965	District: 2,876 ST copper; 1,222 oz gold; 126,901 oz silver; 180 ST lead; 9 ST zinc; 117 units WO_3	473,000,000 ST @ 0.19% copper	LaPointe and others (1991), Fernette and others (2016a)

Table 20. Mined deposits with production and resources within, and partially within, the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, Idaho, Nevada, and Utah.—Continued

Mine/Deposit name	Assessment tract name	Mining district	County, state	Commodity	Production years	Production	Resource	Notes; source
Consolation-Boies, Big Ledge, Hunch, Jungle A, Jungle, Little Dry	INBB02, Snake Mountains 1	Snake Mountains	Elko, NV	Barite	1974–1985	District: 1,008,964 ST barite		LaPointe and others (1991)
Batholith	—	Charleston	Elko, NV	Tungsten	1954–56	452 units WO_3	—	Stager and Tingley (1988)
Prunty	—	—	—	Gold, silver, copper, lead, antimony, tungsten	—	District: 2,177 oz gold; 2,861 oz silver; 4 ST copper; 7 ST lead; <1 ST zinc; 16 ST antimony	—	LaPointe and others (1991)
Garnet	—	Alder	Elko, NV	Tungsten	—	—	748,000 ST @ 0.43% WO_3	LaPointe and others (1991)
Ashbrook	INPR15, Ashbrook	Ashbrook	Box Elder, UT	—	—	District: 180,000 ST ore; 3,440,000 oz silver		Gloyn and Krahulec (2006)

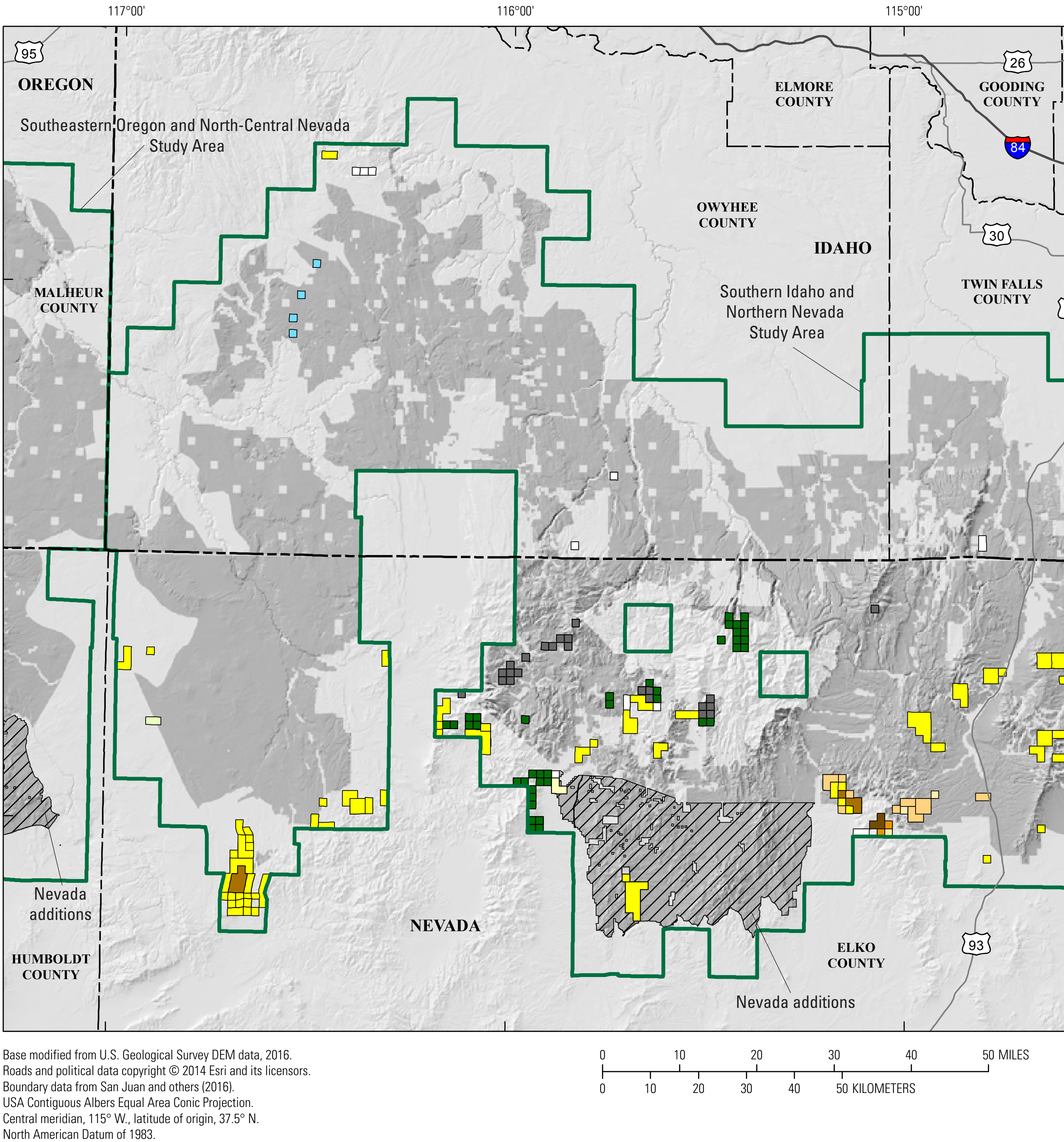
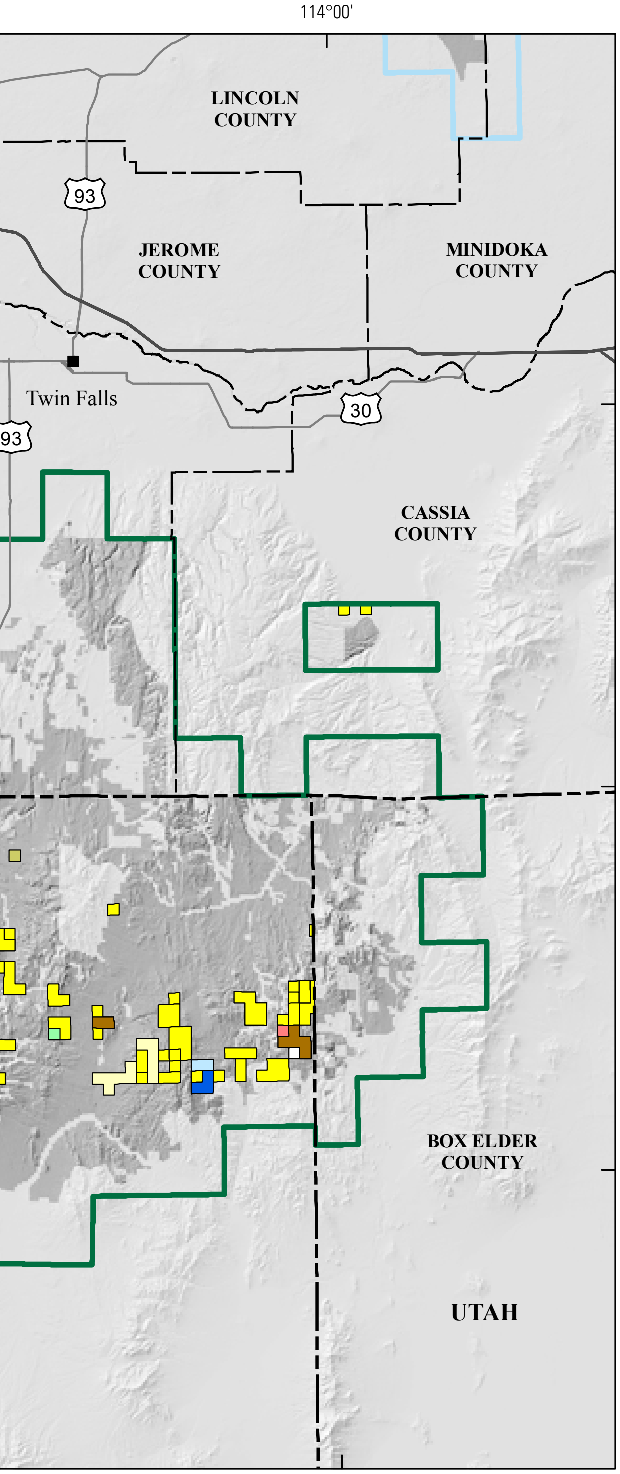
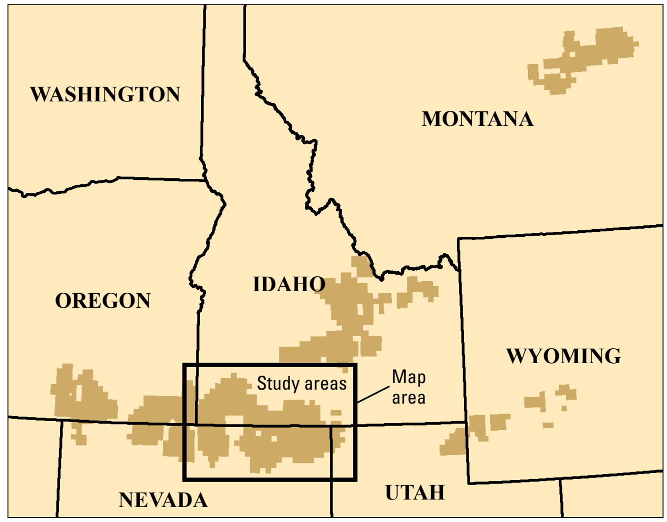


Figure 28. Map showing active and closed surface-management plans for locatable minerals in the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, Nevada and Oregon, including data from the Bureau of Land Management (Dicken and San Juan, 2016, 43 Code of Federal Regulations [CFR] 3809 data) and the U.S. Forest Service (Susan G. Summer Elliott, U.S. Forest Service [USFS], written commun., March 9, 2016, for USFS 36 CFR 228 Subpart A plans). USGS, U.S. Geological Survey.





EXPLANATION

BLM—Locatable commodities: commodity; case disposition; case type

- Gold, gold lode; authorized, pending; surface management-notice
- Gold lode; pending; surface management-plan
- Gold, gold lode, gold placer, copper; closed, expired, cancelled; surface management-notice
- Gold, gold lode; closed; surface management-plan
- Gold; closed; surface management-plan-WLD REV
- Barium, barite; authorized; surface management-notice
- Barium, barite; authorized; surface management-plan
- Barium, barite; closed, expired; surface management-notice
- Barium, barite; closed; surface management-plan
- Travertine; closed; surface management-notice
- Tungsten, lode and placer; authorized; surface management-plan
- Tungsten; closed; surface management-notice
- Uranium, uranium and other min., uranium, (U_3O_8 content); closed; surface management-notice
- Soil/other, diatomite; authorized; surface management-plan
- Other (all locatables, none, to be defined)

U.S. Forest Service—Management plans

- Active
- Inactive

Base data

- USGS study area boundary
- USGS study area boundary (North-Central Idaho Study Area)
- Proposed withdrawal areas
- Proposed withdrawal additions
- State boundaries
- County boundaries

Figure 28.—Continued

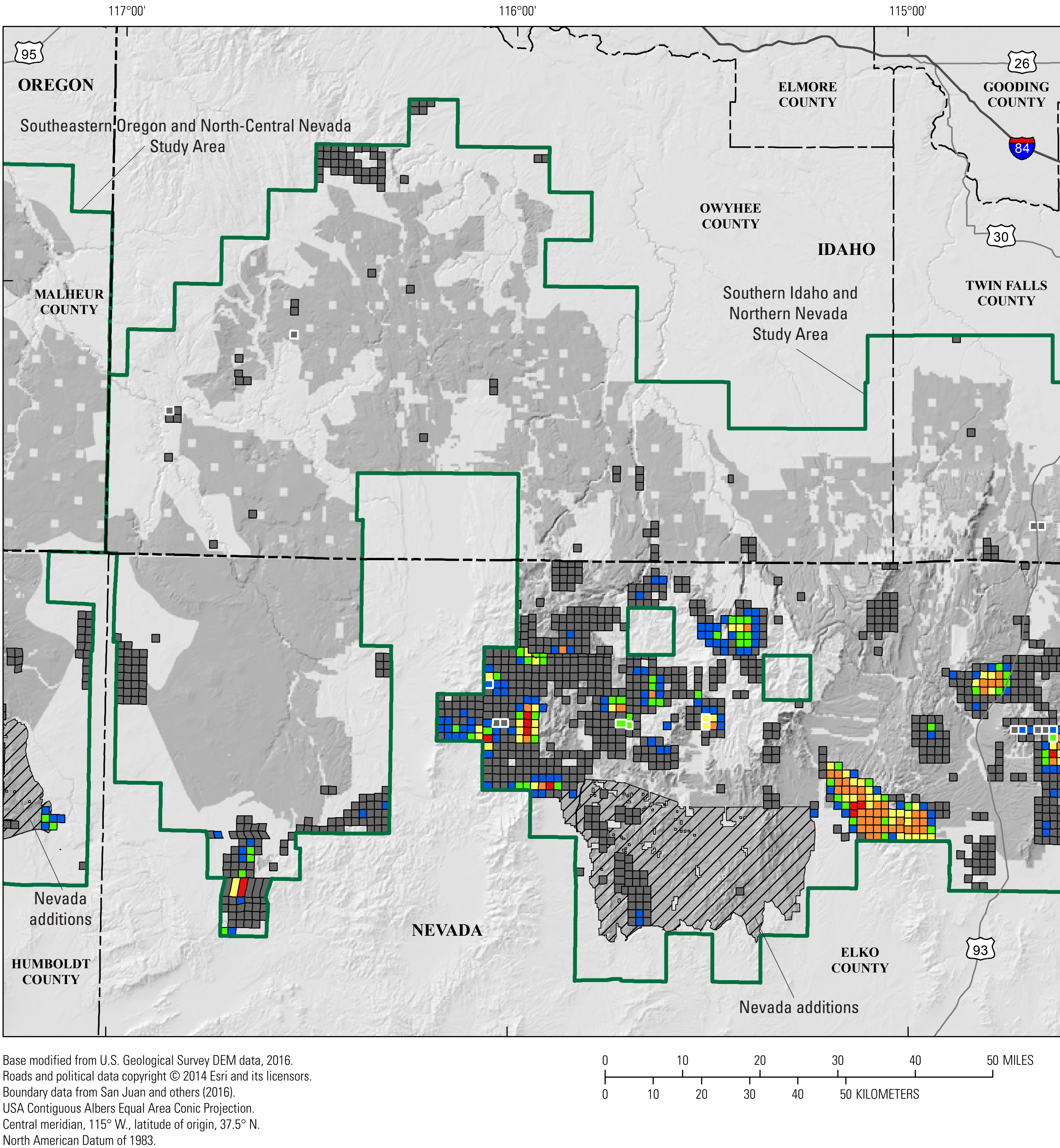
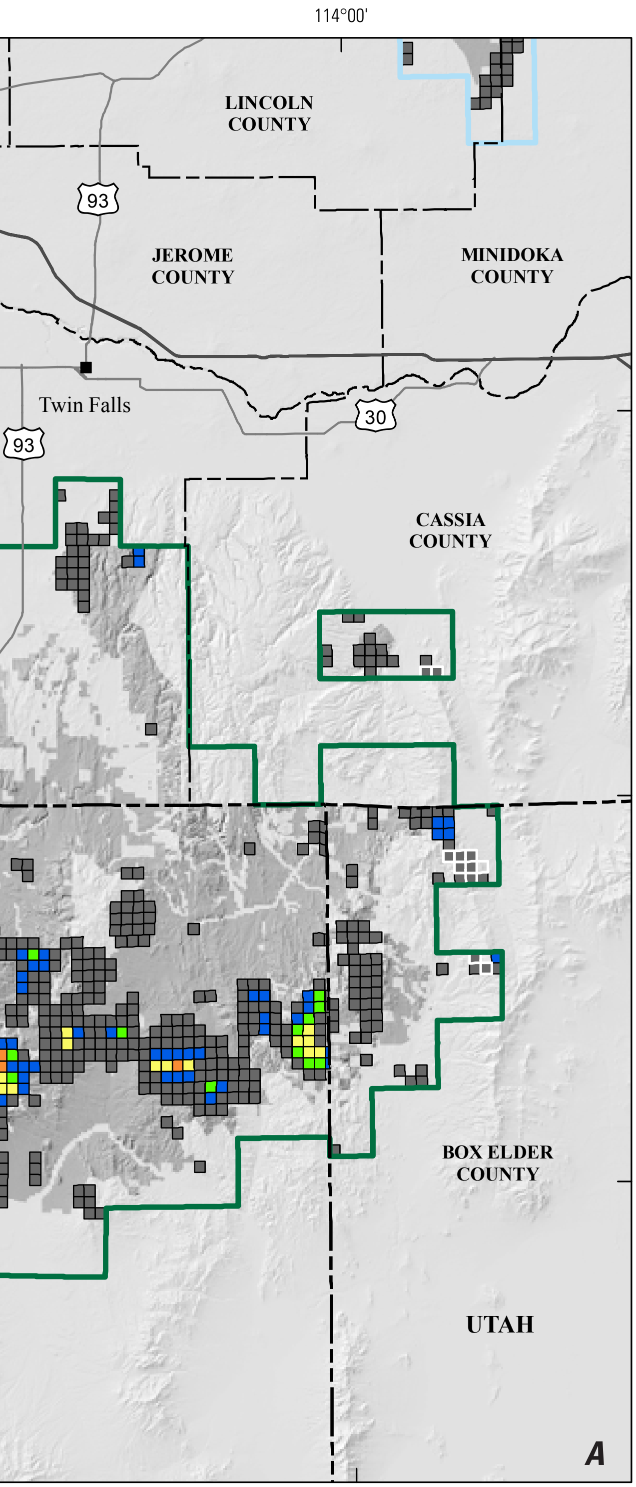
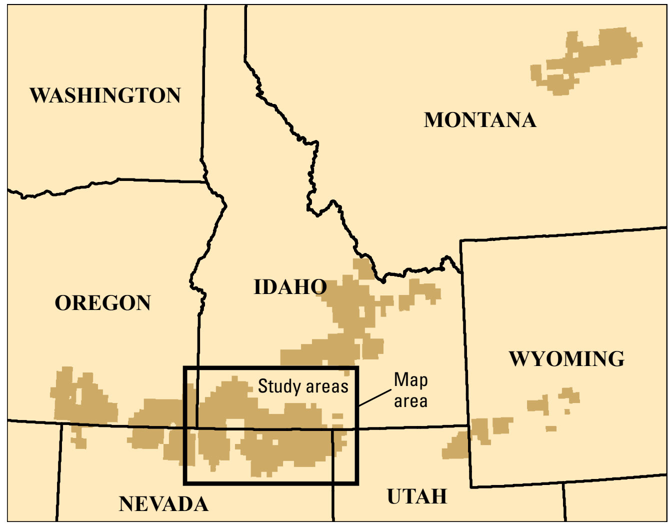


Figure 29. Maps showing mining claims by Public Land Survey System (PLSS) section in the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, Nevada and Oregon. *A*, Number of active lode claims and placer claims per section (Dicken and San Juan, 2016). *B*, Thirty-five year averages of the number of active lode claims by section for mining claims located between 1976 and 2010 (Causey, 2007, 2011).





EXPLANATION

Number of active lode claims per section

52–82

37–51

22–36

9–21

1–8

Sections with only closed claims (including placer)

Sections with one or more active placer claims outlined in white

Base data

USGS study area boundary

USGS study area boundary (North-Central Idaho Study Area)

Proposed withdrawal areas

Proposed withdrawal additions

State boundaries

County boundaries

Figure 29.—Continued

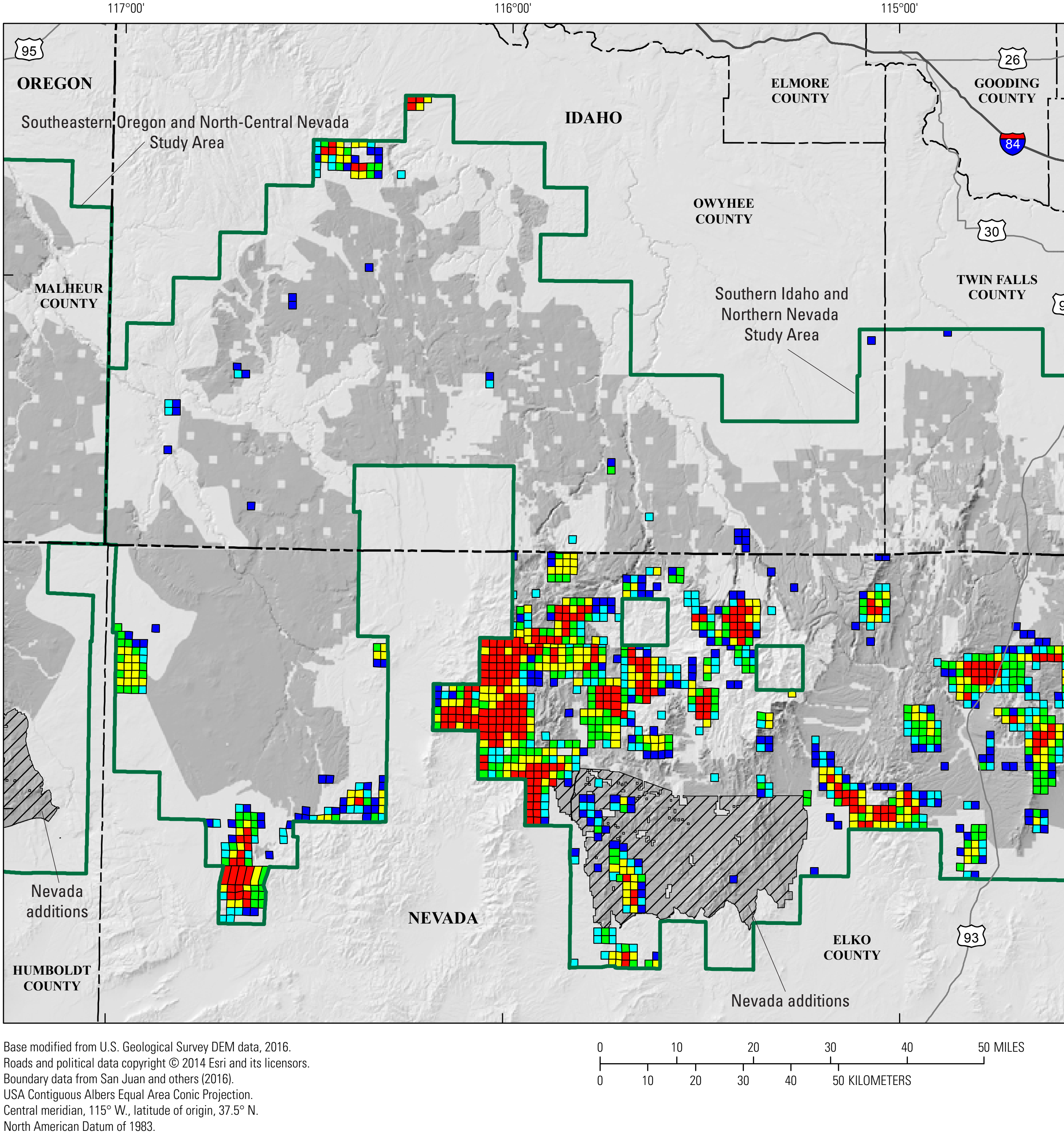


Figure 29. Maps showing mining claims by Public Land Survey System (PLSS) section in the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, Nevada and Oregon. *A*, Number of active lode claims and placer claims per section (Dicken and San Juan, 2016). *B*, Thirty-five year averages of the number of active lode claims by section for mining claims located between 1976 and 2010 (Causey, 2007, 2011).

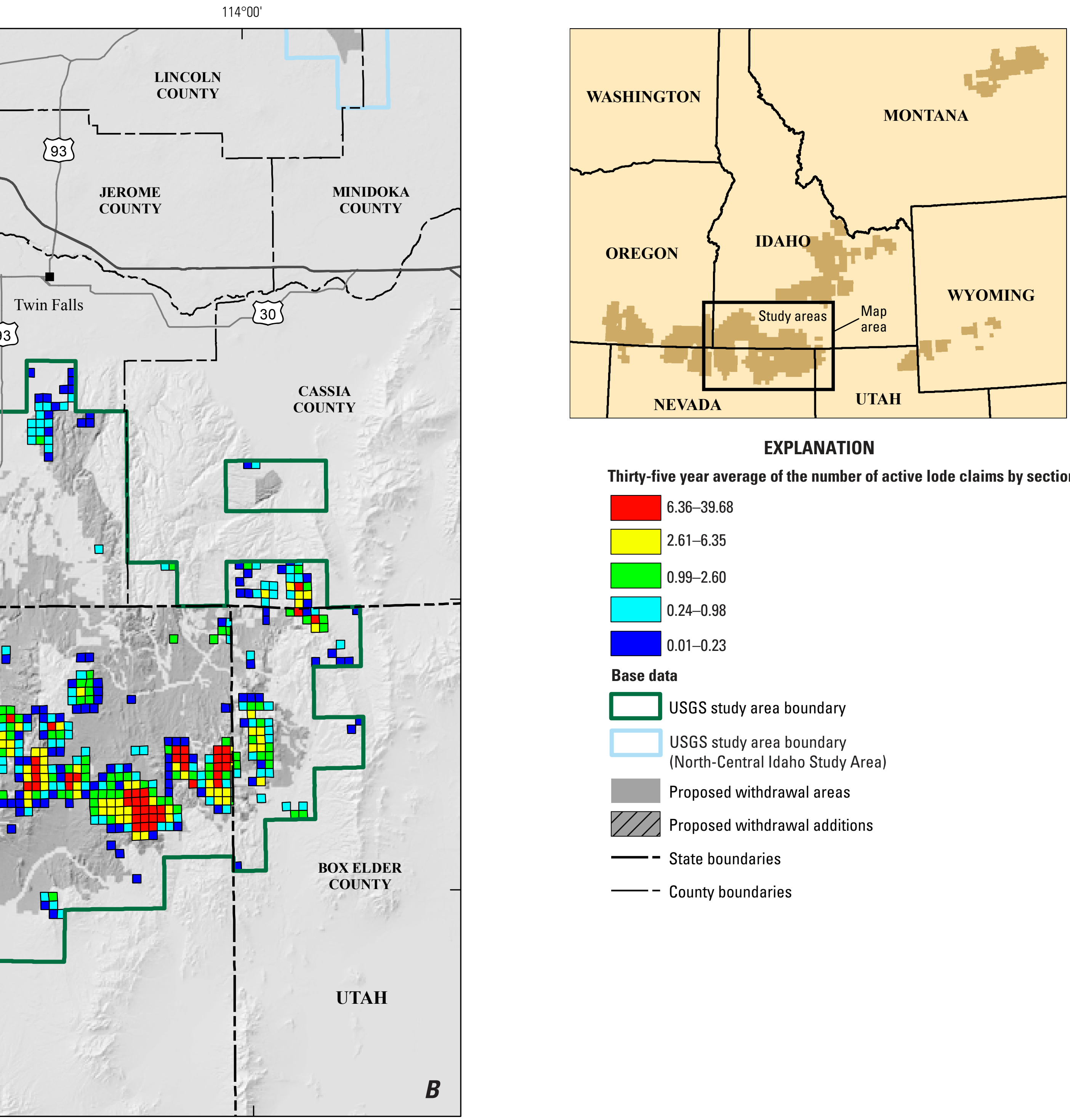
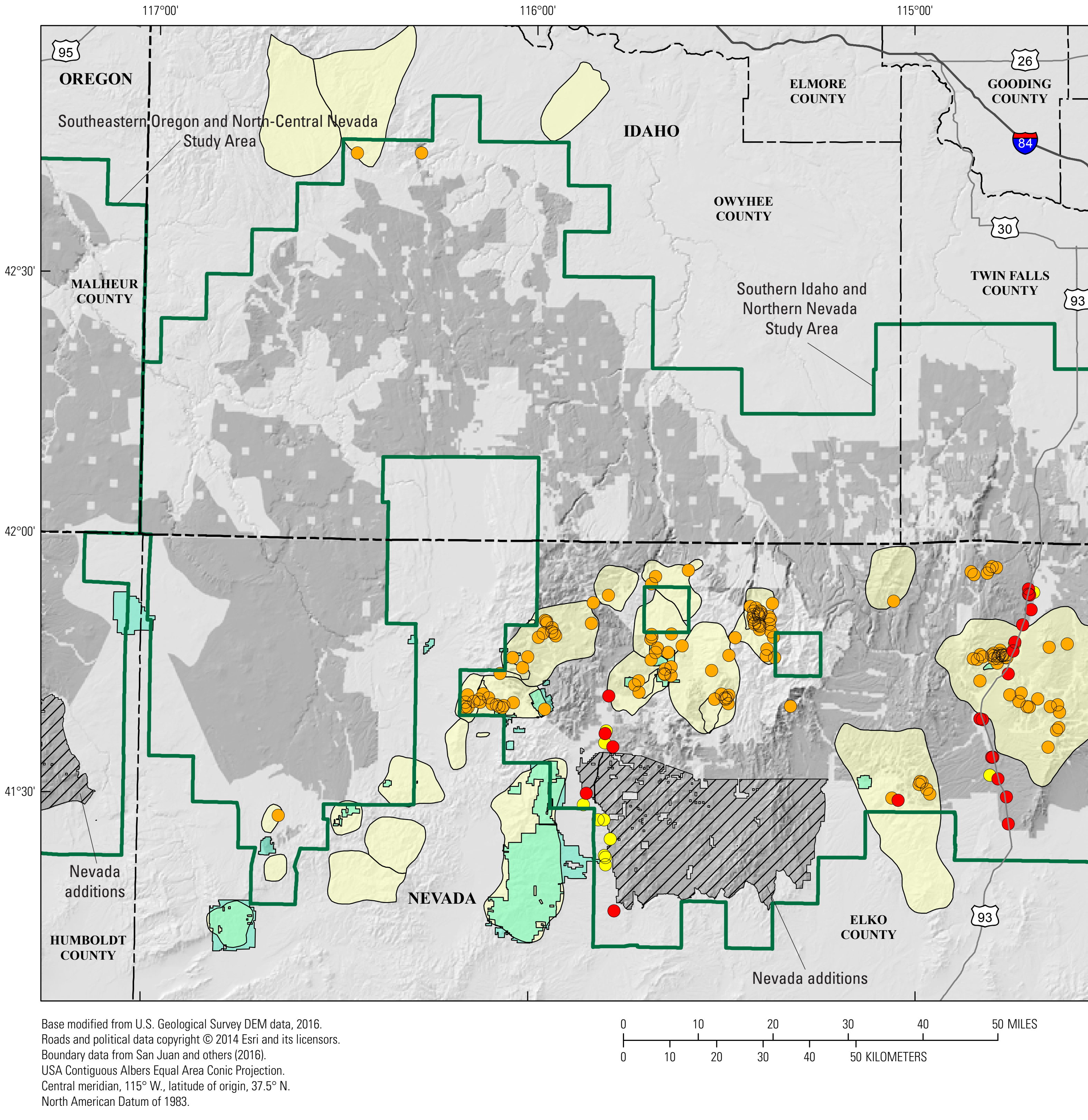
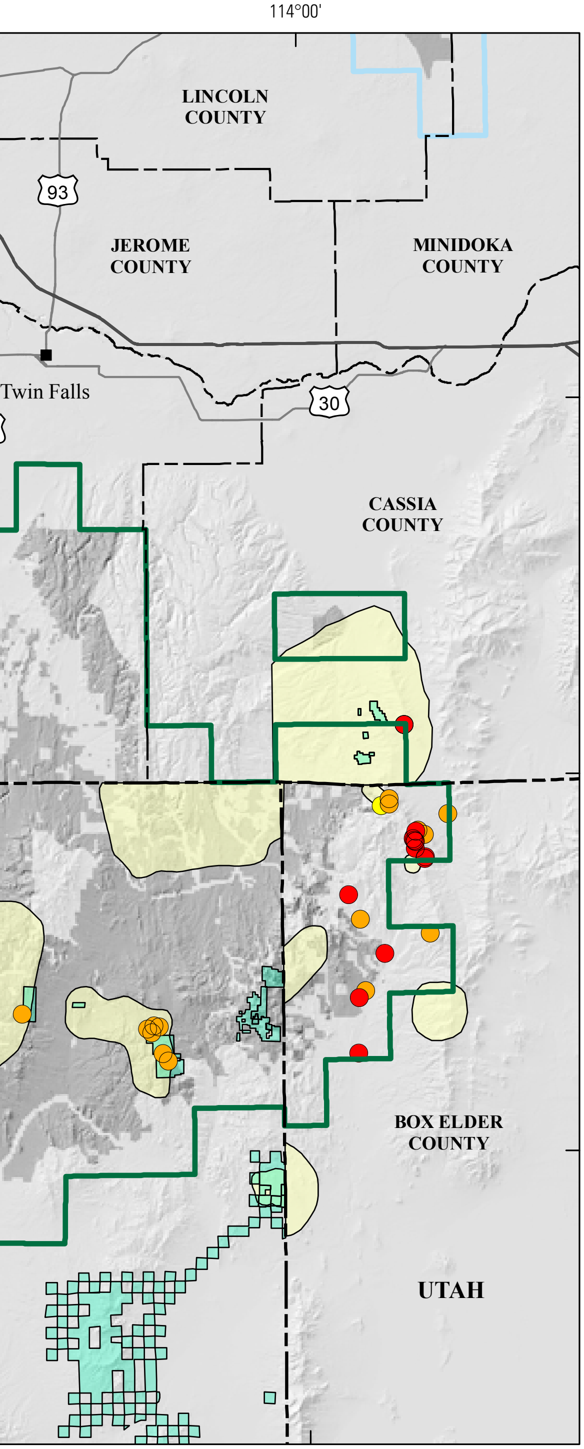


Figure 29.—Continued



Base modified from U.S. Geological Survey DEM data, 2016.
Roads and political data copyright © 2014 Esri and its licensors.
Boundary data from San Juan and others (2016).
USA Contiguous Albers Equal Area Conic Projection.
Central meridian, 115° W., latitude of origin, 37.5° N.
North American Datum of 1983.

Figure 30. Map showing mining districts, mine status, and active exploration areas in or near the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, Nevada, Idaho, and Utah (Fernette and others, 2016a,b). USGS, U.S. Geological Survey.



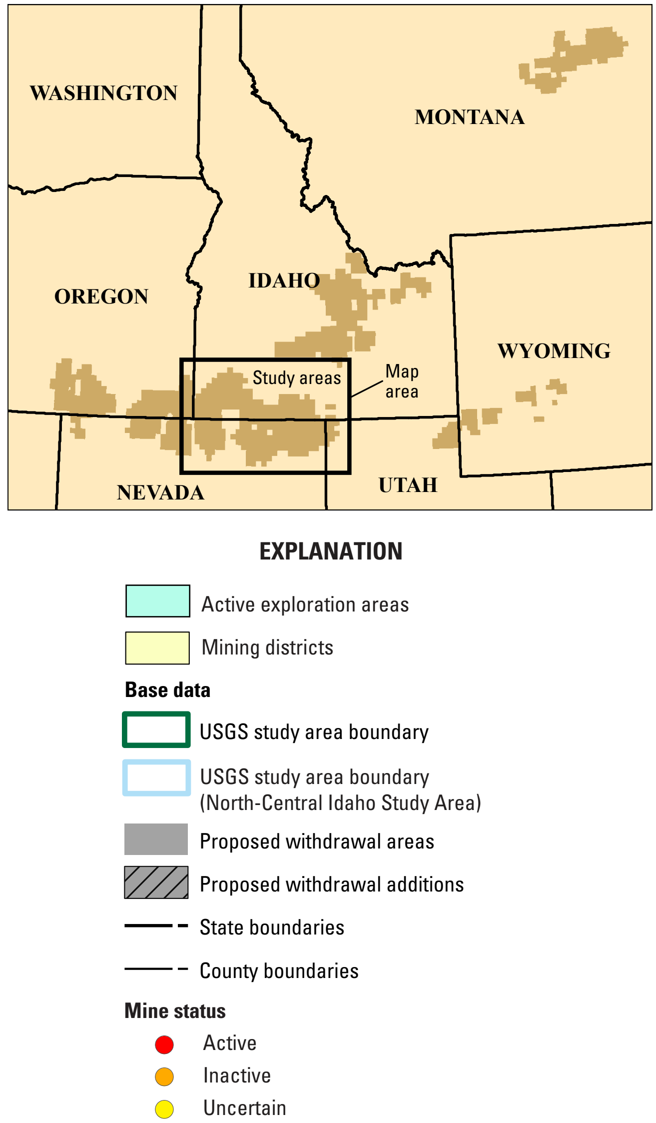


Figure 30.—Continued

Mineral Potential of Locatable Minerals

Potential for undiscovered deposits of locatable mineral commodities (metallic locatable minerals and nonmetallic locatable minerals) within this study area was evaluated for locatable commodities gold, silver, uranium, copper, lead, zinc, tungsten, diatomite, and barite. These mineral commodities were selected for evaluation based on deposits in this study area with production and (or) defined resources, prospects, hydrothermal alteration, stratigraphy and structure of host rocks, and other geological characteristics of deposit types for these commodities (Day and others, 2016; appendix 2; table 1). Records of active and historic mining claims and surface-management plans provided by the BLM and USFS were also used in the assessment process. Mineral-resource potential is represented by rated tracts; tracts consist of areas favorable for undiscovered deposits of one or more commodities that are enclosed by tract boundaries, assigned qualitative potential (high, moderate, or low/permissive), and assigned a level of potential certainty. Tract boundaries include buffers of variable dimensions that reflect spatial uncertainty of one or more of the characteristics used to delineate the tract. The qualitative mineral potential ratings are derived from a classification matrix that merges mineral potential and level of certainty (appendix 1).

Tract delineations and ratings are based entirely on publications from libraries and Web sites, and on technical reports, documents, and maps from Web sites, downloaded from Web sites that are no longer maintained, and provided by companies with mineral rights on lands included in the proposed withdrawal area. Technical reports, documents, and maps not available on Web sites and those provided by companies can be accessed in a database that includes mineral deposits with production and resources, and mineral exploration sites within the study areas (Fernette and others, 2016a). All publications, technical reports, documents, and maps used to delineate and rate tracts are cited in tract descriptions, in tables of tract characteristics, and in tables of deposit production, resources, and mineral exploration sites. We did not perform field examinations, mapping, or analyses of the tracts, deposits, and resources described in this report section.

Mineral Potential Tracts for Epithermal Gold and Silver Deposits

Ten mineral potential tracts for epithermal gold and silver deposits were delineated and rated in the study area: tract INEP01, Burner; tract INEP02, Cornucopia; tract INEP10, Good Hope; tract INEP03, Wood Gulch; tract INEP04, Jarbidge; tract INEP05, TJ; tract INEP06, Angel Wing; tract INE07, Oakley; tract INEP08, Star Lake; and tract INEP09, Gollaher.

Tract INEP01, Burner—A moderate potential (M), at certainty level C, for epithermal gold, silver, and mercury deposits is assigned to an area in the Burner Hills, Elko County, Nevada (tract INEP01, Burner; fig. 31*A*; appendix 2). This area consists of Paleozoic siliciclastic metasedimentary rocks that are unconformably overlain and intruded by Oligocene(?) andesites and tuffs, which in turn are overlain by late Miocene to Pliocene sedimentary rocks of the Big Island Formation (Coats, 1987; Crafford, 2007). Several brecciated quartz veins cut the Paleozoic rocks and Oligocene(?) andesites. Mining of these quartz veins, mostly in the late 19th century, produced small amounts of silver and lead (Emmons, 1910; LaPointe and others, 1991).

The tract was delineated using a 3-km buffer around small quartz vein deposits at the Mint and Silver Queen Mines. Sinter deposits occur nearby in the Oligocene(?) andesites in two places (Rice, 2003). Widespread argillic alteration in the Oligocene tuffs and andesites is delineated by interpreted ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) remote-sensing imagery (Rockwell and others, 2015). Fourteen active lode claims in the area, as well as closed notices and closed lode claims indicate recent and historic exploration activity (tables 16, 17, 18, 19; figs. 28, 29; Causey, 2007, 2011).

Tract INEP02, Cornucopia—A moderate potential (M), at certainty level C, for epithermal gold and silver, and hot spring mercury deposits is assigned to a large area encompassing the Cornucopia Mining District and prospects to the west in Elko County, Nevada (Tingley, 1992; tract INEP02, Cornucopia; fig. 31*A*; appendix 2). This area consists of Eocene sedimentary rocks, Eocene to Oligocene andesite lava flows and dikes and rhyolite ash-flow tuffs, Miocene rhyolite tuffs and lava flows, and Miocene to Pliocene sedimentary rocks (Coats, 1987; Crafford, 2007). In the late 19th century, mining of silver-rich quartz veins and silicified fault zones in Eocene and Oligocene rocks produced an estimated 760,000 oz of silver and 13,000 oz of gold (Emmons, 1910; Buchanan, 1981; LaPointe and others, 1991). Mine tailings from the Cornucopia district were reprocessed in the late 1930s (LaPointe and others, 1991).

The tract was delineated using a 3-km buffer around mines and prospects in the Cornucopia district and includes the Wild Horse exploration project, about 6 km to the west in the western part of the district (Harrington, 2006). The area includes widespread propylitic alteration and local silicification, quartz-sericite-pyrite, and argillic alteration (Blakestad, 1990; LaPointe and others, 1991). Hot spring deposits including sinter are exposed at Wild Horse (Harrington, 2006) and are delineated by argillic and advanced argillic alteration interpreted from ASTER imagery (Rockwell and others, 2015). Composite geochemical anomalies occur in the eastern part of the district (Ludington and others, 2006). The tract includes active lode claims and active exploration areas for gold and silver in the Cornucopia district and at Wild Horse (Fernette and others, 2016a; tables 16, 17), and closed notices (fig. 28; table 18) and historic lode claims (fig. 29; Causey, 2007, 2011).

Tract INEP10, Good Hope—A moderate potential (M), at certainty level C, for epithermal gold, silver, and mercury deposits is assigned to an area encompassing the Good Hope Mining District in Elko County, Nevada (Tingley, 1992; tract INEP10, Good Hope; fig. 31*A*; appendix 2). This area consists of small exposures of lower Paleozoic metasedimentary rocks that are unconformably overlain by Eocene to Oligocene andesite lava flows and dikes and rhyolite ash-flow tuffs, which are overlain by late Miocene to Pliocene sedimentary rocks of the Big Island Formation (Coats, 1987; Crafford, 2007). Mining in the early 1880s and in 1921 produced about 91,000 oz silver and minor antimony from quartz veins in Eocene or Oligocene tuffs and andesite dikes (Emmons, 1910; Lawrence, 1963; Knox, 1970; LaPointe and others, 1991).

The tract was delineated using a 3-km buffer around mines and prospects in the Good Hope district. The tract includes several areas of advanced argillic and kaolinitic argillic alteration interpreted from ASTER remote-sensing data (Rockwell and others, 2015). Composite geochemical anomalies occur in the southwest part of the area (Ludington and others, 2006). The area has numerous active lode claims and active exploration areas for gold and silver (Fernette and others, 2016a; tables 16, 17), closed notices, and closed and historic lode claims (figs. 28, 29; tables 16, 17; Causey, 2007, 2011).

Tract INEP03, Wood Gulch—A high potential (H), at certainty level D, for epithermal gold and silver deposits is assigned to an area encompassing the Wood Gulch Mine and the Gravel Creek exploration project, Elko County, Nevada (tract INEP03, Wood Gulch; fig. 31*A*; appendix 2). The area consists of upper Paleozoic clastic sedimentary rocks unconformably overlain by Eocene volcaniclastic rocks and tuffs that are overlain by middle Miocene Jarbidge Rhyolite (Coats, 1987; Crafford, 2007; Christensen and others, 2015). The Wood Gulch Mine produced moderate amounts of gold and silver from narrow quartz veins and silicified zones in Paleozoic sedimentary rocks during mining from 1988 to 1990 (LaPointe and others, 1991; Anderson, 2008). A resource of about 93,600 oz of gold has been defined at Wood Gulch (table 20). A resource of about 1.36 Moz of gold and about 20.3 Moz of silver has been defined at Gravel Creek; gold and silver occur in quartz veins and hydrothermal breccias in Eocene volcaniclastic rocks and tuffs (table 20; Christensen and others, 2015; Fernette and others, 2016a).

This tract was delineated using 3-km buffers around the Wood Gulch Mine, the Gravel Creek exploration project, the Rail Creek target, and hot spring deposits and alteration features that are inferred to be surficial expressions of the Gravel Creek hydrothermal system (Christensen and others, 2015). Numerous active lode claims (more than 300) and active exploration projects have been located in in this tract (Anderson, 2008; Christensen and others, 2015; Fernette and others, 2016a; tables 16, 17, 18, 19), and numerous closed and historic lode claims are in the tract (figs. 28, 29; tables 16, 17; Causey, 2007, 2011).

Tract INEP04, Jarbidge—A high potential (H), at certainty level D, for epithermal gold and silver deposits is assigned to an area surrounding the Jarbidge Mining District, Elko County, Nevada (Tingley, 1992; tract INEP04, Jarbidge; fig. 31*A*; appendix 2). This area mostly consists of lava flows, domes, and tuffs of the middle Miocene Jarbidge Rhyolite that are overlain by late Miocene sedimentary rocks and tuffs at the north end of the tract (Coats, 1987; Crafford, 2007). Lower Paleozoic metasedimentary and upper Paleozoic and Triassic marine sedimentary rocks are exposed near the south end of the tract. In the Jarbidge district, numerous epithermal quartz-adularia veins formed along north- to northwest-striking normal faults in the Jarbidge Rhyolite during middle Miocene hydrothermal activity. Approximately 0.36 Moz of gold and 1.67 Moz of silver were produced from these veins between 1910 and 1950 (table 20; Schrader, 1923; LaPointe and others, 1991).

This tract was delineated using 3-km buffers around mines and prospects in the Jarbidge district. Extensive areas of argillic, advanced argillic, and sericitic alteration interpreted from ASTER remote-sensing spectra characterize the area (Rockwell and others, 2015). Stream-sediment samples have anomalous values for gold, arsenic, mercury, and selenium, and composite hydrothermal mineralization geochemical anomalies both upstream and downstream from the Jarbidge district (Ludington and others, 2006). Numerous active lode claims have been located in the area (Fernette and others, 2016a; tables 16, 17); there is active exploration in the area and numerous closed and historic lode claims are in the tract (figs. 28, 29; tables 16, 17; Causey, 2007, 2011).

Tract INEP05, TJ—A moderate potential (M), at certainty level B, for epithermal gold and silver and hot spring mercury deposits is assigned to an area near Trout Creek (TJ) on the northeast side of Granite Range, Elko County, Nevada (tract INEP05, TJ; fig. 31*A*; appendix 2). This area consists of conglomerate, sandstone, siltstone, and volcaniclastic rocks of the late Miocene Humboldt Formation that unconformably overlie the Late Jurassic Contact pluton (Coats, 1987; Limbach, 1991). Late Tertiary ash-flow tuffs, tuffs, and tuffaceous sedimentary rocks overlie the Humboldt Formation on the east side of the tract. Sedimentary rocks of the Humboldt Formation were deposited in north-trending grabens that transect the west-elongated Contact pluton. Sinter, silicification, advanced argillic, and argillic alteration related to a hot spring system are present in Humboldt Formation rocks at the TJ (Trout Creek) prospect (Limbach, 1991, 1993). The altered rocks locally contain anomalous concentrations of gold, silver, mercury, and other elements characteristic of epithermal gold and silver deposits.

The tract was delineated using 3-km buffers around prospects (Limbach, 1991, 1993) and was expanded to the northwest and northeast to encompass adjacent areas of advanced argillic and kaolinitic argillic alteration, and hydrous silica in Miocene sedimentary rocks interpreted from ASTER remote-sensing spectra (Rockwell and others, 2015). Numerous active lode claims have been located in the tract, and many closed and historic lode claims are in the tract (figs. 28, 29; tables 16, 17; Causey, 2007, 2011).

Tract INEP06, Angel Wing—A high potential (H), at certainty level C, for epithermal gold and silver deposits is assigned to an area along the Nevada-Utah border in northeastern Elko County, Nevada, and northwestern Box Elder County, Utah (tract INEP06, Angel Wing; fig. 31*A*; appendix 2). This area

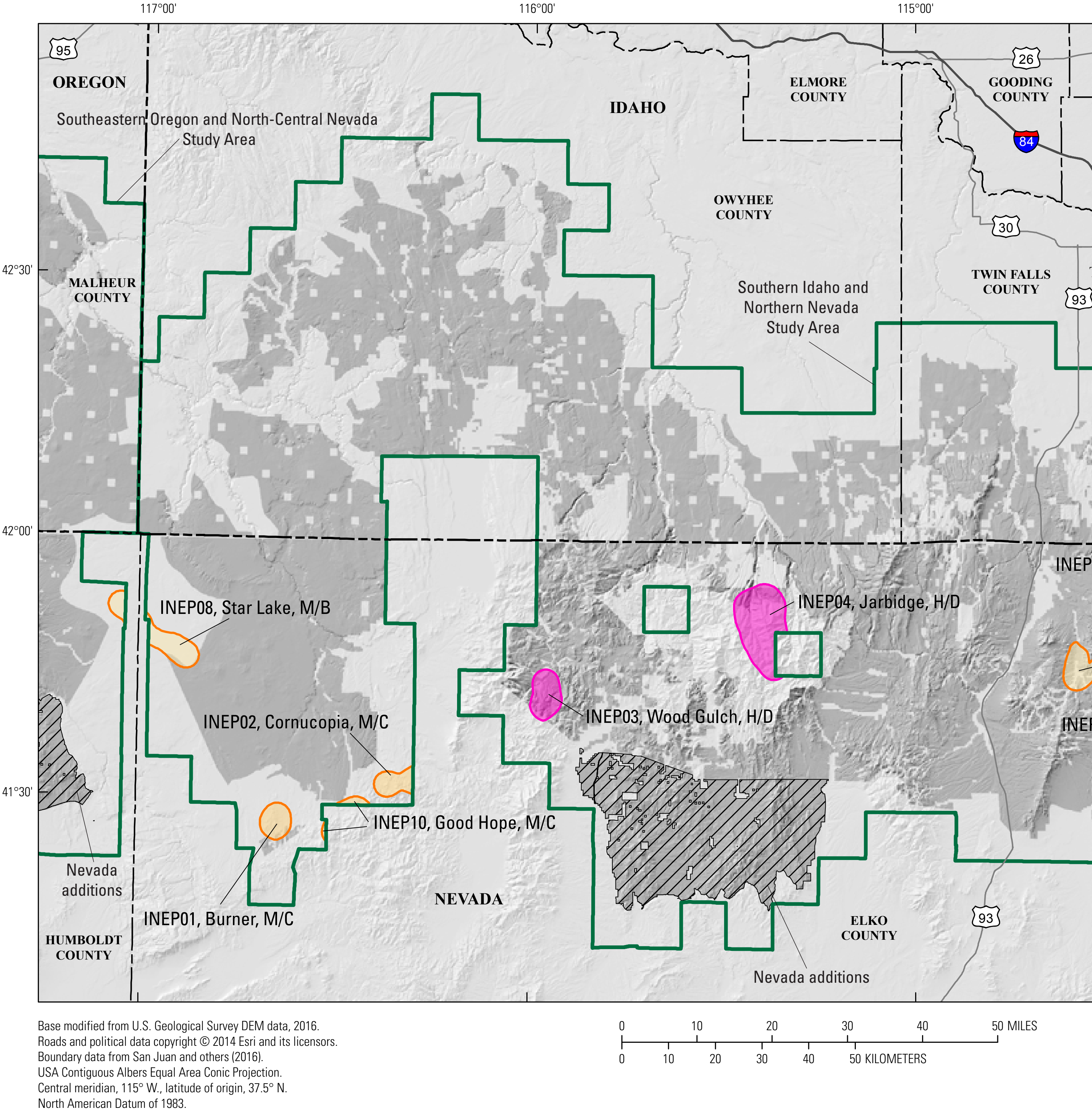
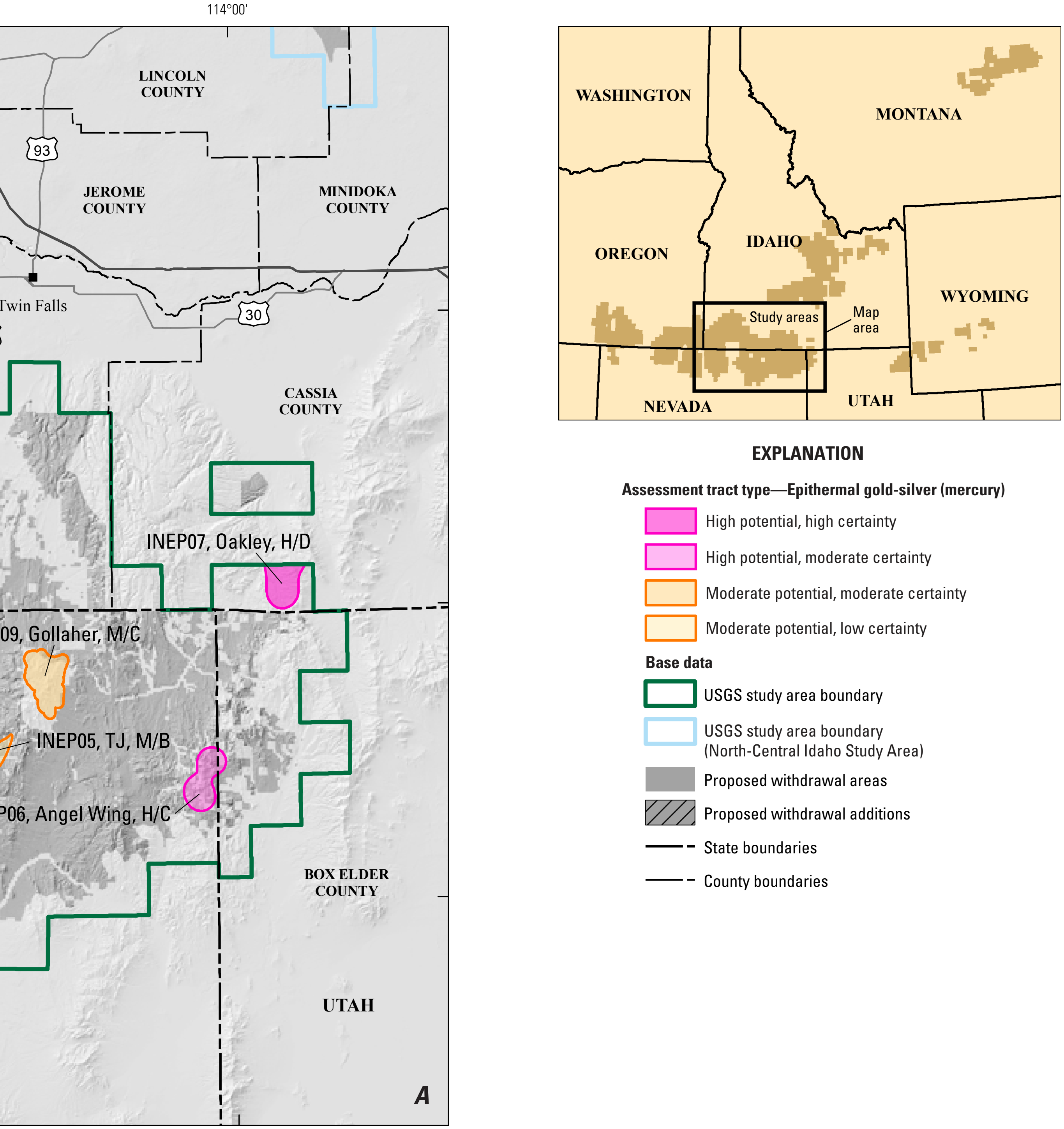


Figure 31*A*–*U*. Maps showing assessment tracts for metallic locatable minerals and nonmetallic locatable minerals in the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, Nevada, Idaho, and Utah (San Juan and others, 2016); USGS, U.S. Geological Survey; *A*, Assessment tracts for epithermal gold-silver (mercury); *B*, Assessment tract for hydroallogenic volcanic-hosted uranium; *C*, Assessment tracts for polymetallic vein, porphyry copper, copper skarn, and arc-related porphyry molybdenum (low-fluorine); *D*, Assessment tract for distal disseminated gold-silver; *E*, Assessment tracts for polymetallic replacement, polymetallic vein, and tungsten vein; *F*, Assessment tracts for tungsten skarn and polymetallic vein; *G*, Assessment tracts for distal disseminated gold-silver, polymetallic vein and skarn; *H*, Assessment tract for polymetallic vein;



I, Assessment tracts for polymetallic vein, copper skarn, and tungsten skarn; *J*, Assessment tracts for porphyry copper, copper skarn, polymetallic vein, and tungsten skarn; *K*, Assessment tract for polymetallic replacement; *L*, Assessment tract for molybdenum-tungsten greisen; *M*, Assessment tract for polymetallic vein; *N*, Assessment tract for distal disseminated gold-silver and polymetallic vein; *O*, Assessment tract for Climax-type porphyry molybdenum; *P*, Assessment tracts for distal disseminated silver-gold, polymetallic replacement, and polymetallic vein; *Q*, Assessment tract for multiple intrusion-related deposit types; *R*, Assessment tracts for volcanogenic massive sulfide (Besshi-subtype); *S*, Assessment tracts for Carlin-type gold (silver, mercury, antimony); *T*, Assessment tracts for lacustrine diatomite; and *U*, Assessment tracts for bedded barite.

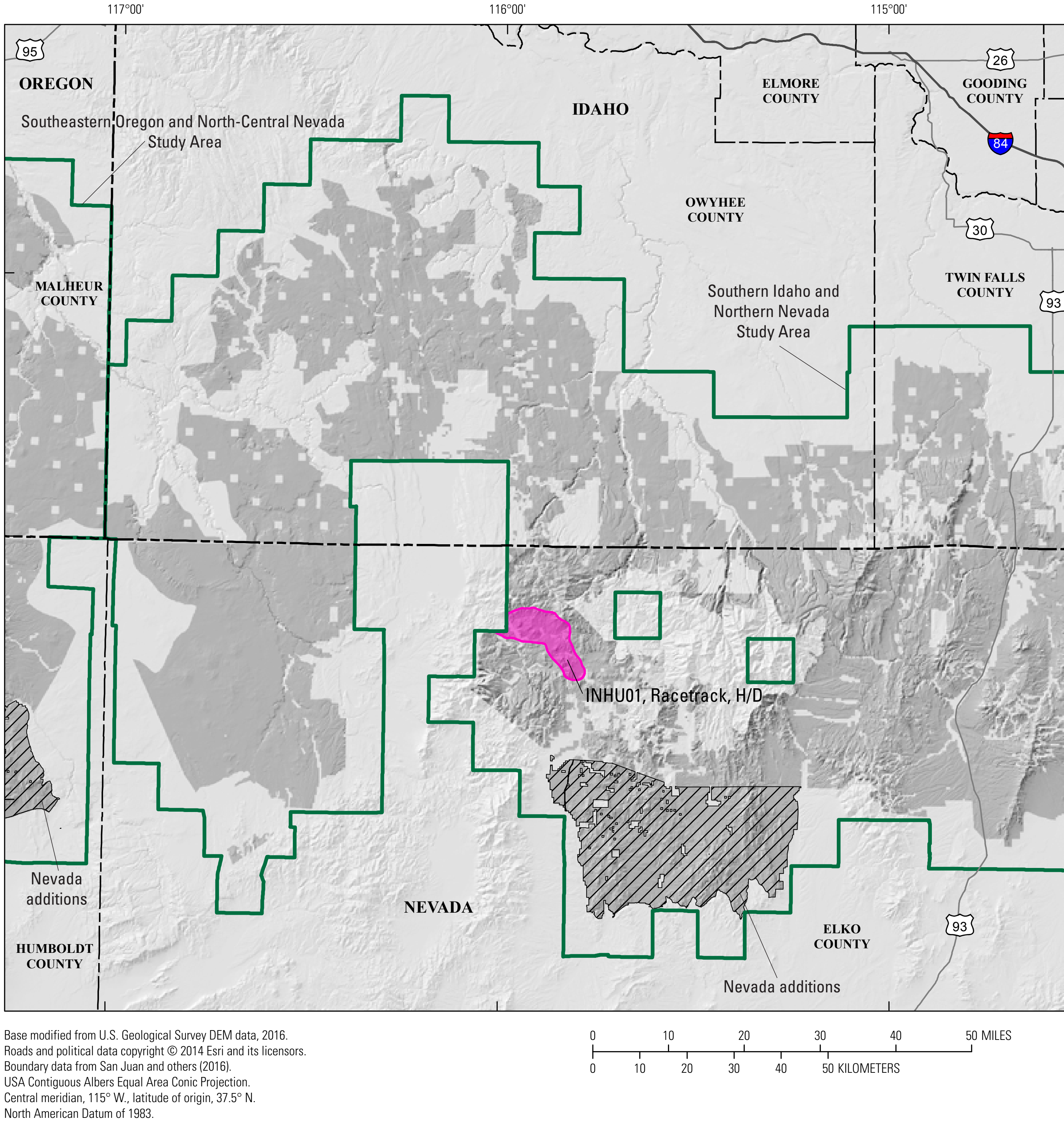
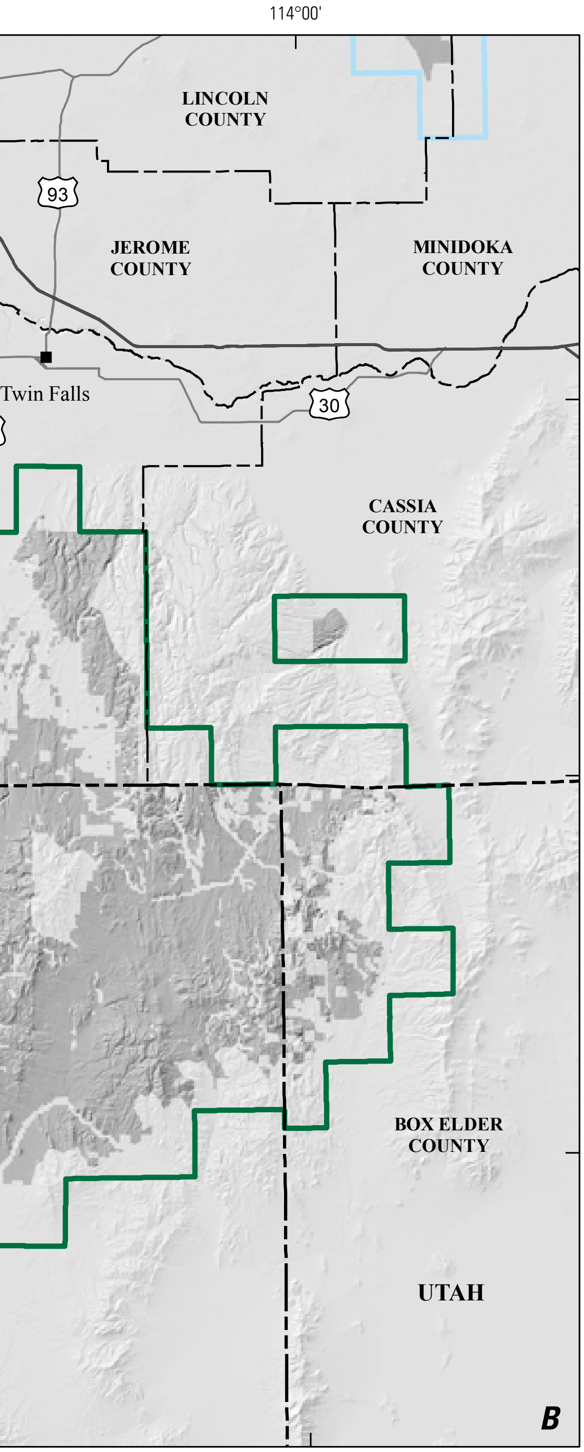
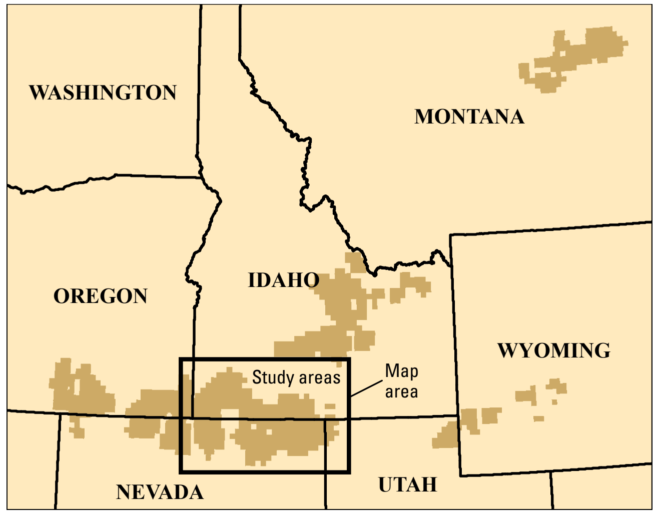


Figure 31*A*–*U*. Maps showing assessment tracts for metallic locatable minerals and nonmetallic locatable minerals in the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, Nevada, Idaho, and Utah (San Juan and others, 2016); USGS, U.S. Geological Survey; *A*, Assessment tracts for epithermal gold-silver (mercury); *B*, Assessment tract for hydroallogenic volcanic-hosted uranium; *C*, Assessment tracts for polymetallic vein, porphyry copper, copper skarn, and arc-related porphyry molybdenum (low-fluorine); *D*, Assessment tract for distal disseminated gold-silver; *E*, Assessment tracts for polymetallic replacement, polymetallic vein, and tungsten vein; *F*, Assessment tracts for tungsten skarn and polymetallic vein; *G*, Assessment tracts for distal disseminated gold-silver, polymetallic vein and skarn; *H*, Assessment tract for polymetallic vein;





EXPLANATION

Assessment tract type—Hydroallogenic volcanic-hosted uranium

High potential, high certainty

Base data

USGS study area boundary

USGS study area boundary (North-Central Idaho Study Area)

Proposed withdrawal areas

Proposed withdrawal additions

State boundaries

County boundaries

I, Assessment tracts for polymetallic vein, copper skarn, and tungsten skarn; *J*, Assessment tracts for porphyry copper, copper skarn, polymetallic vein, and tungsten skarn; *K*, Assessment tract for polymetallic replacement; *L*, Assessment tract for molybdenum-tungsten greisen; *M*, Assessment tract for polymetallic vein; *N*, Assessment tract for distal disseminated gold-silver and polymetallic vein; *O*, Assessment tract for Climax-type porphyry molybdenum; *P*, Assessment tracts for distal disseminated silver-gold, polymetallic replacement, and polymetallic vein; *Q*, Assessment tract for multiple intrusion-related deposit types; *R*, Assessment tracts for volcanogenic massive sulfide (Besshi-subtype); *S*, Assessment tracts for Carlin-type gold (silver, mercury, antimony); *T*, Assessment tracts for lacustrine diatomite; and *U*, Assessment tracts for bedded barite.—Continued

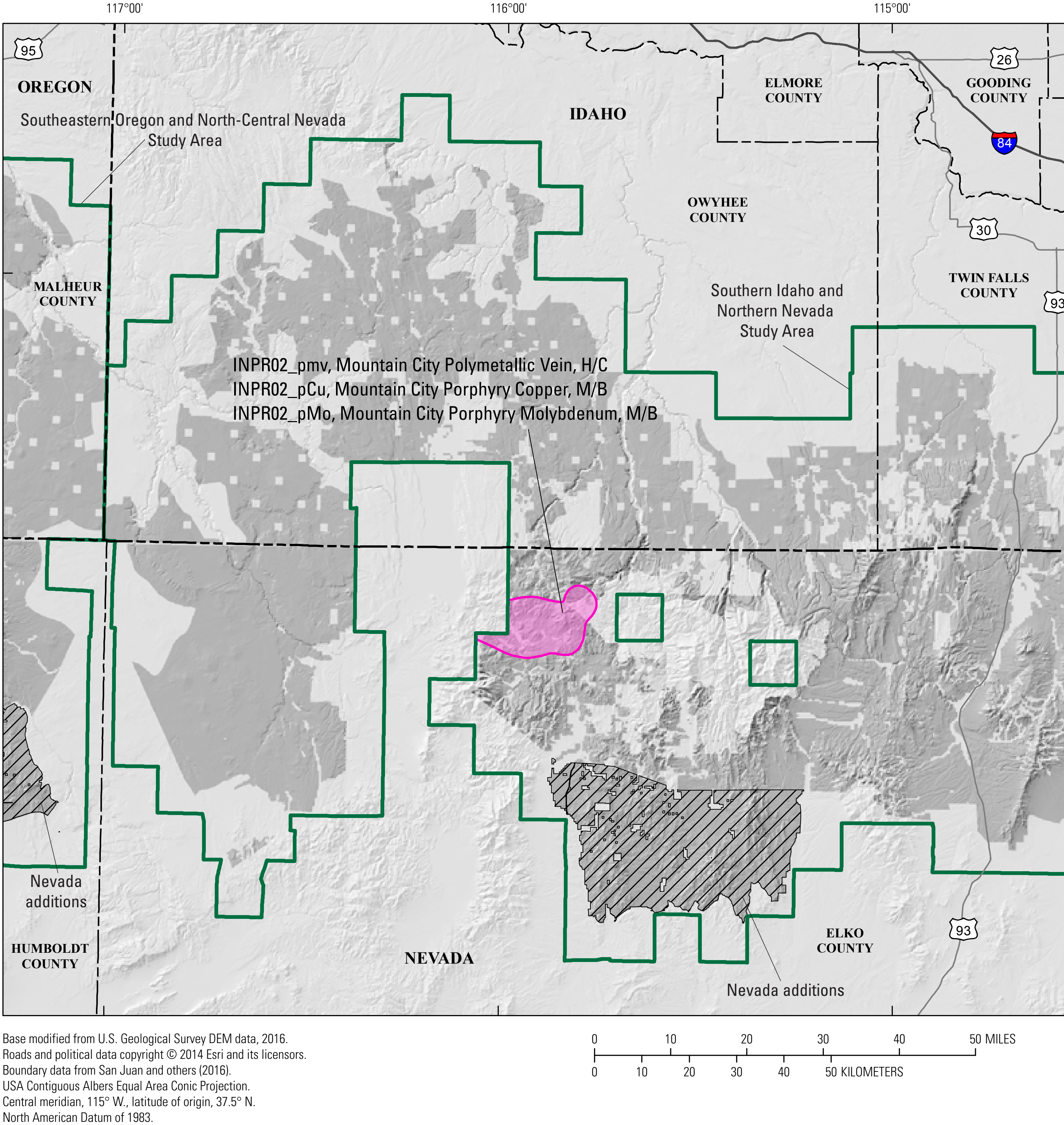
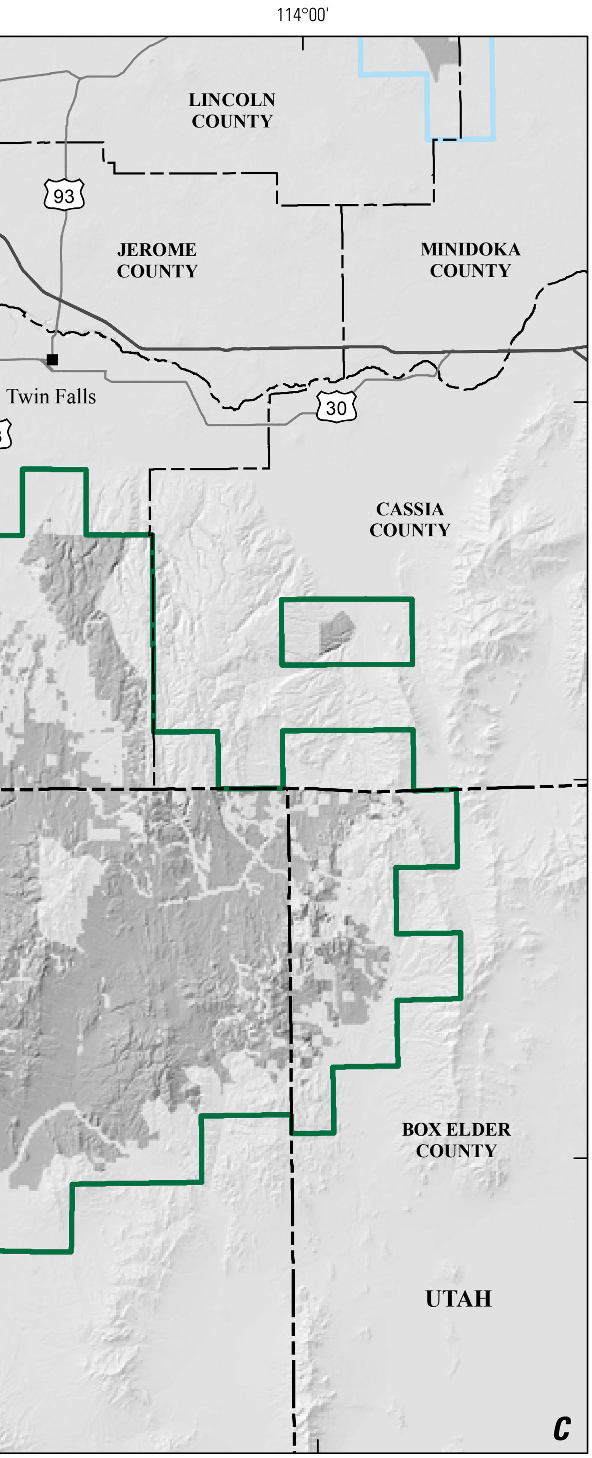
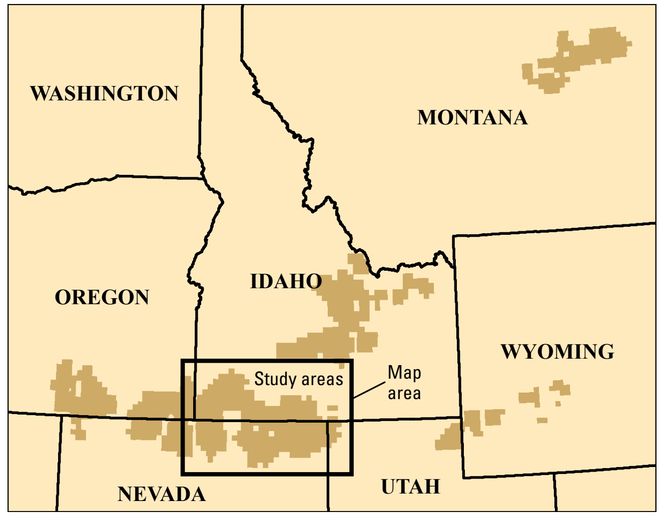


Figure 31*A*–*U*. Maps showing assessment tracts for metallic locatable minerals and nonmetallic locatable minerals in the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, Nevada, Idaho, and Utah (San Juan and others, 2016); USGS, U.S. Geological Survey; *A*, Assessment tracts for epithermal gold-silver (mercury); *B*, Assessment tract for hydroallogenic volcanic-hosted uranium; *C*, Assessment tracts for polymetallic vein, porphyry copper, copper skarn, and arc-related porphyry molybdenum (low-fluorine); *D*, Assessment tract for distal disseminated gold-silver; *E*, Assessment tracts for polymetallic replacement, polymetallic vein, and tungsten vein; *F*, Assessment tracts for tungsten skarn and polymetallic vein; *G*, Assessment tracts for distal disseminated gold-silver, polymetallic vein and skarn; *H*, Assessment tract for polymetallic vein;





EXPLANATION

Assessment tract types—Polymetallic vein, Porphyry copper, Copper skarn, and Arc-related porphyry molybdenum (low-fluorine)

High potential, moderate certainty

Base data

USGS study area boundary

USGS study area boundary (North-Central Idaho Study Area)

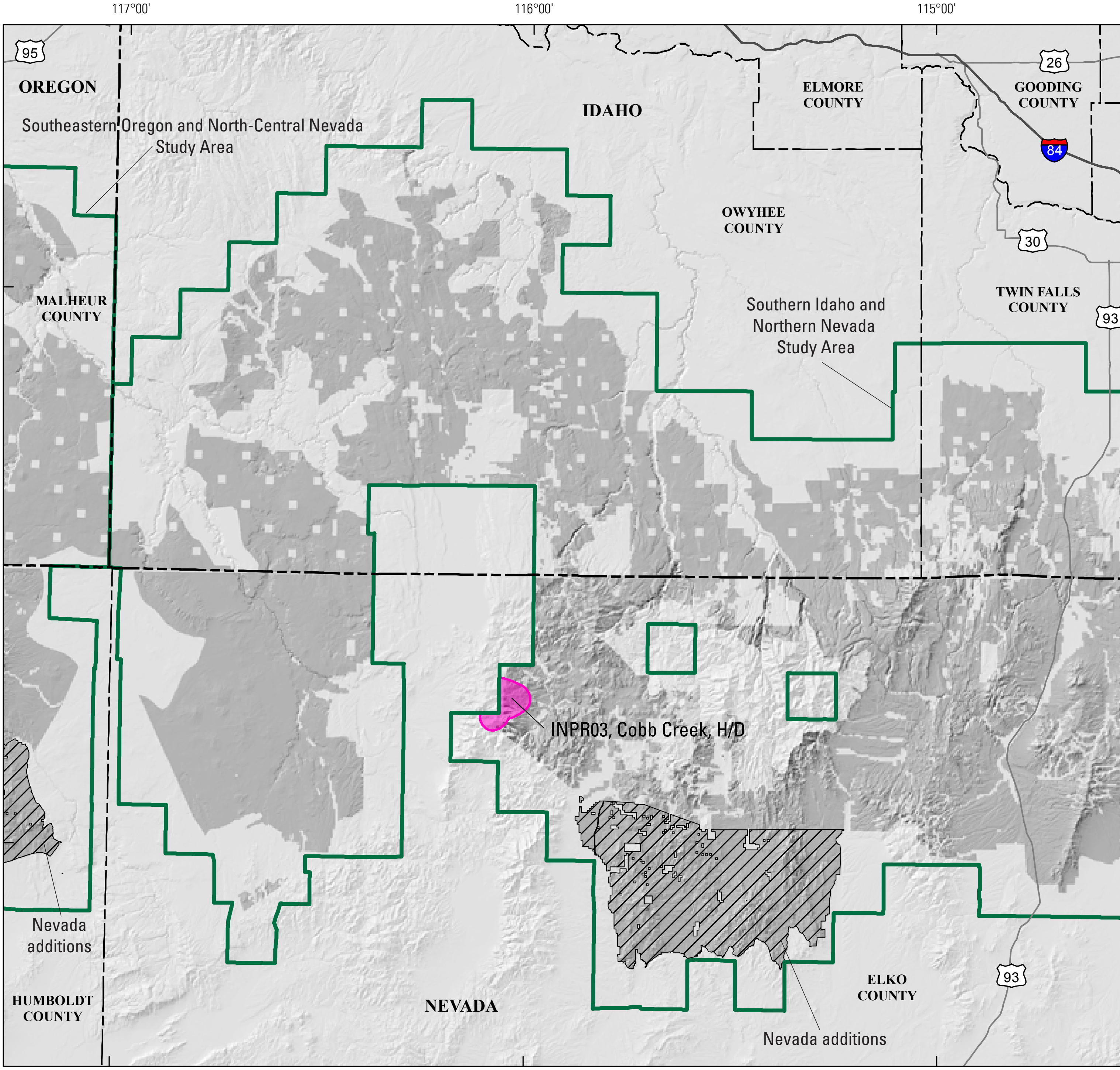
Proposed withdrawal areas

Proposed withdrawal additions

State boundaries

County boundaries

I, Assessment tracts for polymetallic vein, copper skarn, and tungsten skarn; *J*, Assessment tracts for porphyry copper, copper skarn, polymetallic vein, and tungsten skarn; *K*, Assessment tract for polymetallic replacement; *L*, Assessment tract for molybdenum-tungsten greisen; *M*, Assessment tract for polymetallic vein; *N*, Assessment tract for distal disseminated gold-silver and polymetallic vein; *O*, Assessment tract for Climax-type porphyry molybdenum; *P*, Assessment tracts for distal disseminated silver-gold, polymetallic replacement, and polymetallic vein; *Q*, Assessment tract for multiple intrusion-related deposit types; *R*, Assessment tracts for volcanogenic massive sulfide (Besshi-subtype); *S*, Assessment tracts for Carlin-type gold (silver, mercury, antimony); *T*, Assessment tracts for lacustrine diatomite; and *U*, Assessment tracts for bedded barite.—Continued



Base modified from U.S. Geological Survey DEM data, 2016.
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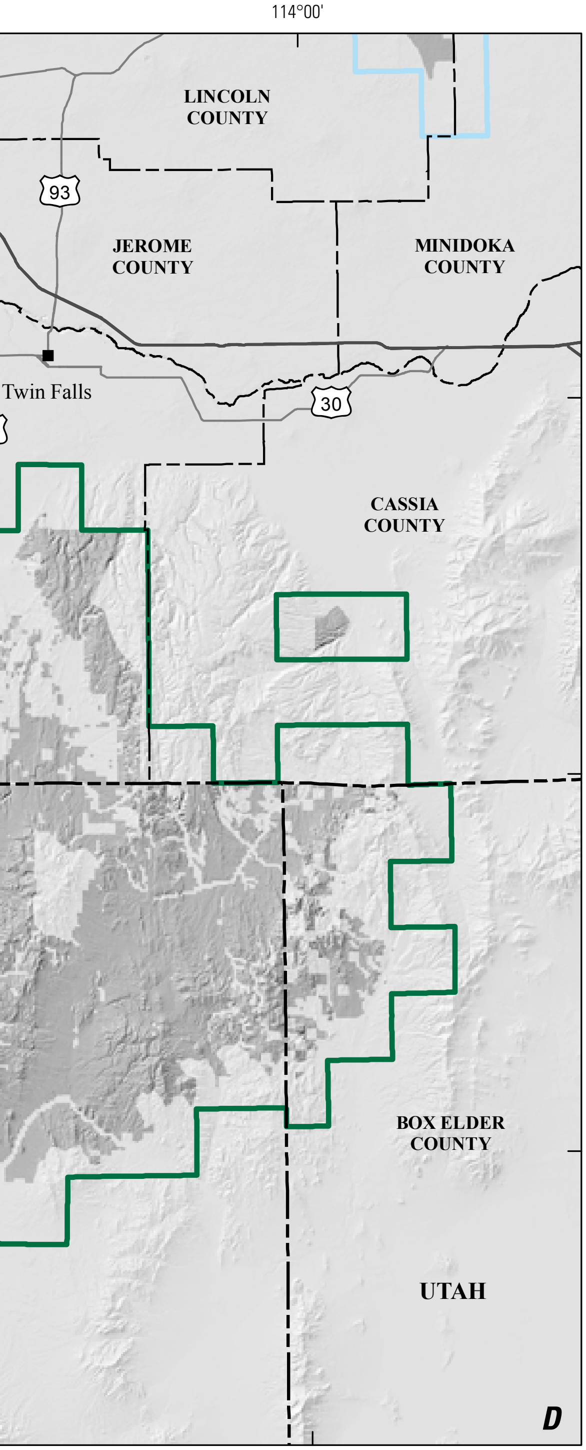
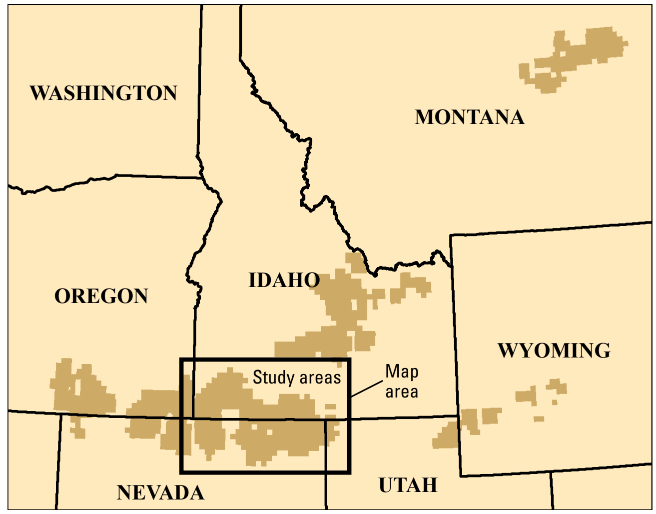
Boundary data from San Juan and others (2016).
USA Contiguous Albers Equal Area Conic Projection.
Central meridian, 115° W., latitude of origin, 37.5° N.
North American Datum of 1983.

Figure 31*A*–*U*. Maps showing assessment tracts for metallic locatable minerals and nonmetallic locatable minerals in the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, Nevada, Idaho, and Utah (San Juan and others, 2016); USGS, U.S. Geological Survey; *A*, Assessment tracts for epithermal gold-silver (mercury); *B*, Assessment tract for hydroallogenic volcanic-hosted uranium; *C*, Assessment tracts for polymetallic vein, porphyry copper, copper skarn, and arc-related porphyry molybdenum (low-fluorine); *D*, Assessment tract for distal disseminated gold-silver; *E*, Assessment tracts for polymetallic replacement, polymetallic vein, and tungsten vein; *F*, Assessment tracts for tungsten skarn and polymetallic vein; *G*, Assessment tracts for distal disseminated gold-silver, polymetallic vein and skarn; *H*, Assessment tract for polymetallic vein;





EXPLANATION

Assessment tract type—Distal disseminated gold-silver

High potential, high certainty

Base data

USGS study area boundary

USGS study area boundary (North-Central Idaho Study Area)

Proposed withdrawal areas

Proposed withdrawal additions

State boundaries

County boundaries

I, Assessment tracts for polymetallic vein, copper skarn, and tungsten skarn; *J*, Assessment tracts for porphyry copper, copper skarn, polymetallic vein, and tungsten skarn; *K*, Assessment tract for polymetallic replacement; *L*, Assessment tract for molybdenum-tungsten greisen; *M*, Assessment tract for polymetallic vein; *N*, Assessment tract for distal disseminated gold-silver and polymetallic vein; *O*, Assessment tract for Climax-type porphyry molybdenum; *P*, Assessment tracts for distal disseminated silver-gold, polymetallic replacement, and polymetallic vein; *Q*, Assessment tract for multiple intrusion-related deposit types; *R*, Assessment tracts for volcanogenic massive sulfide (Besshi-subtype); *S*, Assessment tracts for Carlin-type gold (silver, mercury, antimony); *T*, Assessment tracts for lacustrine diatomite; and *U*, Assessment tracts for bedded barite.—Continued

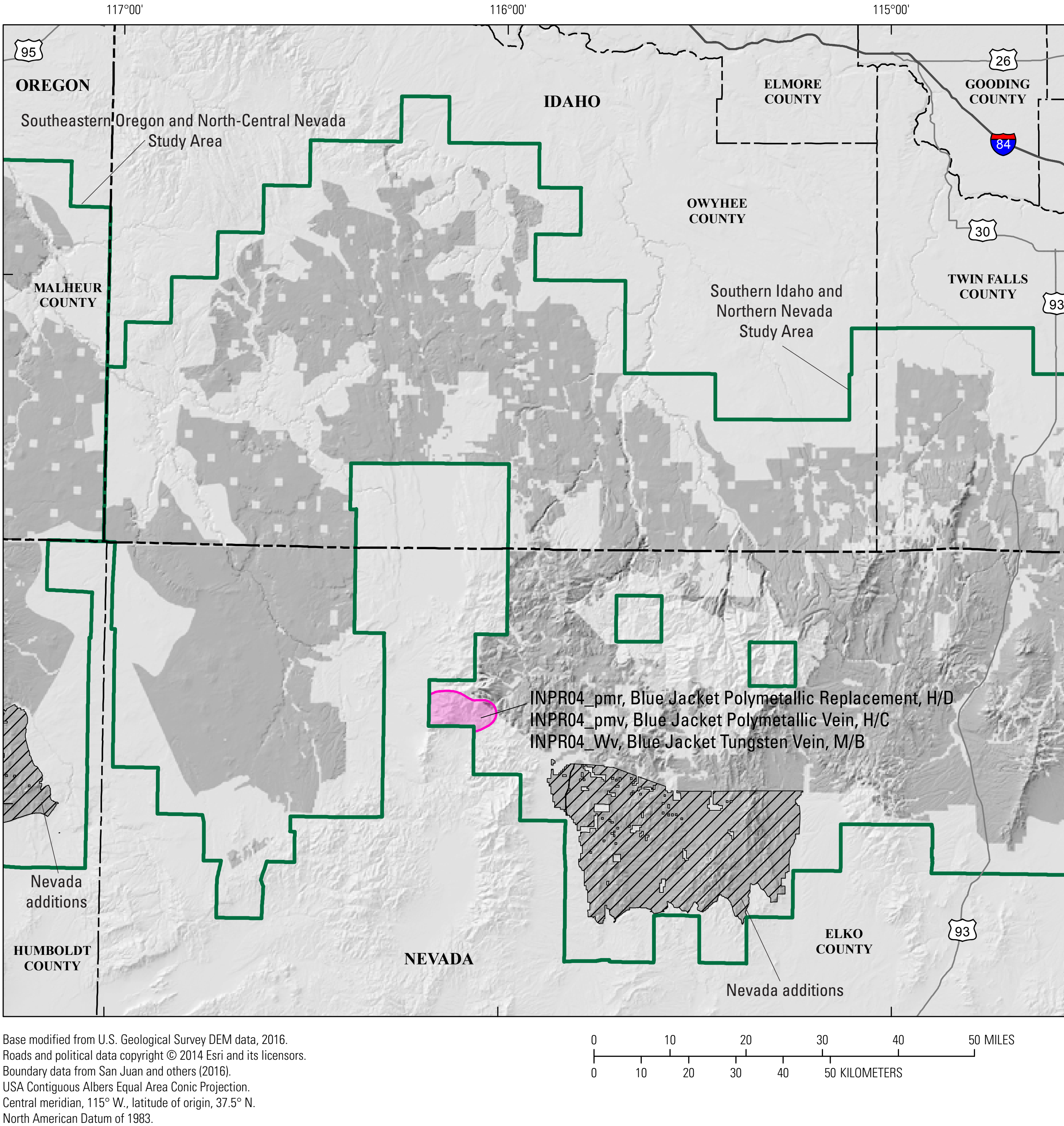
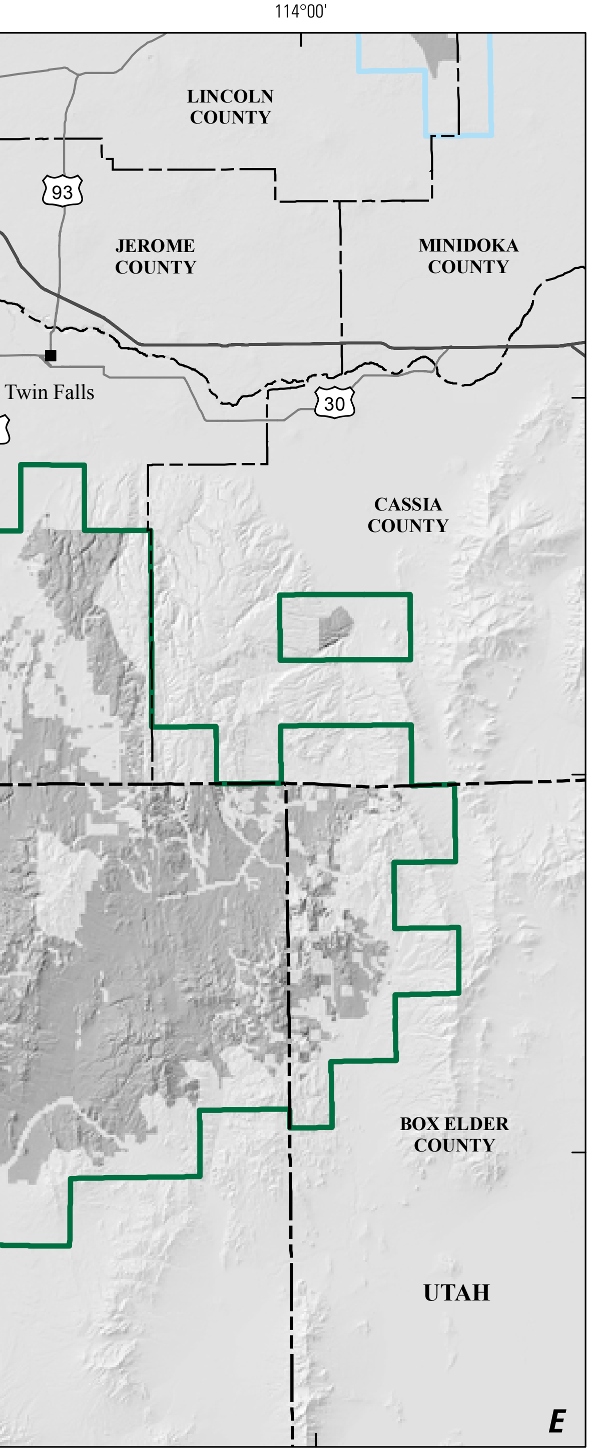
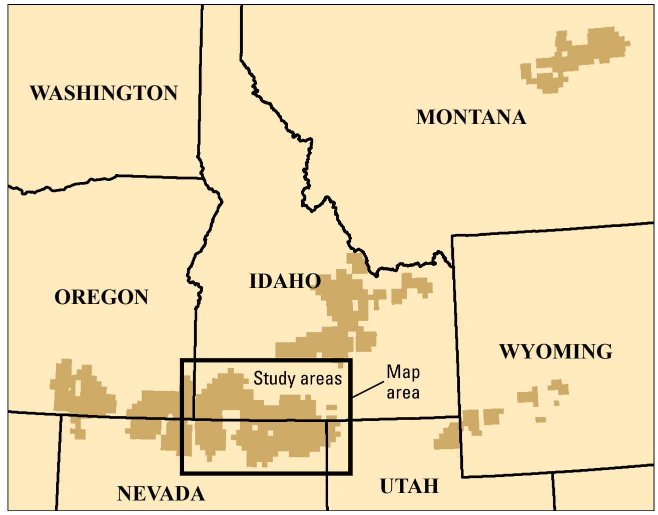


Figure 31*A*–*U*. Maps showing assessment tracts for metallic locatable minerals and nonmetallic locatable minerals in the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, Nevada, Idaho, and Utah (San Juan and others, 2016); USGS, U.S. Geological Survey; *A*, Assessment tracts for epithermal gold-silver (mercury); *B*, Assessment tract for hydroallogenic volcanic-hosted uranium; *C*, Assessment tracts for polymetallic vein, porphyry copper, copper skarn, and arc-related porphyry molybdenum (low-fluorine); *D*, Assessment tract for distal disseminated gold-silver; *E*, Assessment tracts for polymetallic replacement, polymetallic vein, and tungsten vein; *F*, Assessment tracts for tungsten skarn and polymetallic vein; *G*, Assessment tracts for distal disseminated gold-silver, polymetallic vein and skarn; *H*, Assessment tract for polymetallic vein;





EXPLANATION

Assessment tract types—Polymetallic replacement, Polymetallic vein, and Tungsten vein

High potential, high certainty

Base data

USGS study area boundary

USGS study area boundary (North-Central Idaho Study Area)

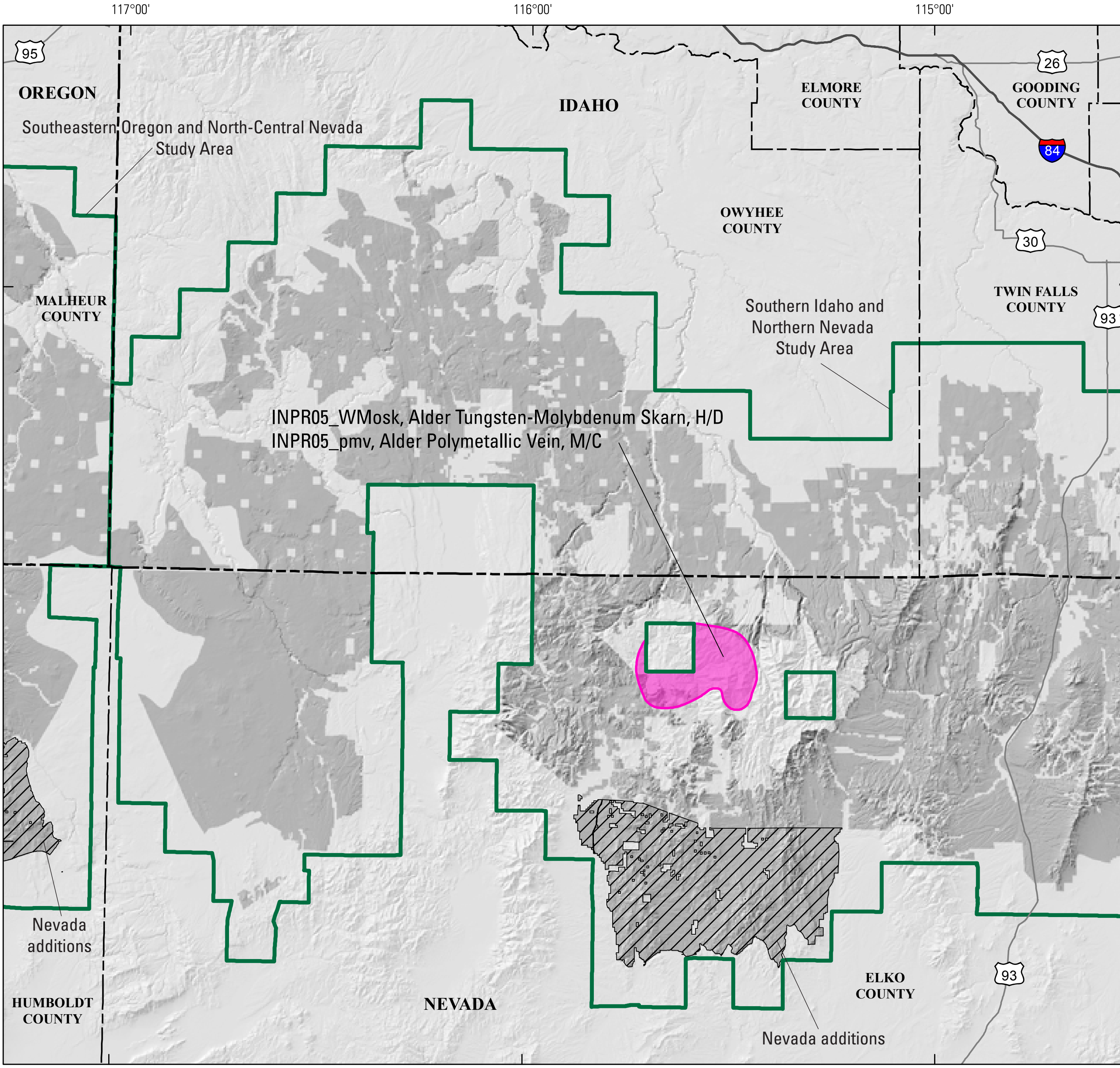
Proposed withdrawal areas

Proposed withdrawal additions

State boundaries

County boundaries

I, Assessment tracts for polymetallic vein, copper skarn, and tungsten skarn; *J*, Assessment tracts for porphyry copper, copper skarn, polymetallic vein, and tungsten skarn; *K*, Assessment tract for polymetallic replacement; *L*, Assessment tract for molybdenum-tungsten greisen; *M*, Assessment tract for polymetallic vein; *N*, Assessment tract for distal disseminated gold-silver and polymetallic vein; *O*, Assessment tract for Climax-type porphyry molybdenum; *P*, Assessment tracts for distal disseminated silver-gold, polymetallic replacement, and polymetallic vein; *Q*, Assessment tract for multiple intrusion-related deposit types; *R*, Assessment tracts for volcanogenic massive sulfide (Besshi-subtype); *S*, Assessment tracts for Carlin-type gold (silver, mercury, antimony); *T*, Assessment tracts for lacustrine diatomite; and *U*, Assessment tracts for bedded barite.—Continued



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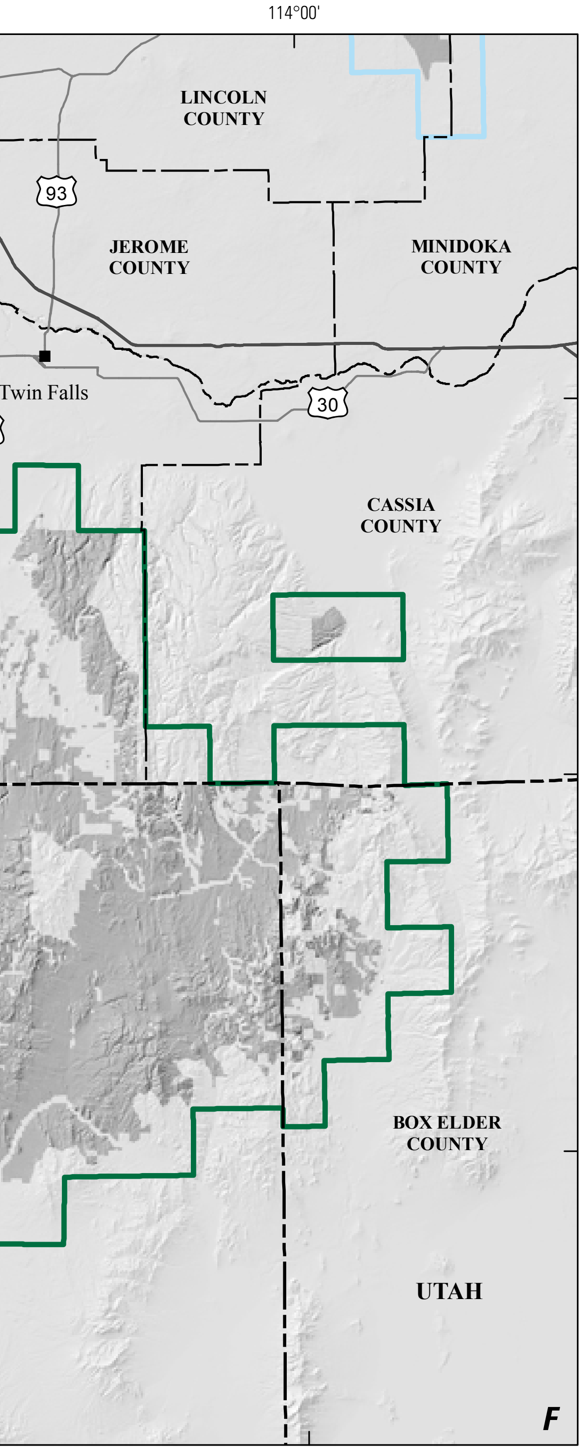
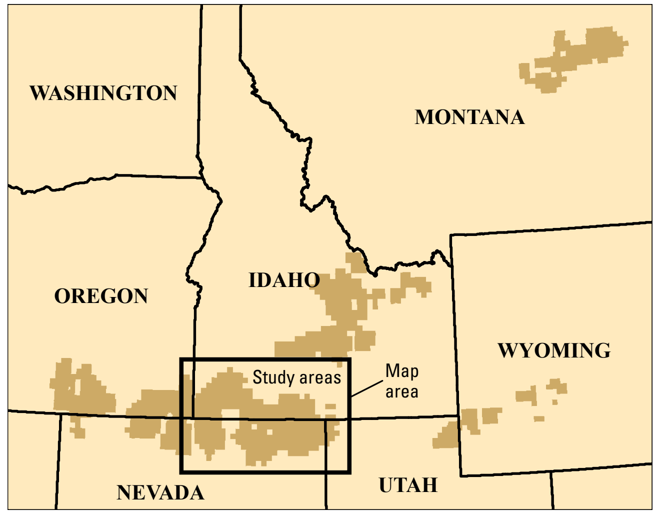
Boundary data from San Juan and others (2016).
USA Contiguous Albers Equal Area Conic Projection.
Central meridian, 115° W., latitude of origin, 37.5° N.
North American Datum of 1983.

0 10 20 30 40 50 MILES
0 10 20 30 40 50 KILOMETERS

Figure 31*A*–*U*. Maps showing assessment tracts for metallic locatable minerals and nonmetallic locatable minerals in the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, Nevada, Idaho, and Utah (San Juan and others, 2016); USGS, U.S. Geological Survey; *A*, Assessment tracts for epithermal gold-silver (mercury); *B*, Assessment tract for hydroallogenic volcanic-hosted uranium; *C*, Assessment tracts for polymetallic vein, porphyry copper, copper skarn, and arc-related porphyry molybdenum (low-fluorine); *D*, Assessment tract for distal disseminated gold-silver; *E*, Assessment tracts for polymetallic replacement, polymetallic vein, and tungsten vein; *F*, Assessment tracts for tungsten skarn and polymetallic vein; *G*, Assessment tracts for distal disseminated gold-silver, polymetallic vein and skarn; *H*, Assessment tract for polymetallic vein;





EXPLANATION

Assessment tract types—Tungsten skarn and Polymetallic vein

High potential, high certainty

Base data

USGS study area boundary

USGS study area boundary (North-Central Idaho Study Area)

Proposed withdrawal areas

Proposed withdrawal additions

State boundaries

County boundaries

I, Assessment tracts for polymetallic vein, copper skarn, and tungsten skarn; *J*, Assessment tracts for porphyry copper, copper skarn, polymetallic vein, and tungsten skarn; *K*, Assessment tract for polymetallic replacement; *L*, Assessment tract for molybdenum-tungsten greisen; *M*, Assessment tract for polymetallic vein; *N*, Assessment tract for distal disseminated gold-silver and polymetallic vein; *O*, Assessment tract for Climax-type porphyry molybdenum; *P*, Assessment tracts for distal disseminated silver-gold, polymetallic replacement, and polymetallic vein; *Q*, Assessment tract for multiple intrusion-related deposit types; *R*, Assessment tracts for volcanogenic massive sulfide (Besshi-subtype); *S*, Assessment tracts for Carlin-type gold (silver, mercury, antimony); *T*, Assessment tracts for lacustrine diatomite; and *U*, Assessment tracts for bedded barite.—Continued

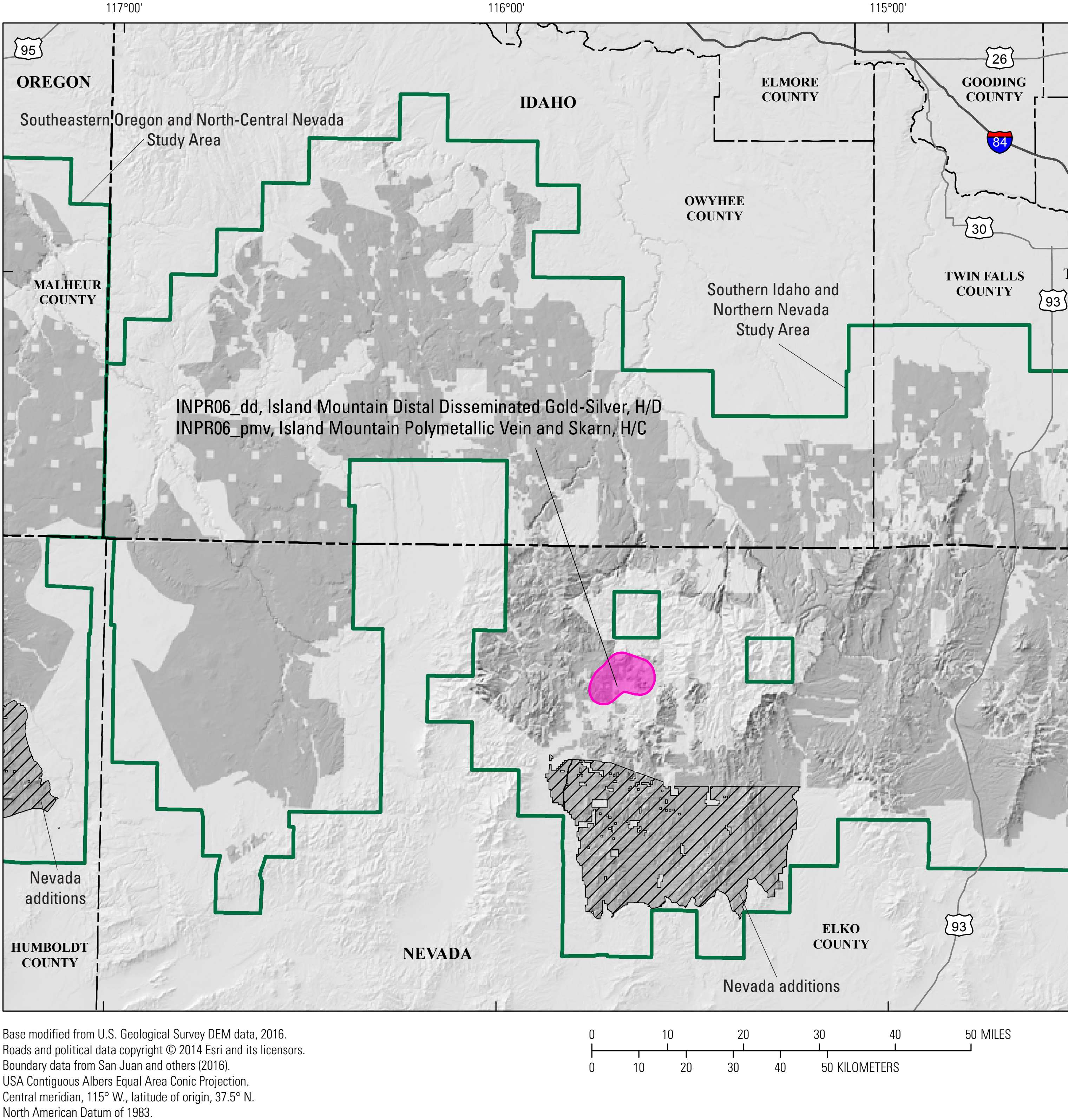
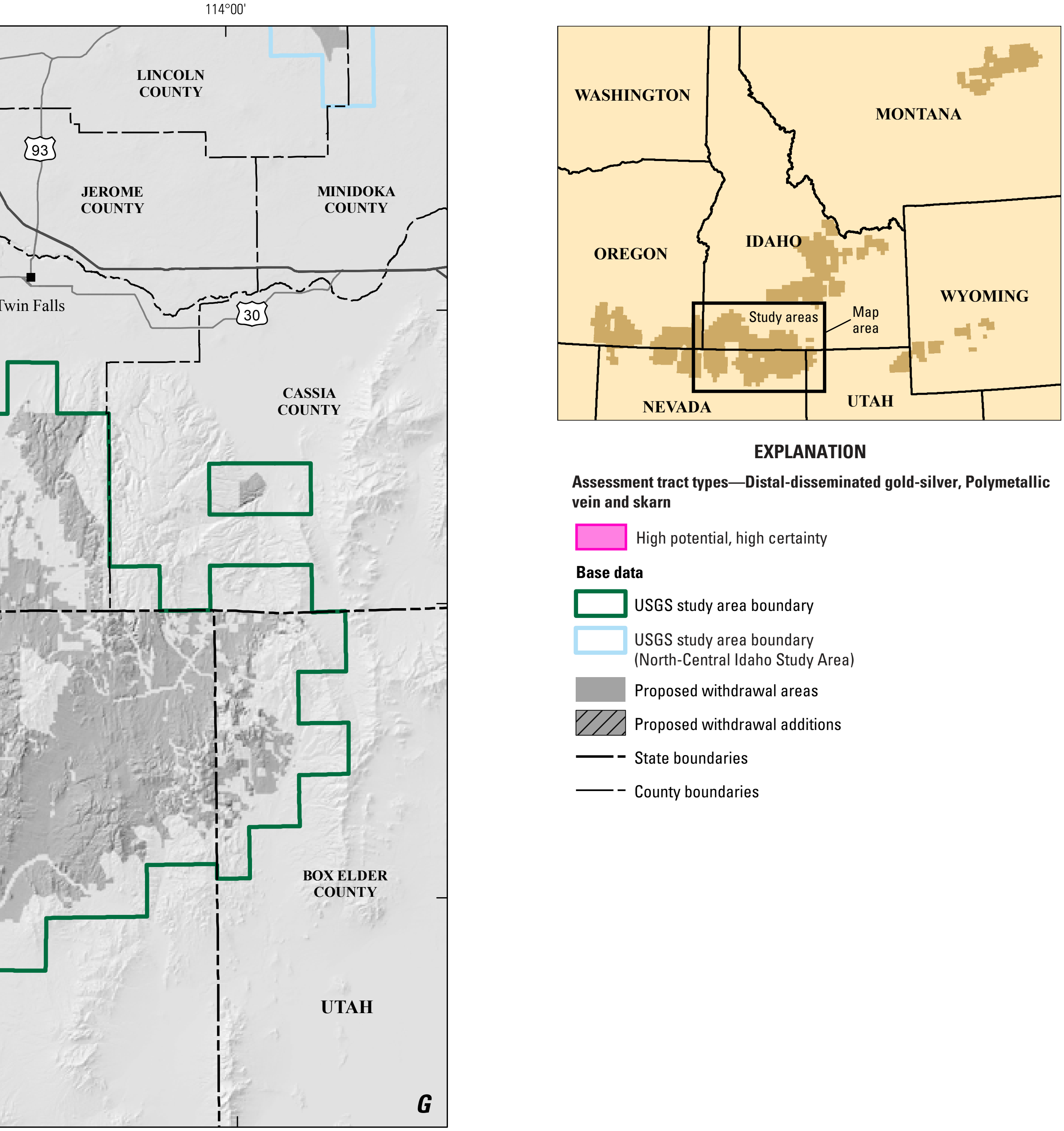
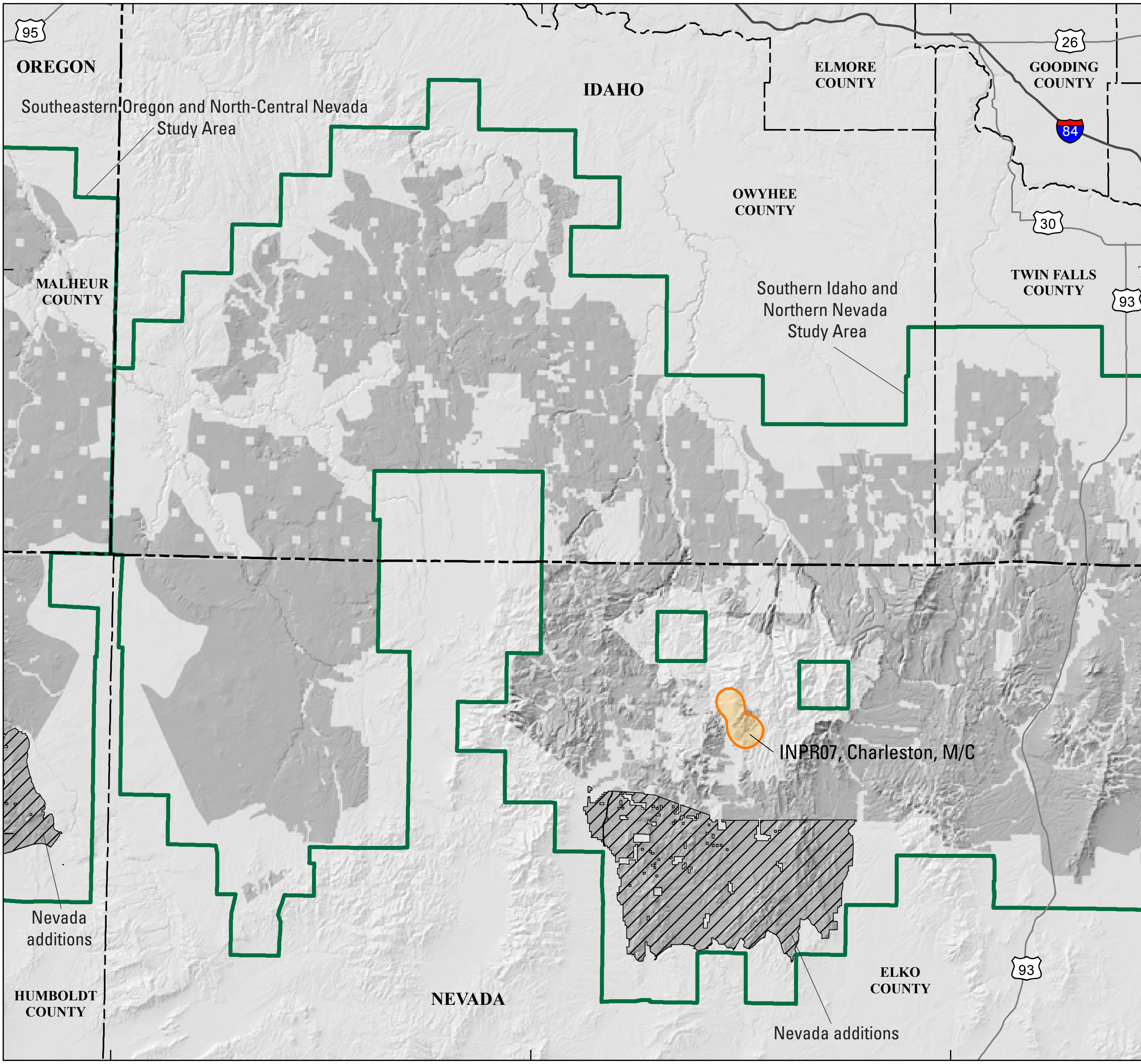


Figure 31*A*–*U*. Maps showing assessment tracts for metallic locatable minerals and nonmetallic locatable minerals in the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, Nevada, Idaho, and Utah (San Juan and others, 2016); USGS, U.S. Geological Survey; *A*, Assessment tracts for epithermal gold-silver (mercury); *B*, Assessment tract for hydroallogenic volcanic-hosted uranium; *C*, Assessment tracts for polymetallic vein, porphyry copper, copper skarn, and arc-related porphyry molybdenum (low-fluorine); *D*, Assessment tract for distal disseminated gold-silver; *E*, Assessment tracts for polymetallic replacement, polymetallic vein, and tungsten vein; *F*, Assessment tracts for tungsten skarn and polymetallic vein; *G*, Assessment tracts for distal disseminated gold-silver, polymetallic vein and skarn; *H*, Assessment tract for polymetallic vein;



I, Assessment tracts for polymetallic vein, copper skarn, and tungsten skarn; *J*, Assessment tracts for porphyry copper, copper skarn, polymetallic vein, and tungsten skarn; *K*, Assessment tract for polymetallic replacement; *L*, Assessment tract for molybdenum-tungsten greisen; *M*, Assessment tract for polymetallic vein; *N*, Assessment tract for distal disseminated gold-silver and polymetallic vein; *O*, Assessment tract for Climax-type porphyry molybdenum; *P*, Assessment tracts for distal disseminated silver-gold, polymetallic replacement, and polymetallic vein; *Q*, Assessment tract for multiple intrusion-related deposit types; *R*, Assessment tracts for volcanogenic massive sulfide (Besshi-subtype); *S*, Assessment tracts for Carlin-type gold (silver, mercury, antimony); *T*, Assessment tracts for lacustrine diatomite; and *U*, Assessment tracts for bedded barite.—Continued



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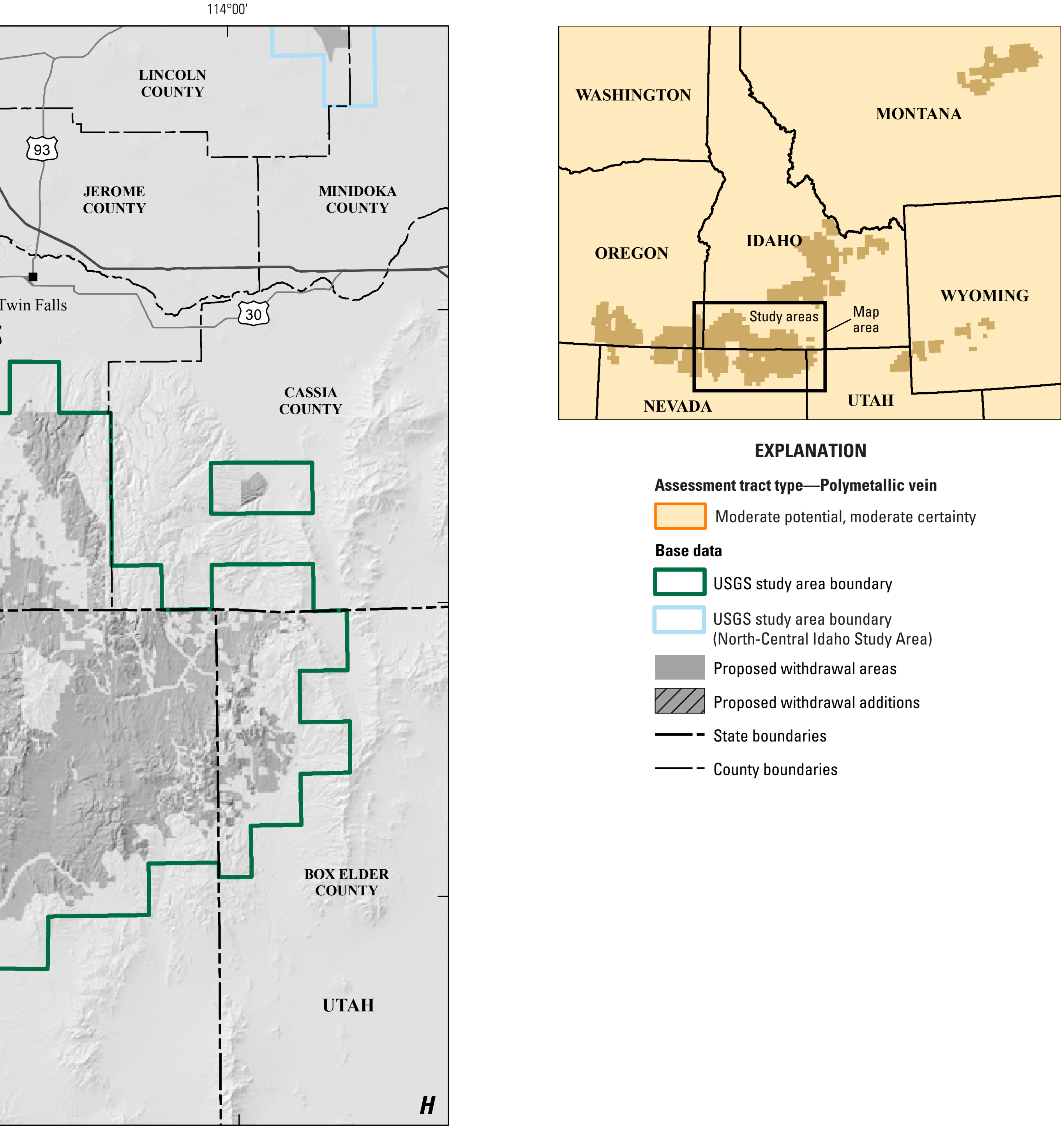
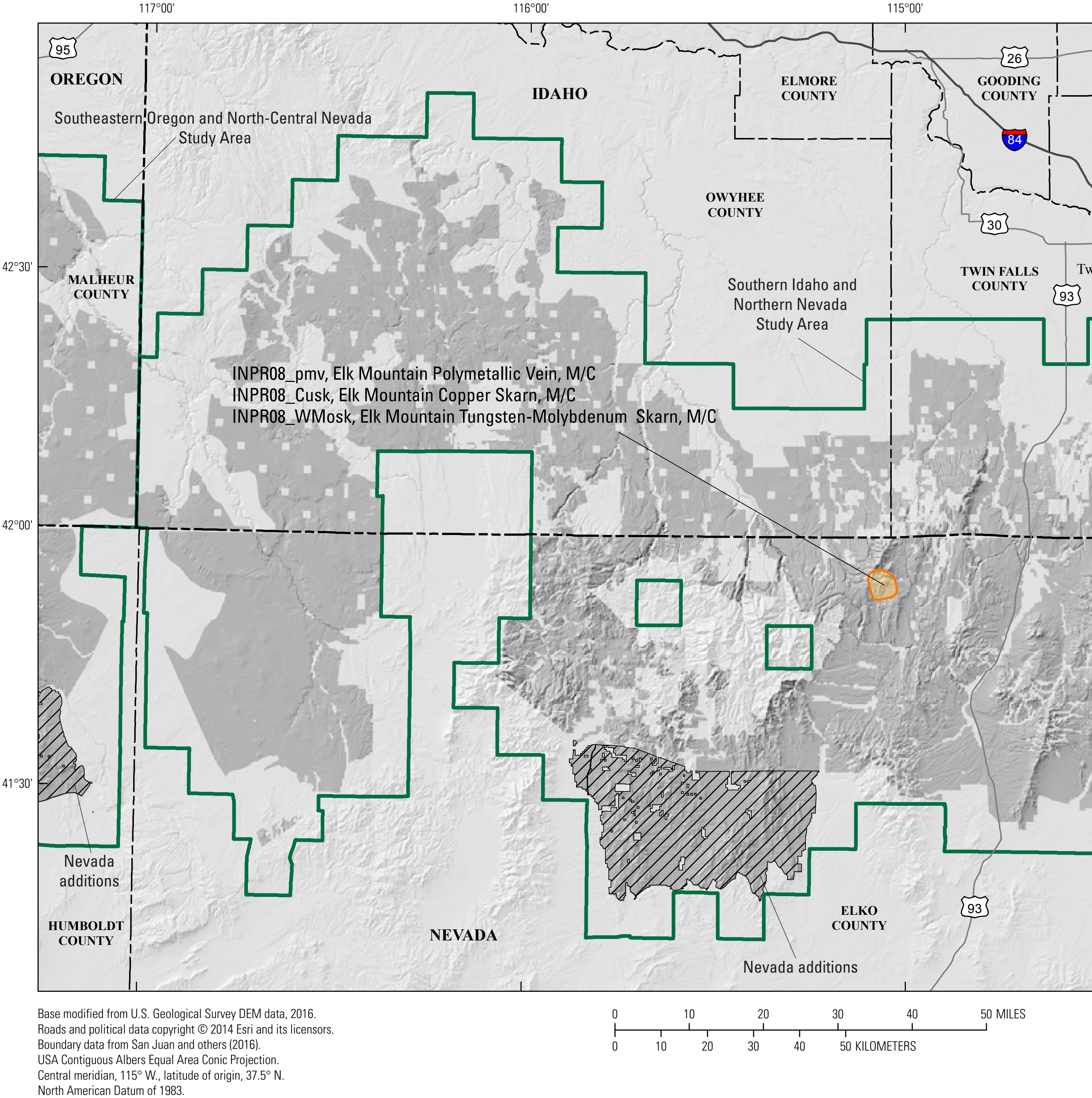
Boundary data from San Juan and others (2016).
USA Contiguous Albers Equal Area Conic Projection.
Central meridian, 115° W., latitude of origin, 37.5° N.
North American Datum of 1983.

Figure 31*A*–*U*. Maps showing assessment tracts for metallic locatable minerals and nonmetallic locatable minerals in the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, Nevada, Idaho, and Utah (San Juan and others, 2016); USGS, U.S. Geological Survey; *A*, Assessment tracts for epithermal gold-silver (mercury); *B*, Assessment tract for hydroallogenic volcanic-hosted uranium; *C*, Assessment tracts for polymetallic vein, porphyry copper, copper skarn, and arc-related porphyry molybdenum (low-fluorine); *D*, Assessment tract for distal disseminated gold-silver; *E*, Assessment tracts for polymetallic replacement, polymetallic vein, and tungsten vein; *F*, Assessment tracts for tungsten skarn and polymetallic vein; *G*, Assessment tracts for distal disseminated gold-silver, polymetallic vein and skarn; *H*, Assessment tract for polymetallic vein;



I, Assessment tracts for polymetallic vein, copper skarn, and tungsten skarn; *J*, Assessment tracts for porphyry copper, copper skarn, polymetallic vein, and tungsten skarn; *K*, Assessment tract for polymetallic replacement; *L*, Assessment tract for molybdenum-tungsten greisen; *M*, Assessment tract for polymetallic vein; *N*, Assessment tract for distal disseminated gold-silver and polymetallic vein; *O*, Assessment tract for Climax-type porphyry molybdenum; *P*, Assessment tracts for distal disseminated silver-gold, polymetallic replacement, and polymetallic vein; *Q*, Assessment tract for multiple intrusion-related deposit types; *R*, Assessment tracts for volcanogenic massive sulfide (Besshi-subtype); *S*, Assessment tracts for Carlin-type gold (silver, mercury, antimony); *T*, Assessment tracts for lacustrine diatomite; and *U*, Assessment tracts for bedded barite.—Continued



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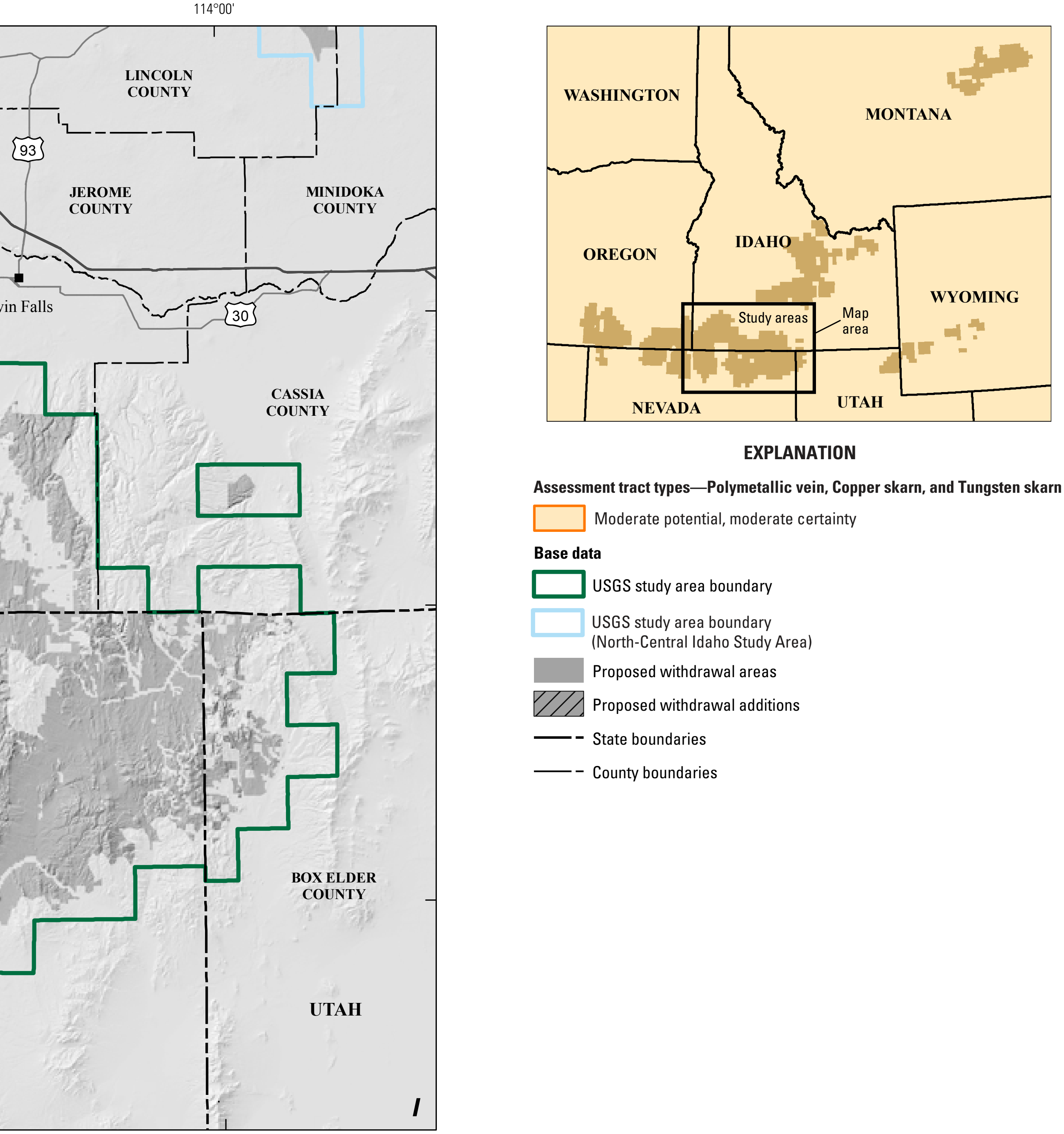


I, Assessment tracts for polymetallic vein, copper skarn, and tungsten skarn; *J*, Assessment tracts for porphyry copper, copper skarn, polymetallic vein, and tungsten skarn; *K*, Assessment tract for polymetallic replacement; *L*, Assessment tract for molybdenum-tungsten greisen; *M*, Assessment tract for polymetallic vein; *N*, Assessment tract for distal disseminated gold-silver and polymetallic vein; *O*, Assessment tract for Climax-type porphyry molybdenum; *P*, Assessment tracts for distal disseminated silver-gold, polymetallic replacement, and polymetallic vein; *Q*, Assessment tract for multiple intrusion-related deposit types; *R*, Assessment tracts for volcanogenic massive sulfide (Besshi-subtype); *S*, Assessment tracts for Carlin-type gold (silver, mercury, antimony); *T*, Assessment tracts for lacustrine diatomite; and *U*, Assessment tracts for bedded barite.—Continued

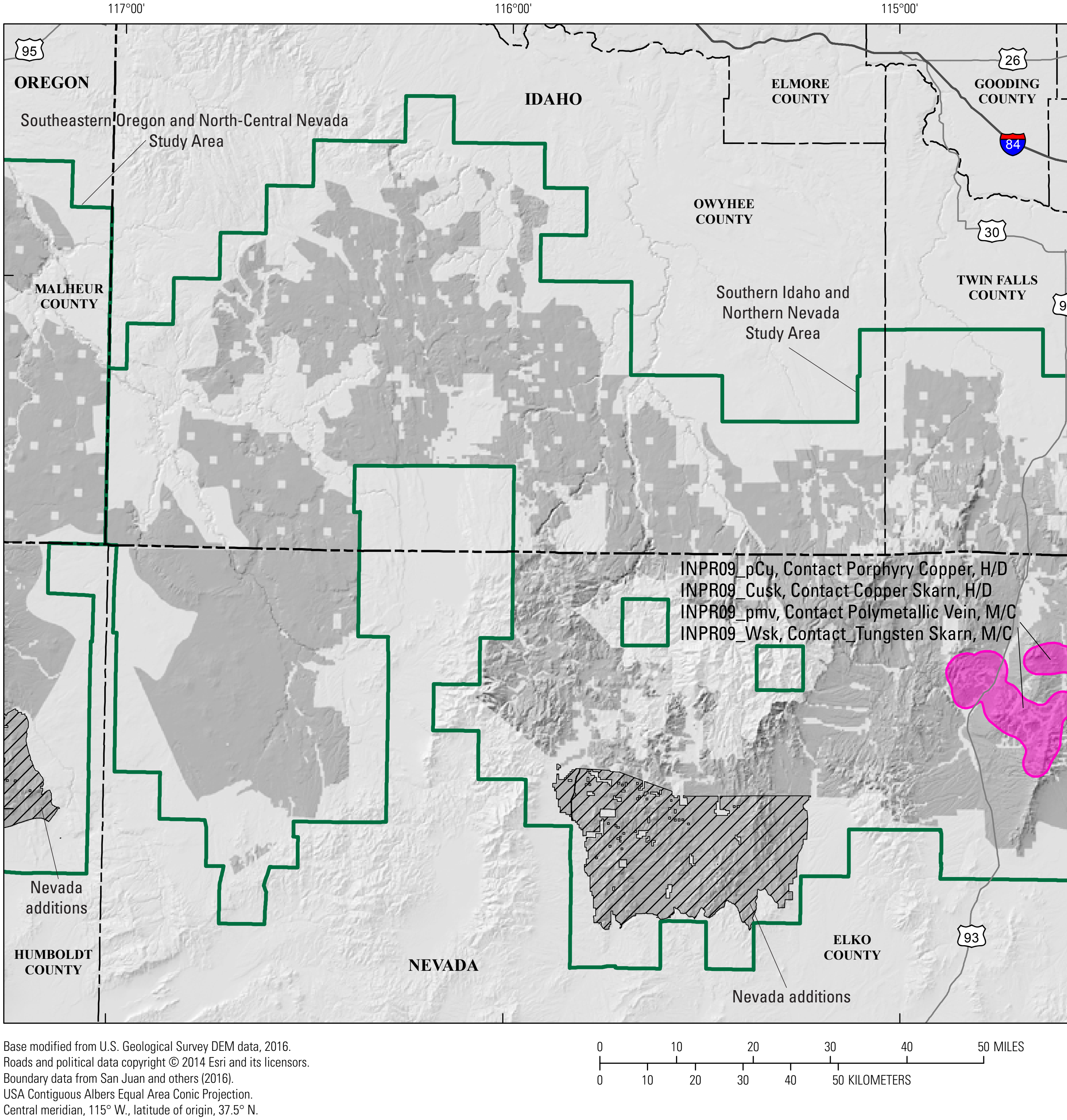
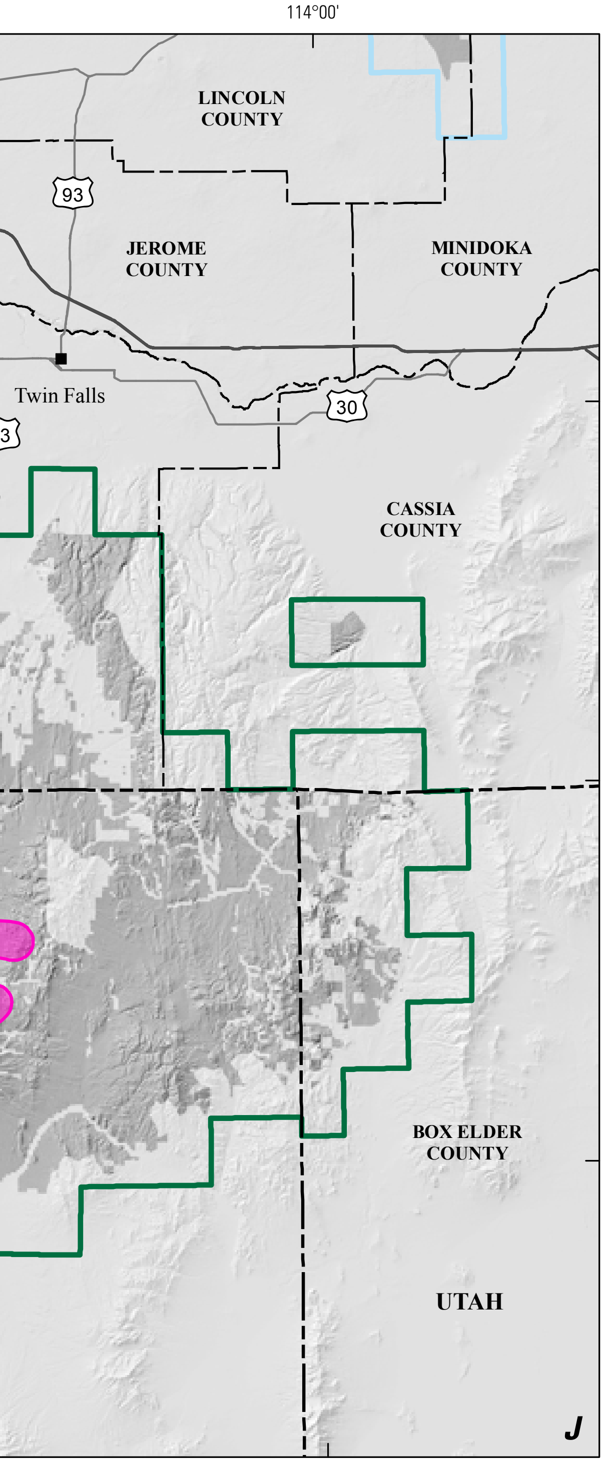
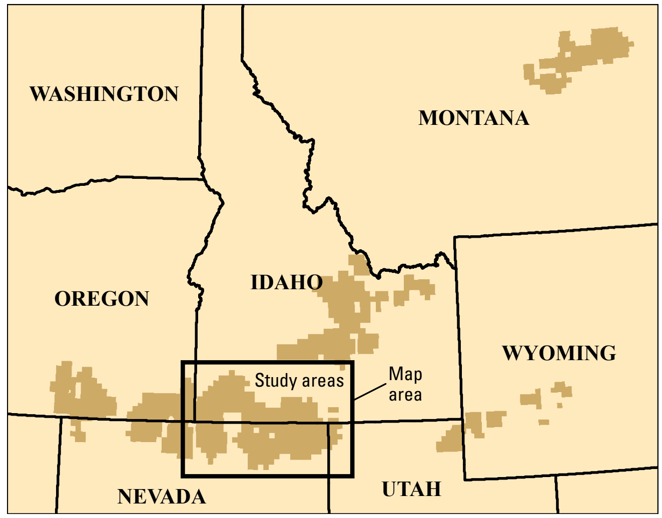


Figure 31*A*–*U*. Maps showing assessment tracts for metallic locatable minerals and nonmetallic locatable minerals in the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, Nevada, Idaho, and Utah (San Juan and others, 2016); USGS, U.S. Geological Survey; *A*, Assessment tracts for epithermal gold-silver (mercury); *B*, Assessment tract for hydroallogenic volcanic-hosted uranium; *C*, Assessment tracts for polymetallic vein, porphyry copper, copper skarn, and arc-related porphyry molybdenum (low-fluorine); *D*, Assessment tract for distal disseminated gold-silver; *E*, Assessment tracts for polymetallic replacement, polymetallic vein, and tungsten vein; *F*, Assessment tracts for tungsten skarn and polymetallic vein; *G*, Assessment tracts for distal disseminated gold-silver, polymetallic vein and skarn; *H*, Assessment tract for polymetallic vein;





EXPLANATION

Assessment tract types—Porphyry copper, Copper skarn, Polymetallic vein, and Tungsten skarn

High potential, high certainty

Base data

USGS study area boundary

USGS study area boundary (North-Central Idaho Study Area)

Proposed withdrawal areas

Proposed withdrawal additions

State boundaries

County boundaries

I, Assessment tracts for polymetallic vein, copper skarn, and tungsten skarn; *J*, Assessment tracts for porphyry copper, copper skarn, polymetallic vein, and tungsten skarn; *K*, Assessment tract for polymetallic replacement; *L*, Assessment tract for molybdenum-tungsten greisen; *M*, Assessment tract for polymetallic vein; *N*, Assessment tract for distal disseminated gold-silver and polymetallic vein; *O*, Assessment tract for Climax-type porphyry molybdenum; *P*, Assessment tracts for distal disseminated silver-gold, polymetallic replacement, and polymetallic vein; *Q*, Assessment tract for multiple intrusion-related deposit types; *R*, Assessment tracts for volcanogenic massive sulfide (Besshi-subtype); *S*, Assessment tracts for Carlin-type gold (silver, mercury, antimony); *T*, Assessment tracts for lacustrine diatomite; and *U*, Assessment tracts for bedded barite.—Continued

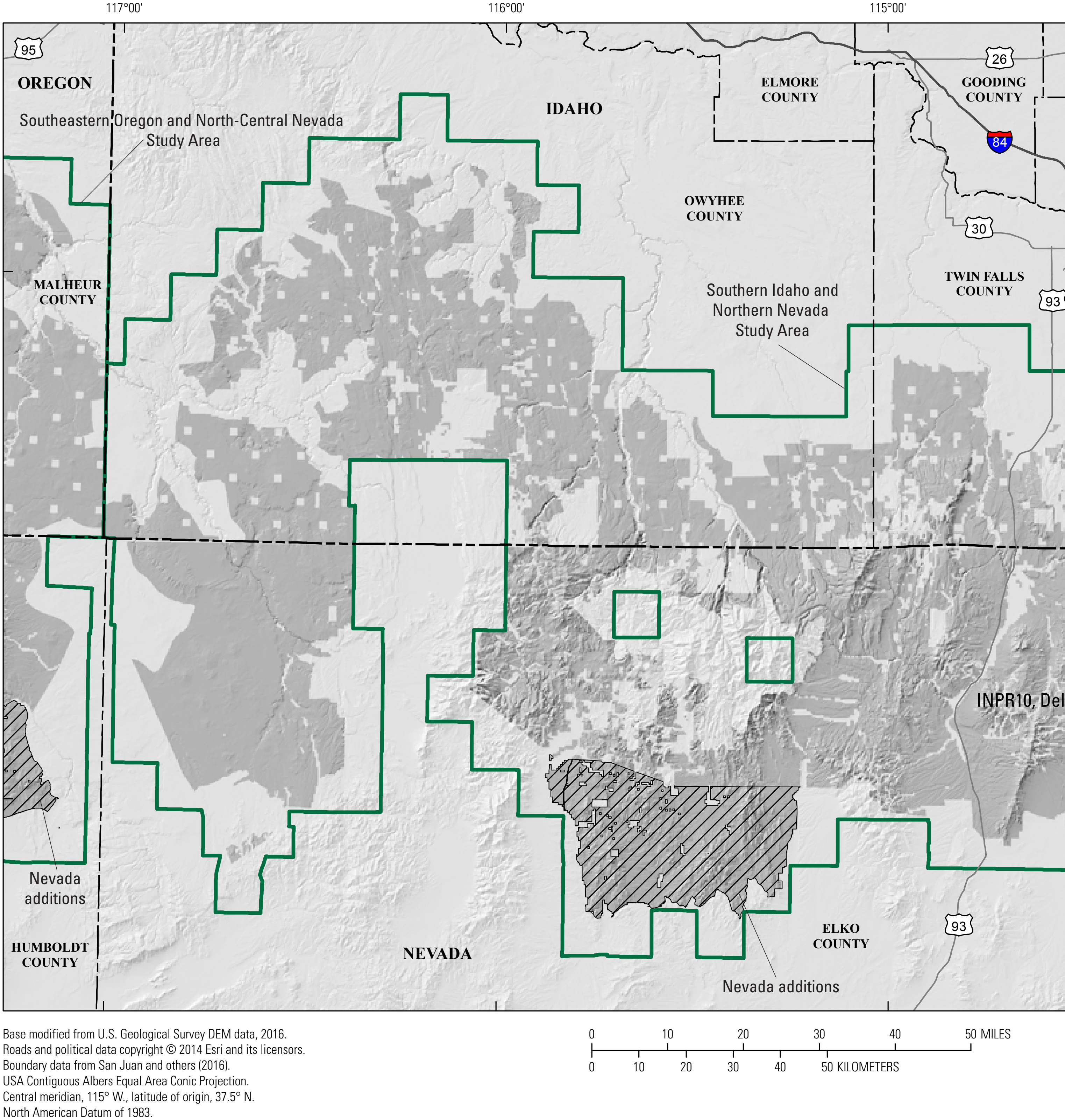
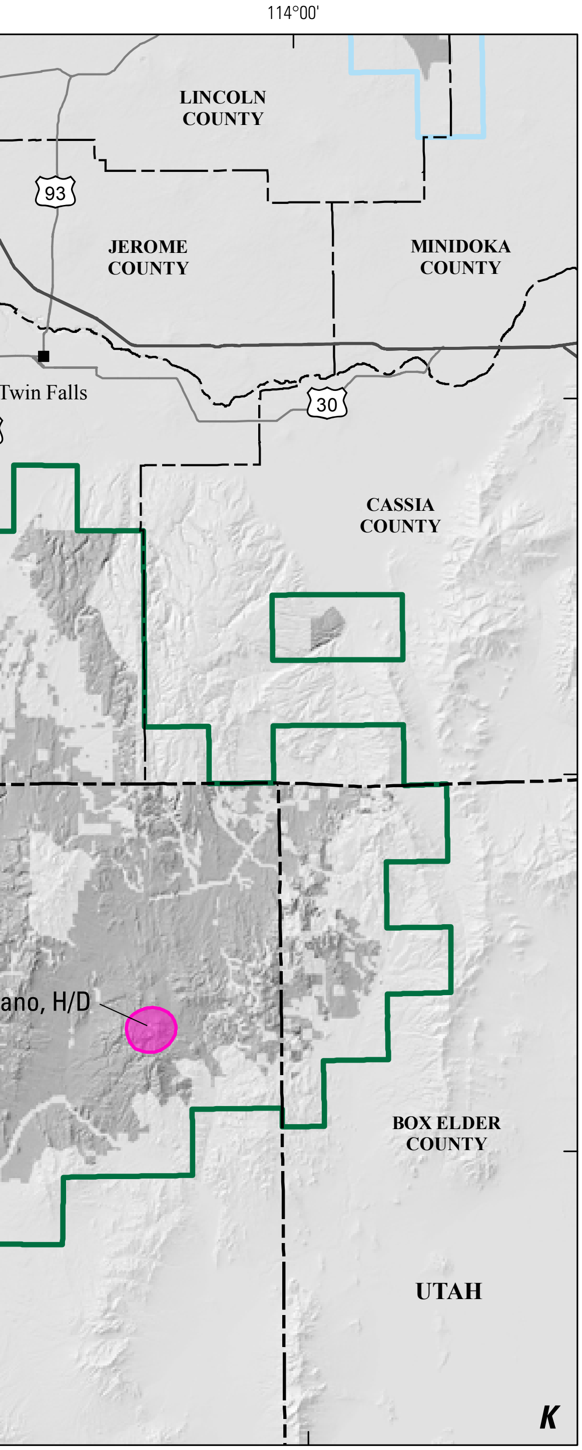
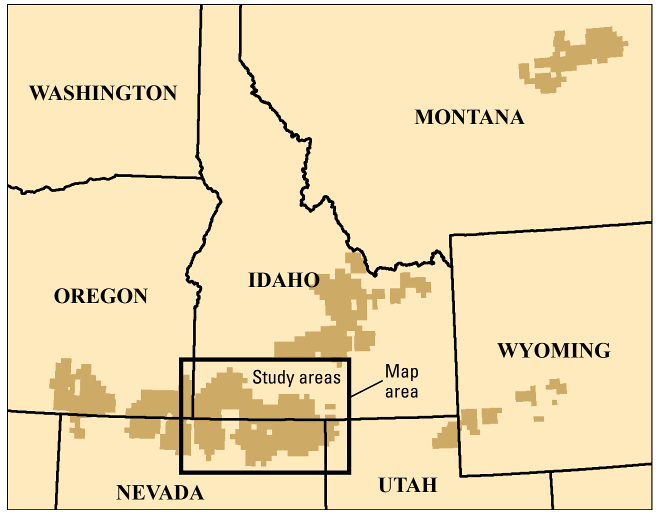


Figure 31*A*–*U*. Maps showing assessment tracts for metallic locatable minerals and nonmetallic locatable minerals in the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, Nevada, Idaho, and Utah (San Juan and others, 2016); USGS, U.S. Geological Survey; *A*, Assessment tracts for epithermal gold-silver (mercury); *B*, Assessment tract for hydroallogenic volcanic-hosted uranium; *C*, Assessment tracts for polymetallic vein, porphyry copper, copper skarn, and arc-related porphyry molybdenum (low-fluorine); *D*, Assessment tract for distal disseminated gold-silver; *E*, Assessment tracts for polymetallic replacement, polymetallic vein, and tungsten vein; *F*, Assessment tracts for tungsten skarn and polymetallic vein; *G*, Assessment tracts for distal disseminated gold-silver, polymetallic vein and skarn; *H*, Assessment tract for polymetallic vein;





EXPLANATION

Assessment tract type—Polymetallic replacement

High potential, high certainty

Base data

USGS study area boundary

USGS study area boundary (North-Central Idaho Study Area)

Proposed withdrawal areas

Proposed withdrawal additions

State boundaries

County boundaries

I, Assessment tracts for polymetallic vein, copper skarn, and tungsten skarn; *J*, Assessment tracts for porphyry copper, copper skarn, polymetallic vein, and tungsten skarn; *K*, Assessment tract for polymetallic replacement; *L*, Assessment tract for molybdenum-tungsten greisen; *M*, Assessment tract for polymetallic vein; *N*, Assessment tract for distal disseminated gold-silver and polymetallic vein; *O*, Assessment tract for Climax-type porphyry molybdenum; *P*, Assessment tracts for distal disseminated silver-gold, polymetallic replacement, and polymetallic vein; *Q*, Assessment tract for multiple intrusion-related deposit types; *R*, Assessment tracts for volcanogenic massive sulfide (Besshi-subtype); *S*, Assessment tracts for Carlin-type gold (silver, mercury, antimony); *T*, Assessment tracts for lacustrine diatomite; and *U*, Assessment tracts for bedded barite.—Continued

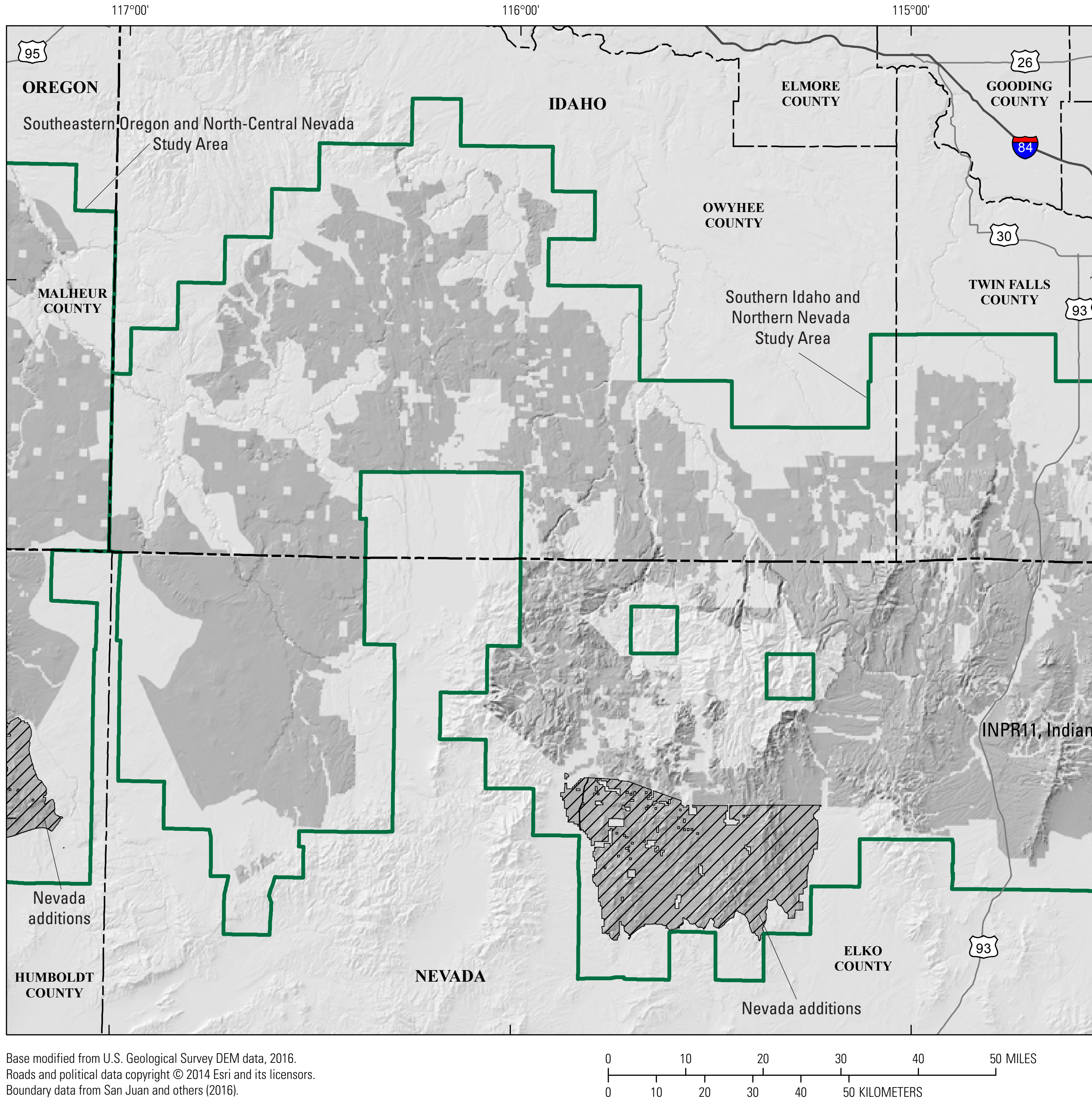
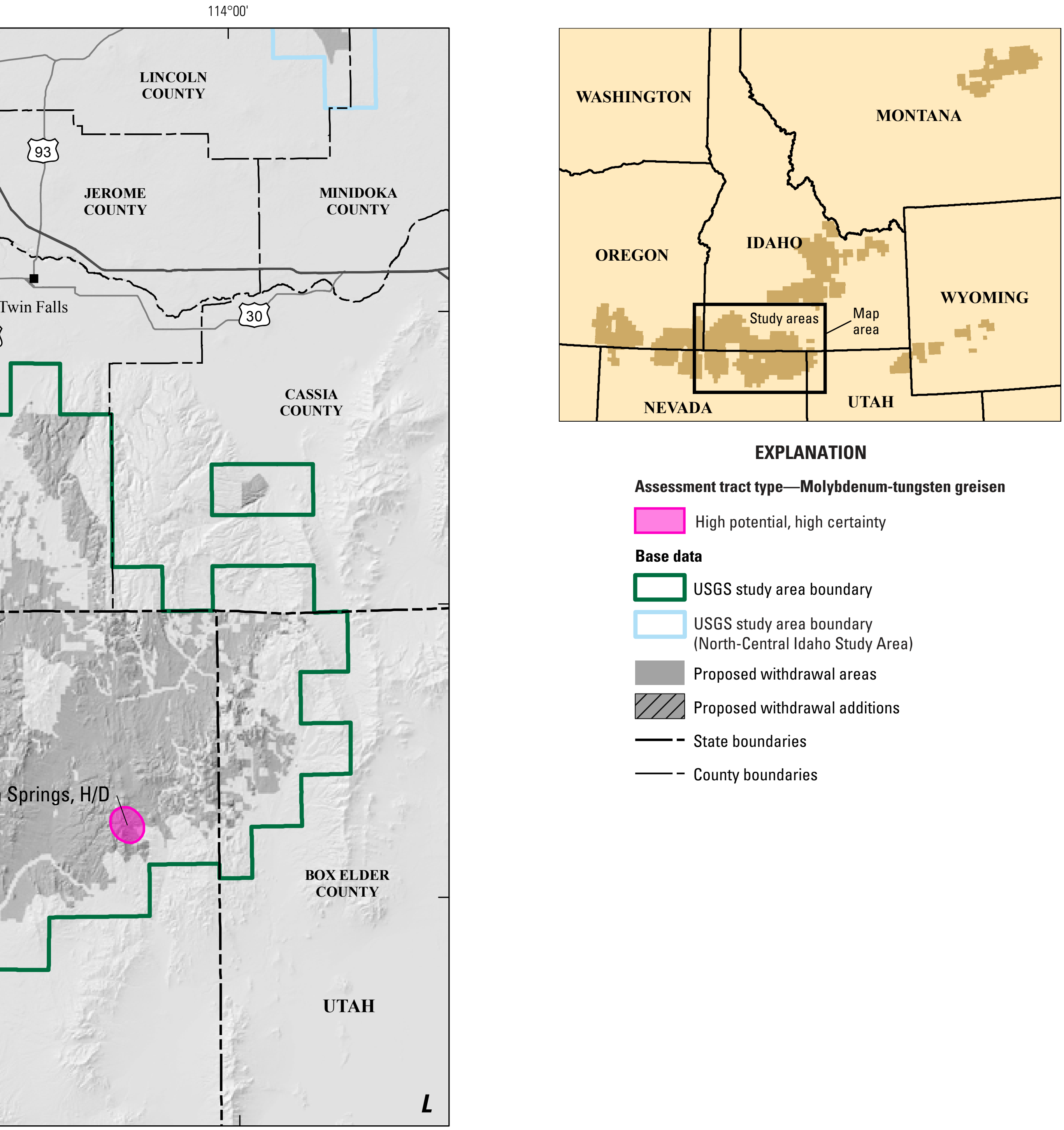
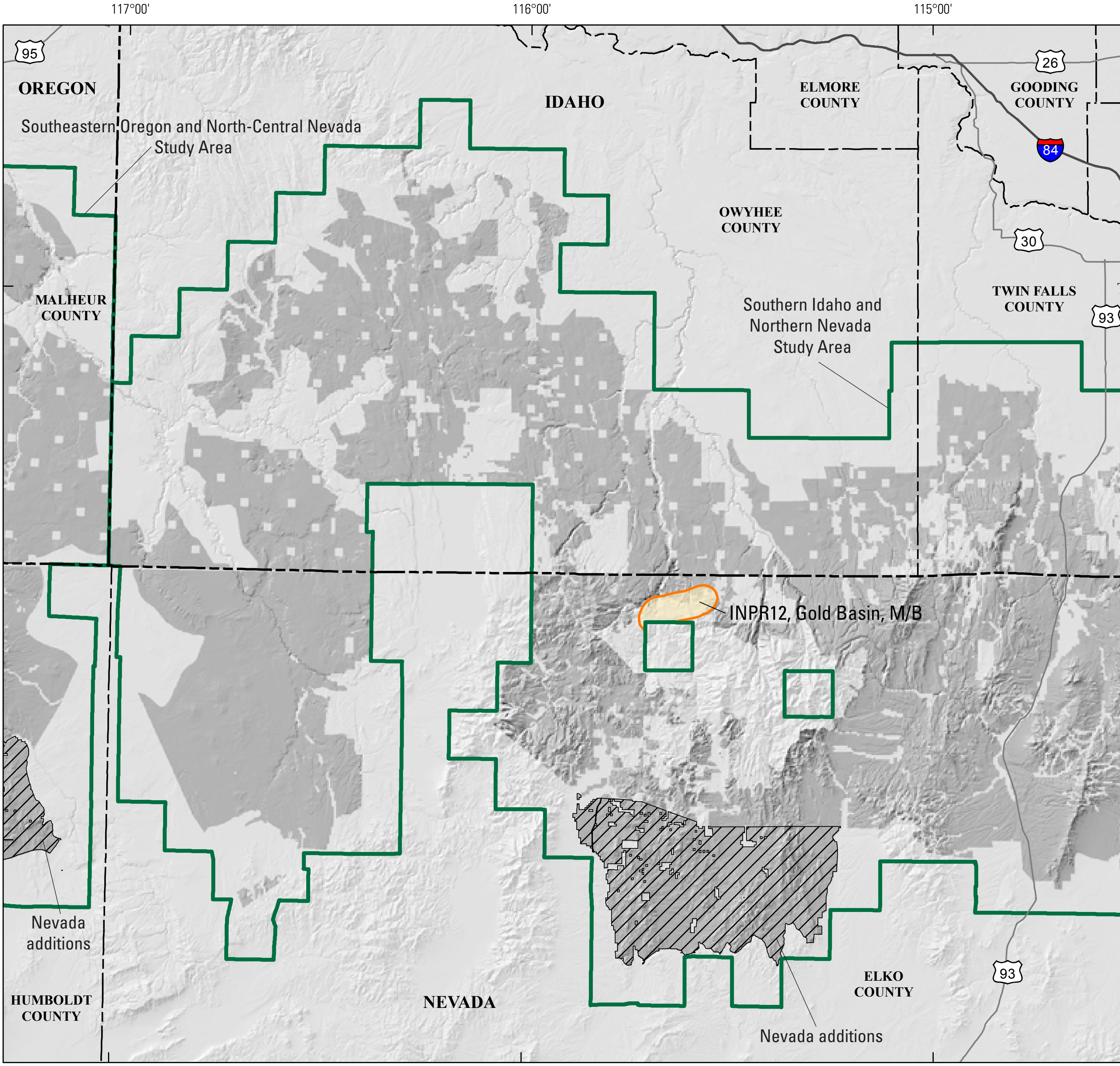


Figure 31*A*–*U*. Maps showing assessment tracts for metallic locatable minerals and nonmetallic locatable minerals in the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, Nevada, Idaho, and Utah (San Juan and others, 2016); USGS, U.S. Geological Survey; *A*, Assessment tracts for epithermal gold-silver (mercury); *B*, Assessment tract for hydroallogenic volcanic-hosted uranium; *C*, Assessment tracts for polymetallic vein, porphyry copper, copper skarn, and arc-related porphyry molybdenum (low-fluorine); *D*, Assessment tract for distal disseminated gold-silver; *E*, Assessment tracts for polymetallic replacement, polymetallic vein, and tungsten vein; *F*, Assessment tracts for tungsten skarn and polymetallic vein; *G*, Assessment tracts for distal disseminated gold-silver, polymetallic vein and skarn; *H*, Assessment tract for polymetallic vein;



I, Assessment tracts for polymetallic vein, copper skarn, and tungsten skarn; *J*, Assessment tracts for porphyry copper, copper skarn, polymetallic vein, and tungsten skarn; *K*, Assessment tract for polymetallic replacement; *L*, Assessment tract for molybdenum-tungsten greisen; *M*, Assessment tract for polymetallic vein; *N*, Assessment tract for distal disseminated gold-silver and polymetallic vein; *O*, Assessment tract for Climax-type porphyry molybdenum; *P*, Assessment tracts for distal disseminated silver-gold, polymetallic replacement, and polymetallic vein; *Q*, Assessment tract for multiple intrusion-related deposit types; *R*, Assessment tracts for volcanogenic massive sulfide (Besshi-subtype); *S*, Assessment tracts for Carlin-type gold (silver, mercury, antimony); *T*, Assessment tracts for lacustrine diatomite; and *U*, Assessment tracts for bedded barite.—Continued



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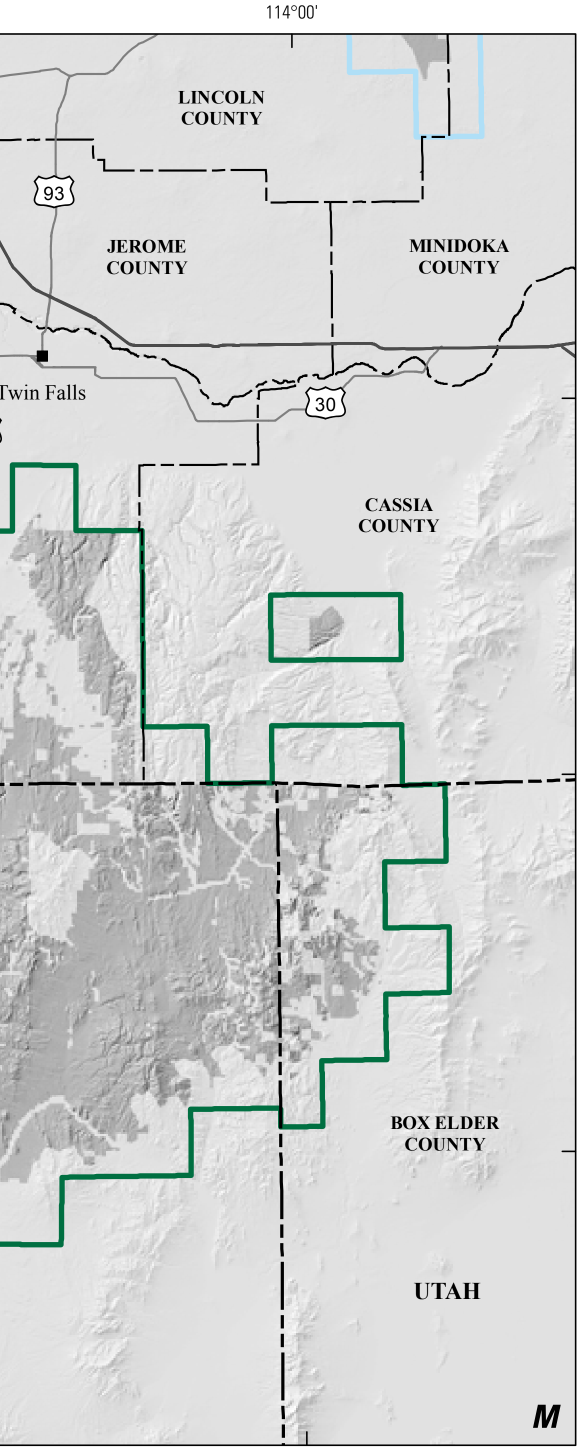
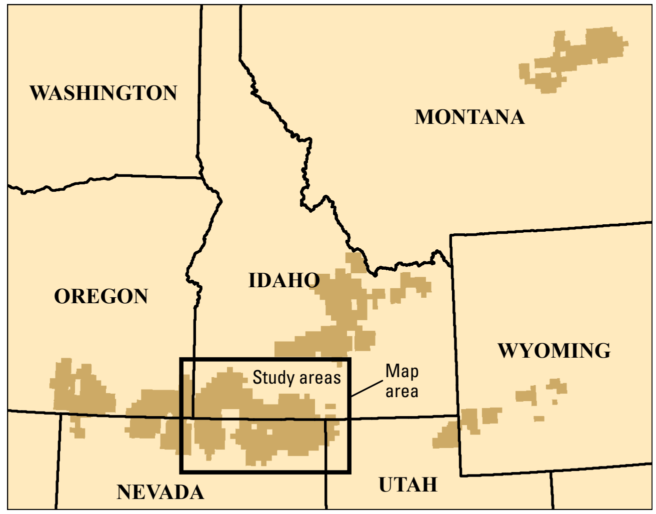
Boundary data from San Juan and others (2016).
USA Contiguous Albers Equal Area Conic Projection.
Central meridian, 115° W., latitude of origin, 37.5° N.
North American Datum of 1983.

0 10 20 30 40 50 MILES
0 10 20 30 40 50 KILOMETERS

Figure 31*A*–*U*. Maps showing assessment tracts for metallic locatable minerals and nonmetallic locatable minerals in the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, Nevada, Idaho, and Utah (San Juan and others, 2016); USGS, U.S. Geological Survey; *A*, Assessment tracts for epithermal gold-silver (mercury); *B*, Assessment tract for hydroallogenic volcanic-hosted uranium; *C*, Assessment tracts for polymetallic vein, porphyry copper, copper skarn, and arc-related porphyry molybdenum (low-fluorine); *D*, Assessment tract for distal disseminated gold-silver; *E*, Assessment tracts for polymetallic replacement, polymetallic vein, and tungsten vein; *F*, Assessment tracts for tungsten skarn and polymetallic vein; *G*, Assessment tracts for distal disseminated gold-silver, polymetallic vein and skarn; *H*, Assessment tract for polymetallic vein;





EXPLANATION

Assessment tract type—Polymetallic vein

Moderate potential, low certainty

Base data

USGS study area boundary

USGS study area boundary (North-Central Idaho Study Area)

Proposed withdrawal areas

Proposed withdrawal additions

State boundaries

County boundaries

I, Assessment tracts for polymetallic vein, copper skarn, and tungsten skarn; *J*, Assessment tracts for porphyry copper, copper skarn, polymetallic vein, and tungsten skarn; *K*, Assessment tract for polymetallic replacement; *L*, Assessment tract for molybdenum-tungsten greisen; *M*, Assessment tract for polymetallic vein; *N*, Assessment tract for distal disseminated gold-silver and polymetallic vein; *O*, Assessment tract for Climax-type porphyry molybdenum; *P*, Assessment tracts for distal disseminated silver-gold, polymetallic replacement, and polymetallic vein; *Q*, Assessment tract for multiple intrusion-related deposit types; *R*, Assessment tracts for volcanogenic massive sulfide (Besshi-subtype); *S*, Assessment tracts for Carlin-type gold (silver, mercury, antimony); *T*, Assessment tracts for lacustrine diatomite; and *U*, Assessment tracts for bedded barite.—Continued

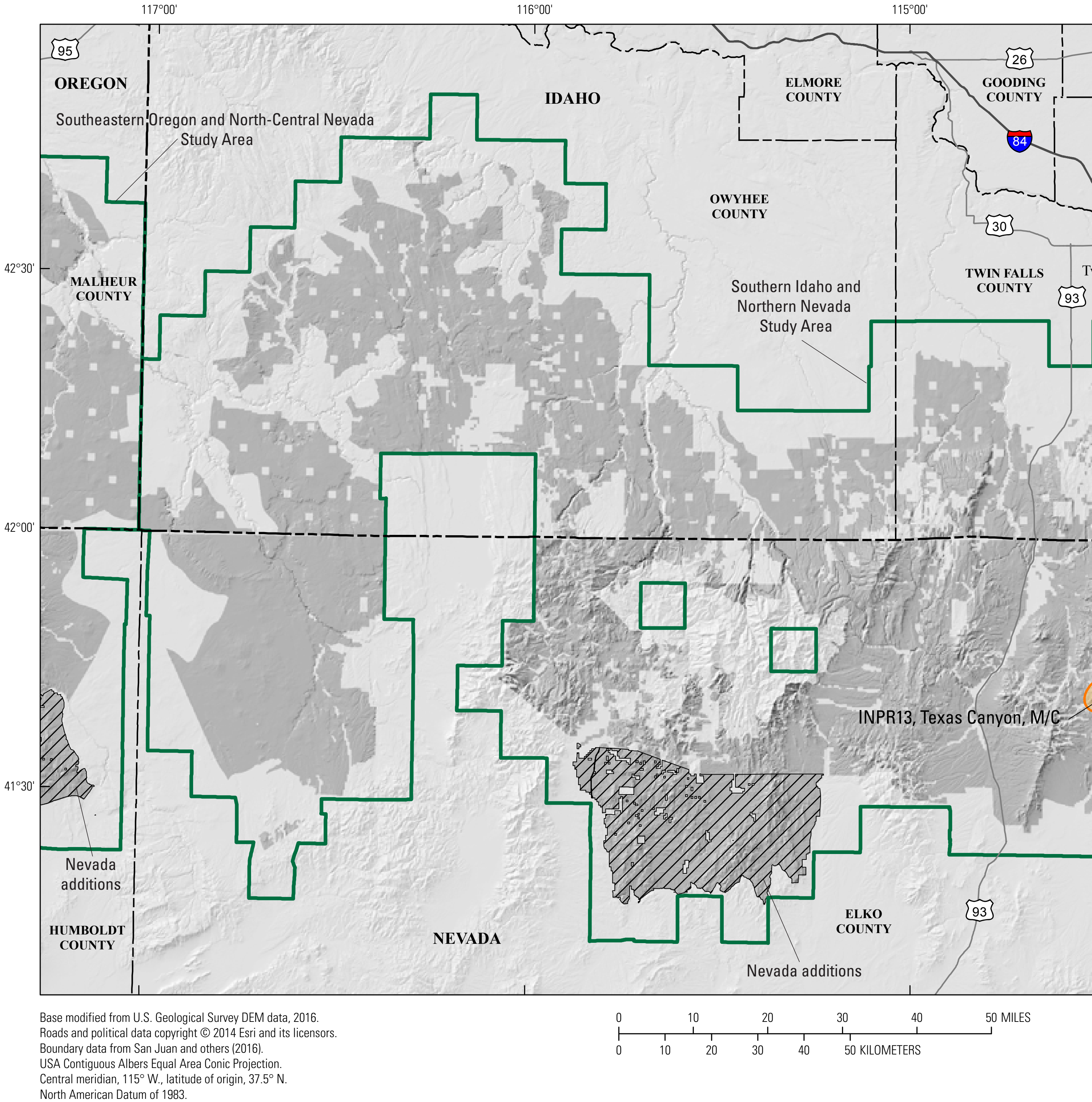
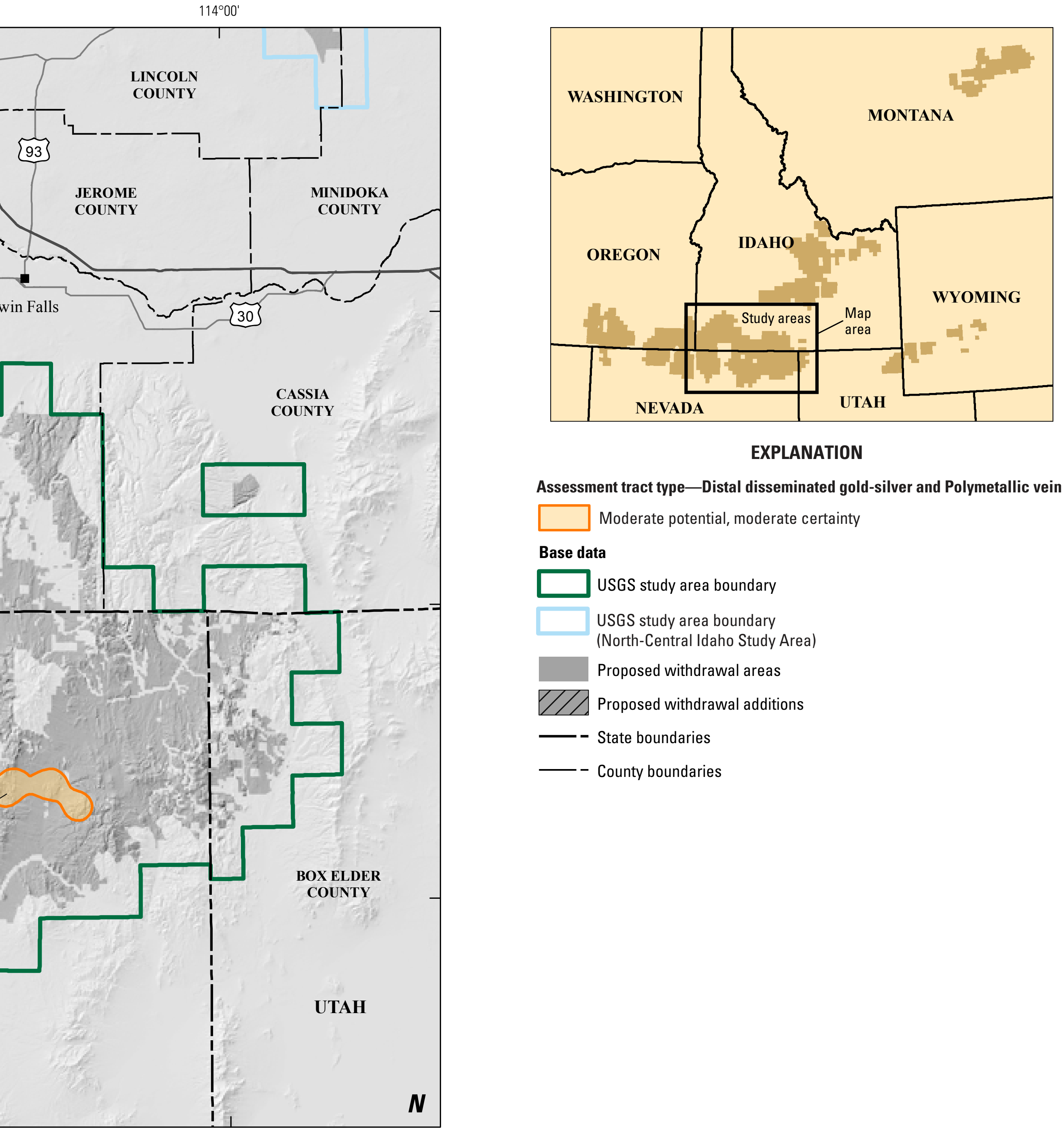
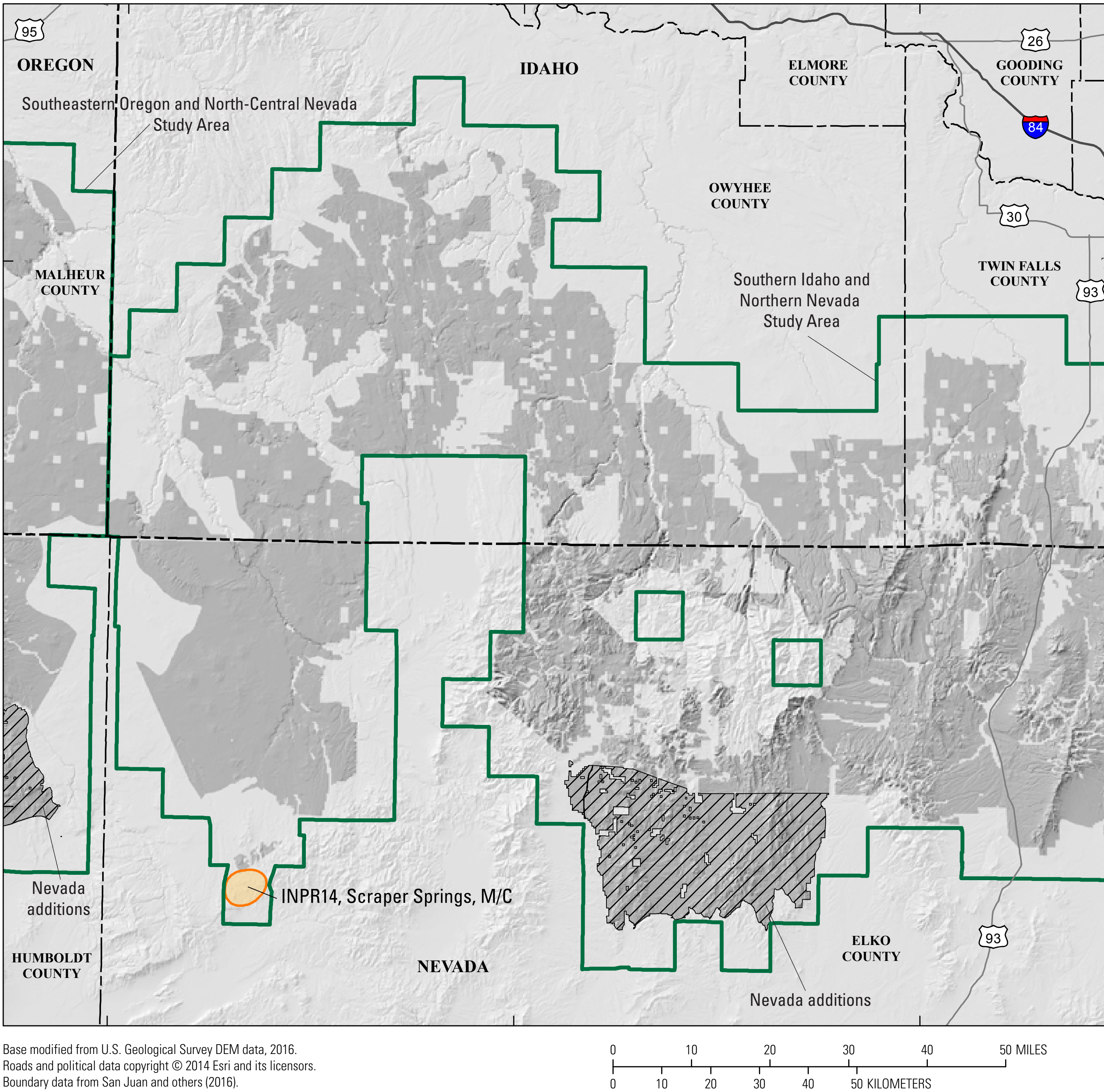


Figure 31*A*–*U*. Maps showing assessment tracts for metallic locatable minerals and nonmetallic locatable minerals in the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, Nevada, Idaho, and Utah (San Juan and others, 2016); USGS, U.S. Geological Survey; *A*, Assessment tracts for epithermal gold-silver (mercury); *B*, Assessment tract for hydroallogenic volcanic-hosted uranium; *C*, Assessment tracts for polymetallic vein, porphyry copper, copper skarn, and arc-related porphyry molybdenum (low-fluorine); *D*, Assessment tract for distal disseminated gold-silver; *E*, Assessment tracts for polymetallic replacement, polymetallic vein, and tungsten vein; *F*, Assessment tracts for tungsten skarn and polymetallic vein; *G*, Assessment tracts for distal disseminated gold-silver, polymetallic vein and skarn; *H*, Assessment tract for polymetallic vein;



I, Assessment tracts for polymetallic vein, copper skarn, and tungsten skarn; *J*, Assessment tracts for porphyry copper, copper skarn, polymetallic vein, and tungsten skarn; *K*, Assessment tract for polymetallic replacement; *L*, Assessment tract for molybdenum-tungsten greisen; *M*, Assessment tract for polymetallic vein; *N*, Assessment tract for distal disseminated gold-silver and polymetallic vein; *O*, Assessment tract for Climax-type porphyry molybdenum; *P*, Assessment tracts for distal disseminated silver-gold, polymetallic replacement, and polymetallic vein; *Q*, Assessment tract for multiple intrusion-related deposit types; *R*, Assessment tracts for volcanogenic massive sulfide (Besshi-subtype); *S*, Assessment tracts for Carlin-type gold (silver, mercury, antimony); *T*, Assessment tracts for lacustrine diatomite; and *U*, Assessment tracts for bedded barite.—Continued



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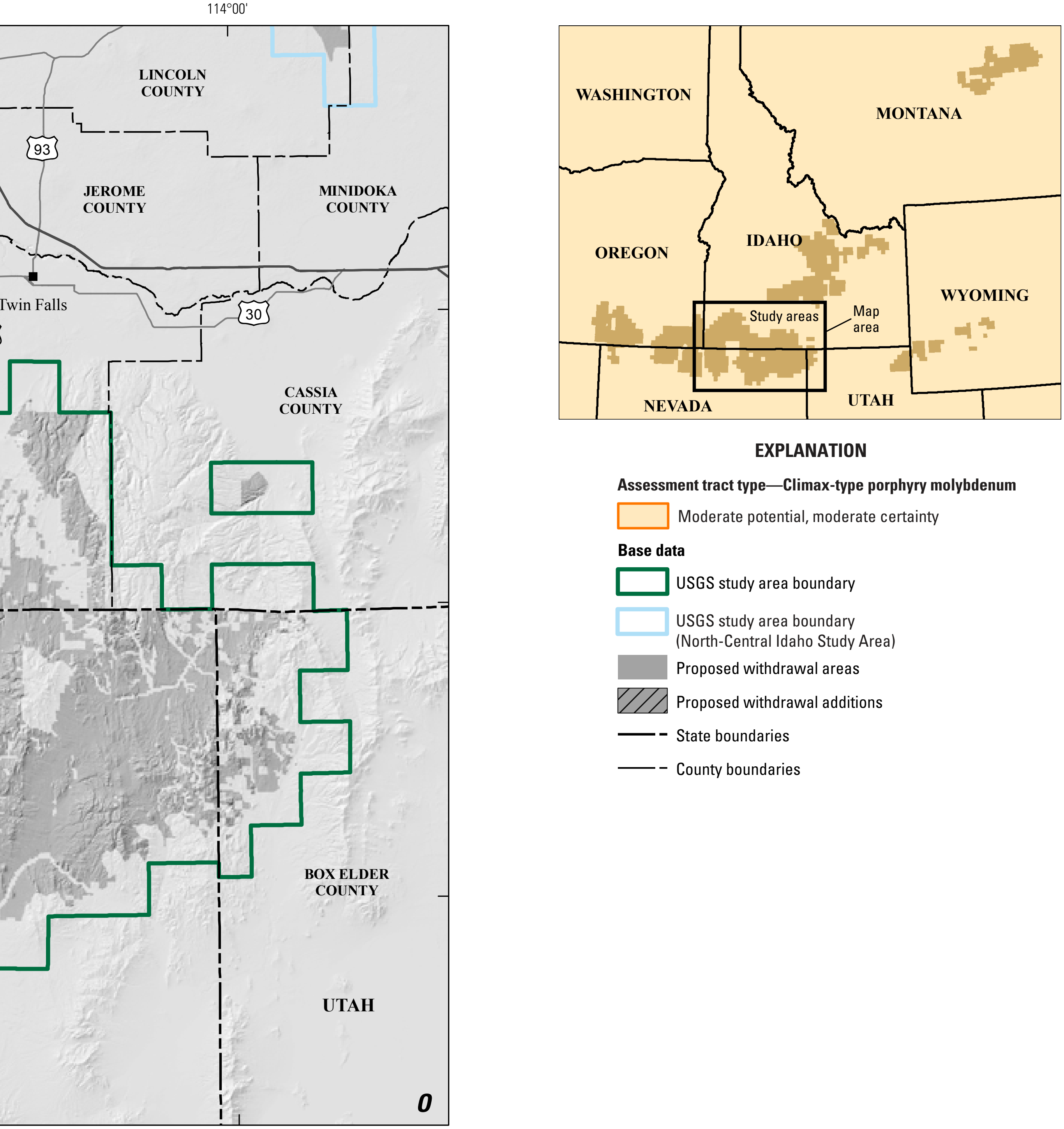
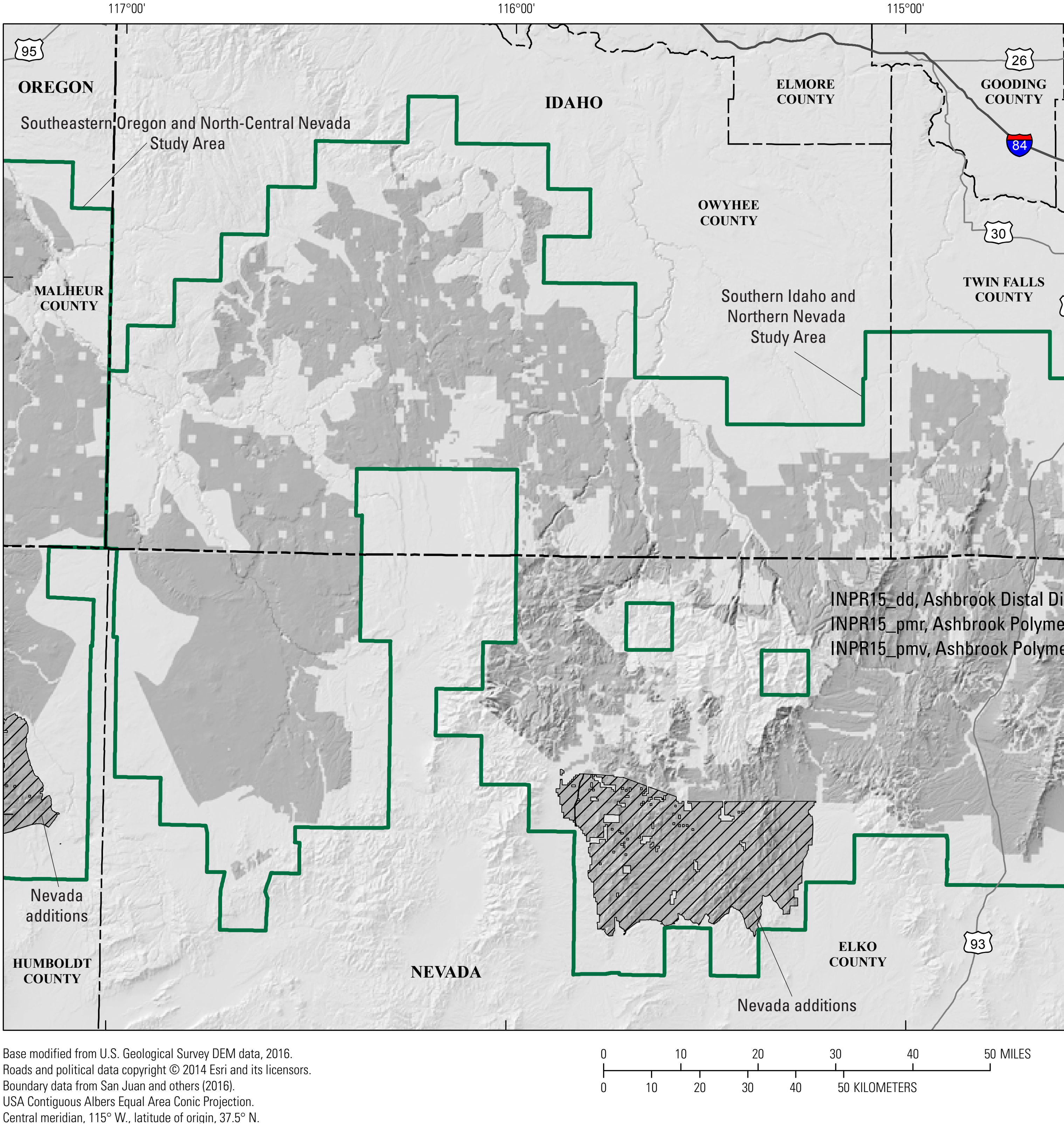
Boundary data from San Juan and others (2016).
USA Contiguous Albers Equal Area Conic Projection.
Central meridian, 115° W., latitude of origin, 37.5° N.
North American Datum of 1983.

Figure 31*A*–*U*. Maps showing assessment tracts for metallic locatable minerals and nonmetallic locatable minerals in the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, Nevada, Idaho, and Utah (San Juan and others, 2016); USGS, U.S. Geological Survey; *A*, Assessment tracts for epithermal gold-silver (mercury); *B*, Assessment tract for hydroallogenic volcanic-hosted uranium; *C*, Assessment tracts for polymetallic vein, porphyry copper, copper skarn, and arc-related porphyry molybdenum (low-fluorine); *D*, Assessment tract for distal disseminated gold-silver; *E*, Assessment tracts for polymetallic replacement, polymetallic vein, and tungsten vein; *F*, Assessment tracts for tungsten skarn and polymetallic vein; *G*, Assessment tracts for distal disseminated gold-silver, polymetallic vein and skarn; *H*, Assessment tract for polymetallic vein;



I, Assessment tracts for polymetallic vein, copper skarn, and tungsten skarn; *J*, Assessment tracts for porphyry copper, copper skarn, polymetallic vein, and tungsten skarn; *K*, Assessment tract for polymetallic replacement; *L*, Assessment tract for molybdenum-tungsten greisen; *M*, Assessment tract for polymetallic vein; *N*, Assessment tract for distal disseminated gold-silver and polymetallic vein; *O*, Assessment tract for Climax-type porphyry molybdenum; *P*, Assessment tracts for distal disseminated silver-gold, polymetallic replacement, and polymetallic vein; *Q*, Assessment tract for multiple intrusion-related deposit types; *R*, Assessment tracts for volcanogenic massive sulfide (Besshi-subtype); *S*, Assessment tracts for Carlin-type gold (silver, mercury, antimony); *T*, Assessment tracts for lacustrine diatomite; and *U*, Assessment tracts for bedded barite.—Continued



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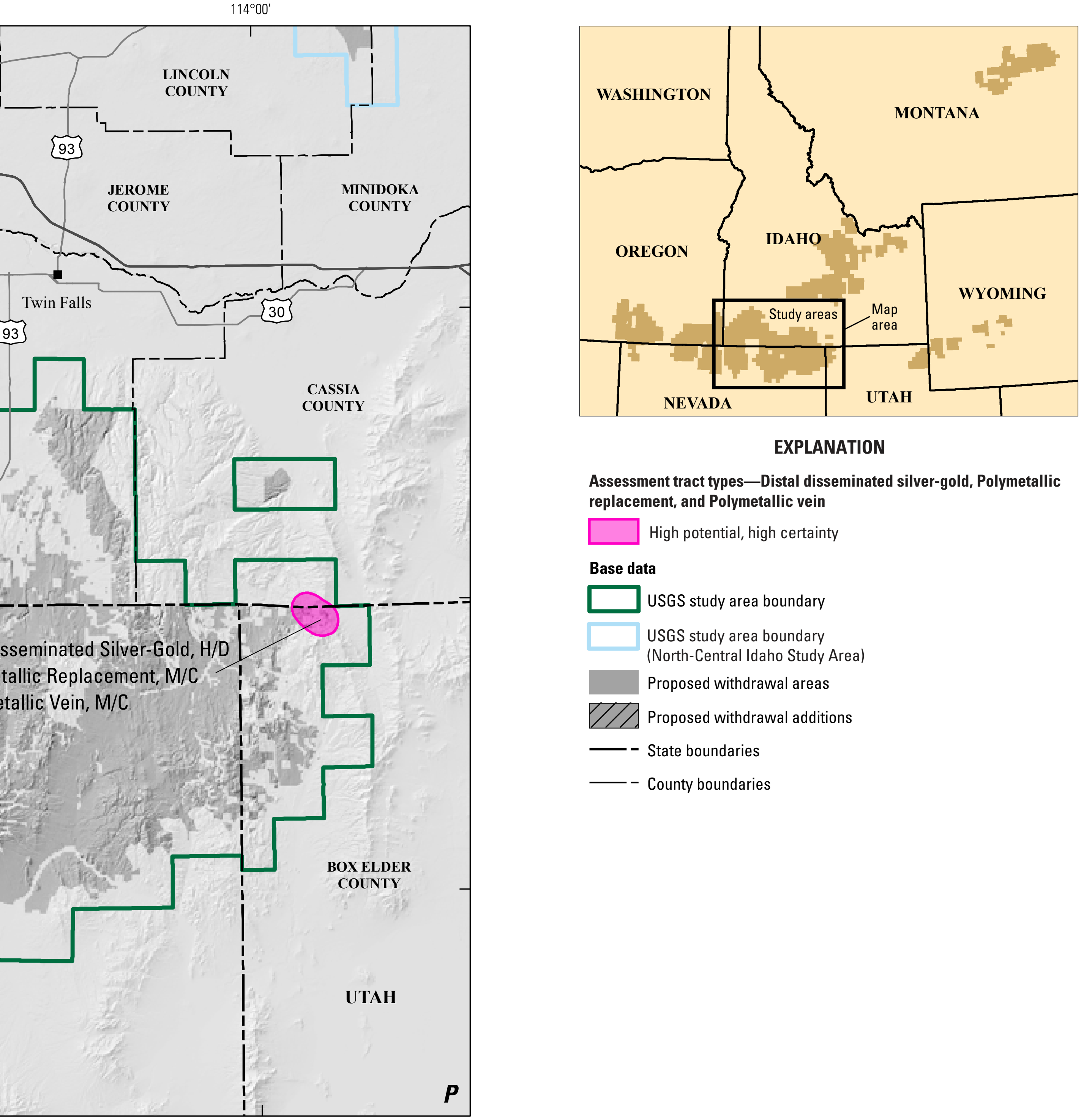
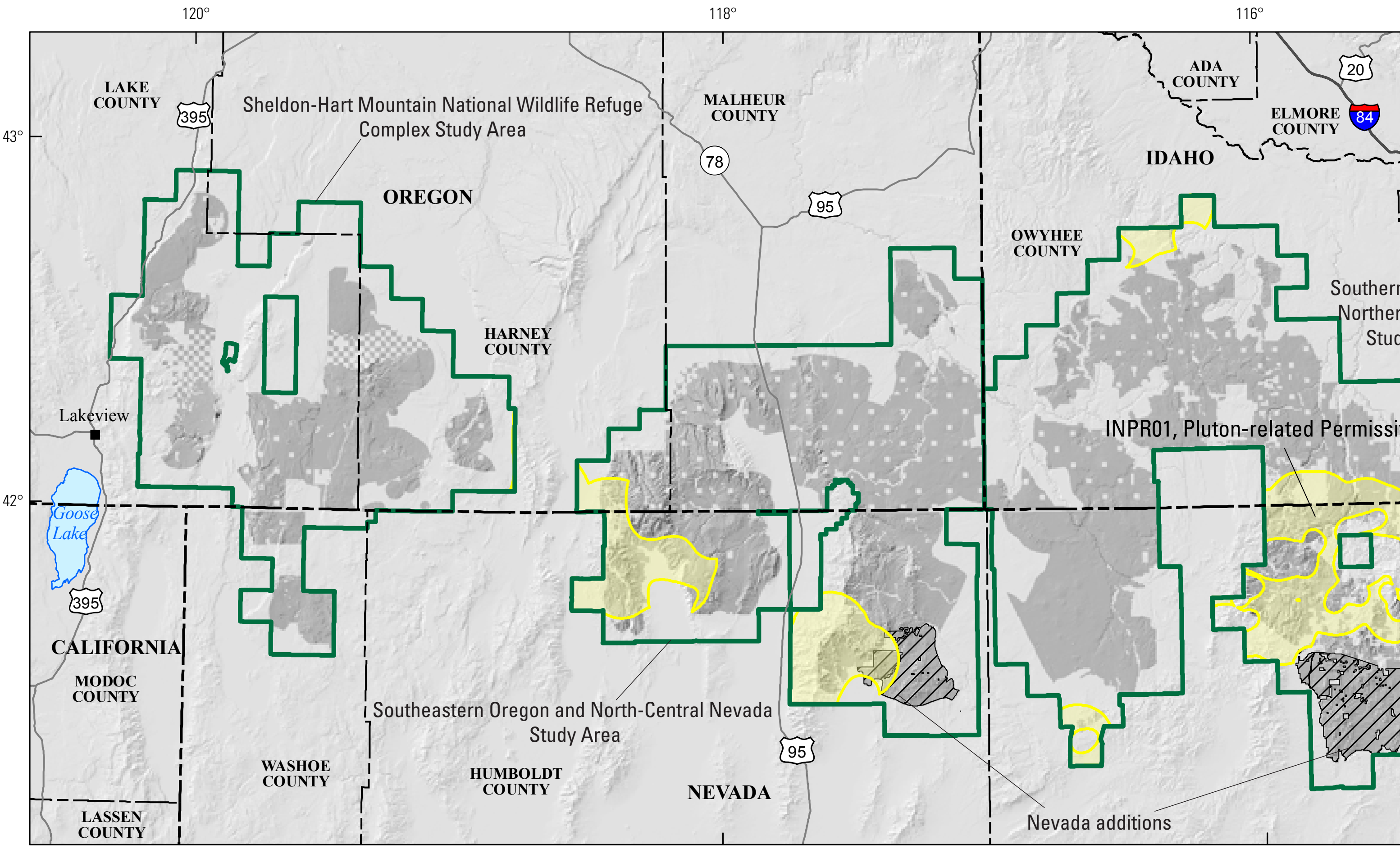


I, Assessment tracts for polymetallic vein, copper skarn, and tungsten skarn; *J*, Assessment tracts for porphyry copper, copper skarn, polymetallic vein, and tungsten skarn; *K*, Assessment tract for polymetallic replacement; *L*, Assessment tract for molybdenum-tungsten greisen; *M*, Assessment tract for polymetallic vein; *N*, Assessment tract for distal disseminated gold-silver and polymetallic vein; *O*, Assessment tract for Climax-type porphyry molybdenum; *P*, Assessment tracts for distal disseminated silver-gold, polymetallic replacement, and polymetallic vein; *Q*, Assessment tract for multiple intrusion-related deposit types; *R*, Assessment tracts for volcanogenic massive sulfide (Besshi-subtype); *S*, Assessment tracts for Carlin-type gold (silver, mercury, antimony); *T*, Assessment tracts for lacustrine diatomite; and *U*, Assessment tracts for bedded barite.—Continued



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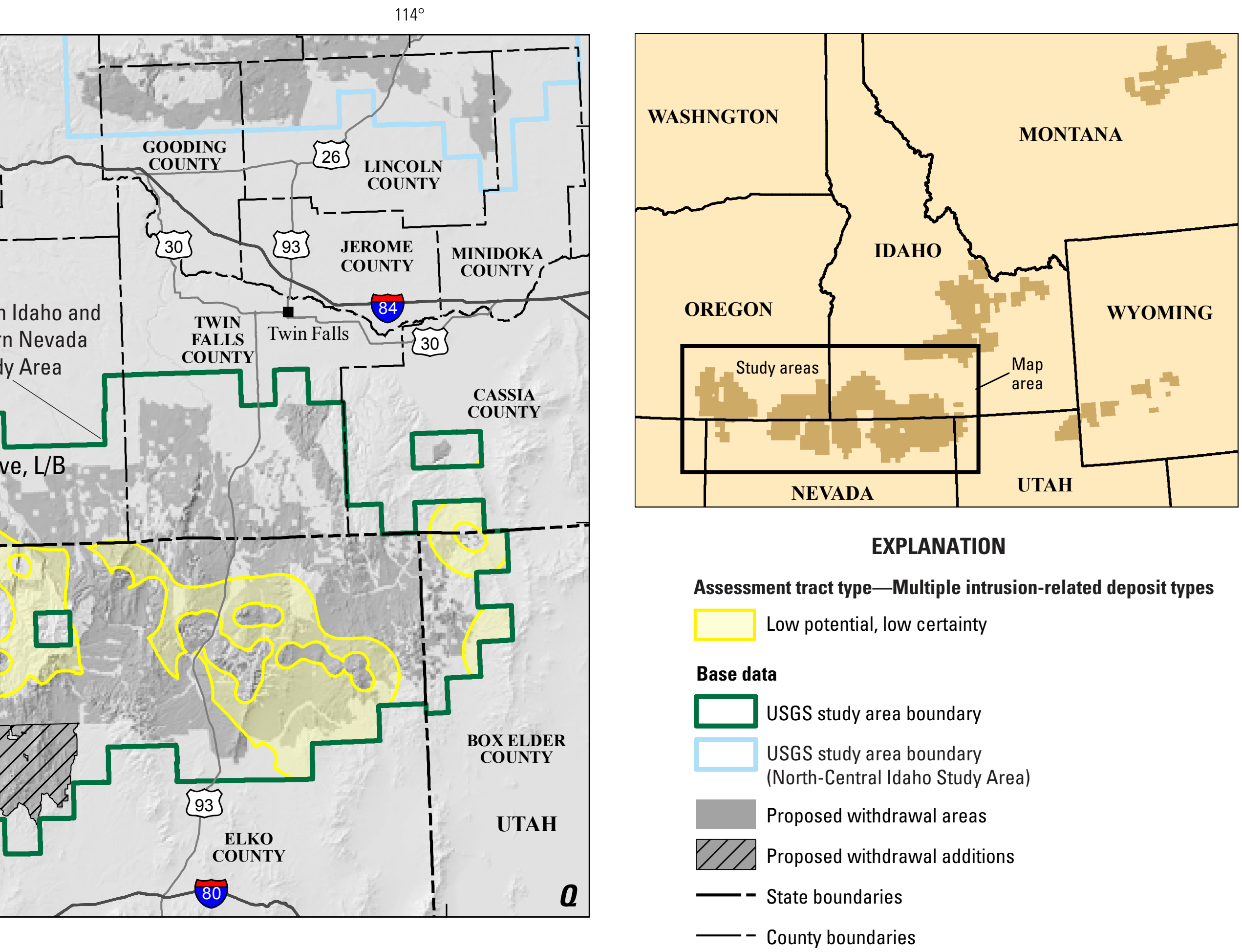
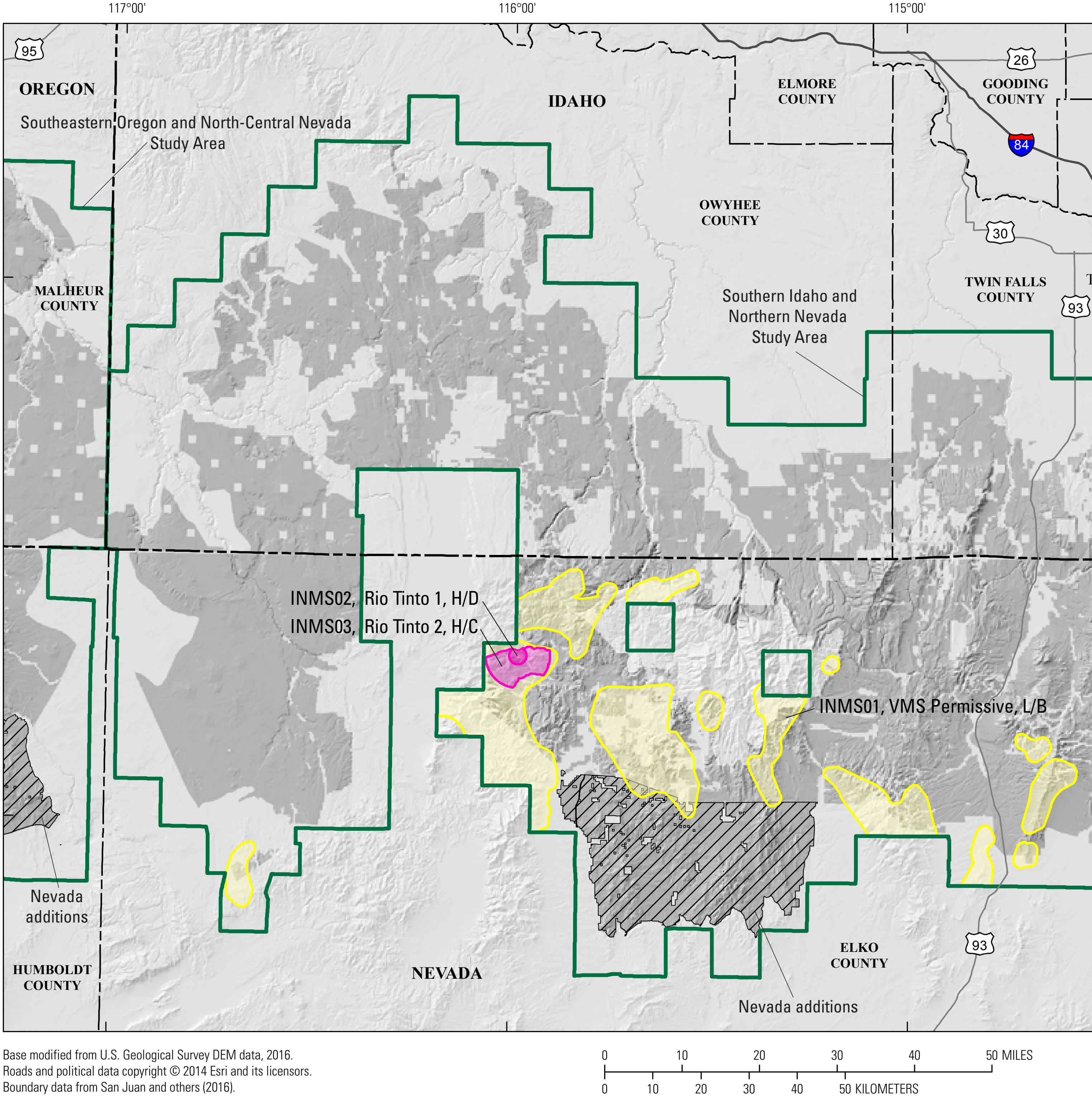
USA Contiguous Albers Equal Area Conic Projection.
Central meridian, 118° W., latitude of origin, 37.5° N.
North American Datum of 1983.

Figure 31*A*–*U*. Maps showing assessment tracts for metallic locatable minerals and nonmetallic locatable minerals in the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, Nevada, Idaho, and Utah (San Juan and others, 2016); USGS, U.S. Geological Survey; *A*, Assessment tracts for epithermal gold-silver (mercury); *B*, Assessment tract for hydroallogenic volcanic-hosted uranium; *C*, Assessment tracts for polymetallic vein, porphyry copper, copper skarn, and arc-related porphyry molybdenum (low-fluorine); *D*, Assessment tract for distal disseminated gold-silver; *E*, Assessment tracts for polymetallic replacement, polymetallic vein, and tungsten vein; *F*, Assessment tracts for tungsten skarn and polymetallic vein; *G*, Assessment tracts for distal disseminated gold-silver, polymetallic vein and skarn; *H*, Assessment tract for polymetallic vein;



I, Assessment tracts for polymetallic vein, copper skarn, and tungsten skarn; *J*, Assessment tracts for porphyry copper, copper skarn, polymetallic vein, and tungsten skarn; *K*, Assessment tract for polymetallic replacement; *L*, Assessment tract for molybdenum-tungsten greisen; *M*, Assessment tract for polymetallic vein; *N*, Assessment tract for distal disseminated gold-silver and polymetallic vein; *O*, Assessment tract for Climax-type porphyry molybdenum; *P*, Assessment tracts for distal disseminated silver-gold, polymetallic replacement, and polymetallic vein; *Q*, Assessment tract for multiple intrusion-related deposit types; *R*, Assessment tracts for volcanogenic massive sulfide (Besshi-subtype); *S*, Assessment tracts for Carlin-type gold (silver, mercury, antimony); *T*, Assessment tracts for lacustrine diatomite; and *U*, Assessment tracts for bedded barite.—Continued



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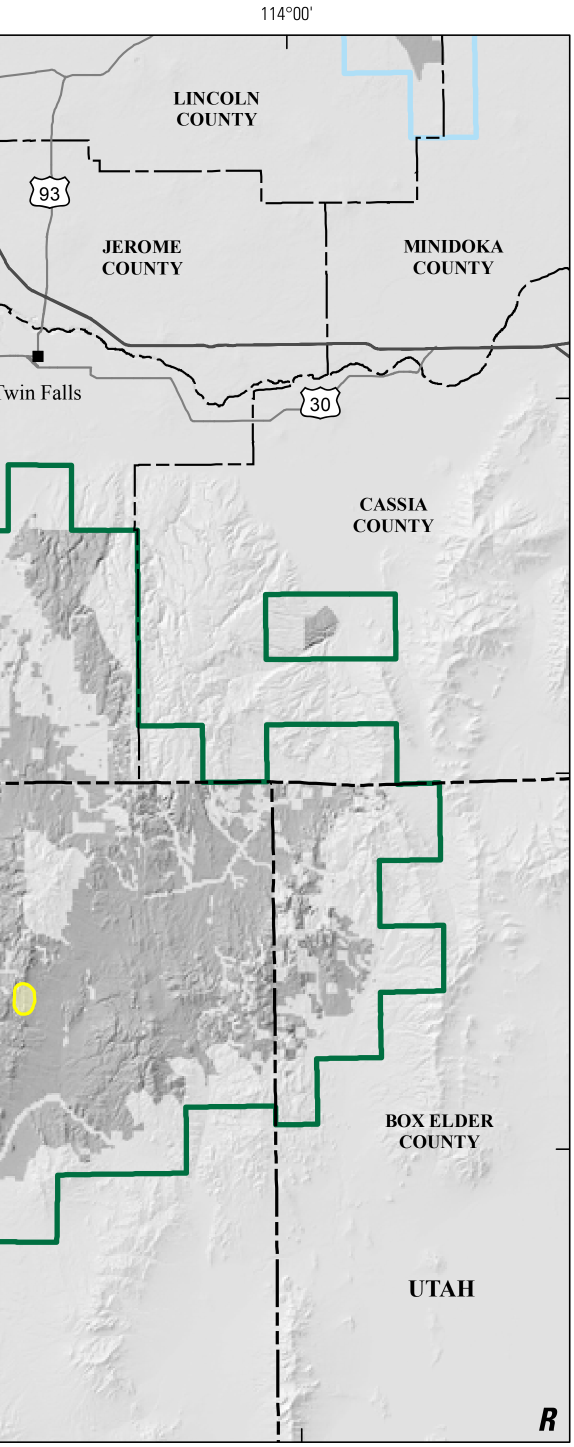
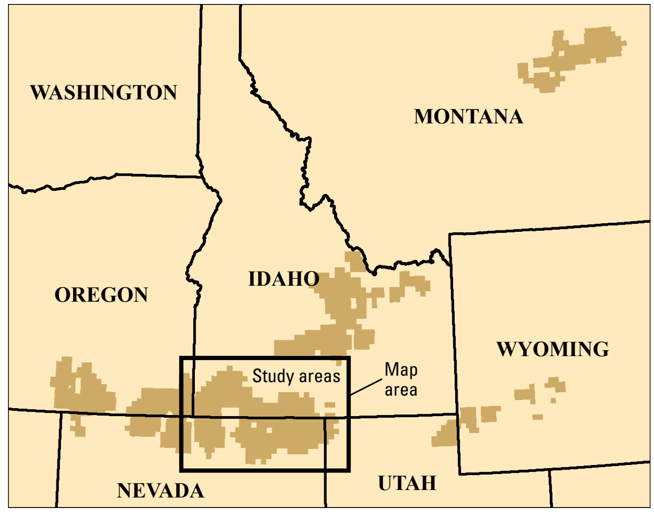




EXPLANATION

Assessment tract type—Volcanogenic massive sulfide (Besshi-subtype)

High potential, high certainty

High potential, moderate certainty

Low potential, low certainty

Base data

USGS study area boundary

USGS study area boundary (North-Central Idaho Study Area)

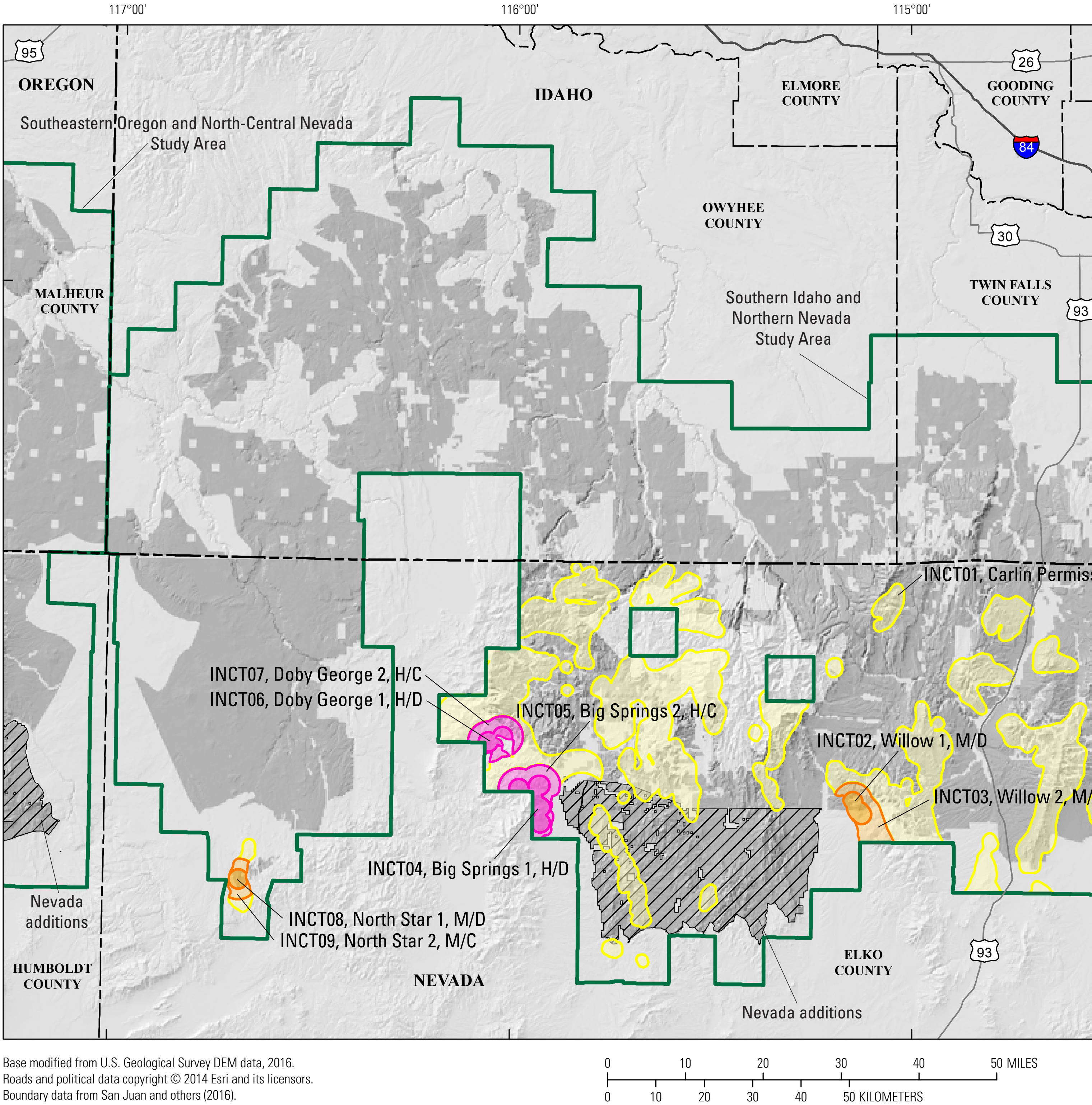
Proposed withdrawal areas

Proposed withdrawal additions

State boundaries

County boundaries

I, Assessment tracts for polymetallic vein, copper skarn, and tungsten skarn; *J*, Assessment tracts for porphyry copper, copper skarn, polymetallic vein, and tungsten skarn; *K*, Assessment tract for polymetallic replacement; *L*, Assessment tract for molybdenum-tungsten greisen; *M*, Assessment tract for polymetallic vein; *N*, Assessment tract for distal disseminated gold-silver and polymetallic vein; *O*, Assessment tract for Climax-type porphyry molybdenum; *P*, Assessment tracts for distal disseminated silver-gold, polymetallic replacement, and polymetallic vein; *Q*, Assessment tract for multiple intrusion-related deposit types; *R*, Assessment tracts for volcanogenic massive sulfide (Besshi-subtype); *S*, Assessment tracts for Carlin-type gold (silver, mercury, antimony); *T*, Assessment tracts for lacustrine diatomite; and *U*, Assessment tracts for bedded barite.—Continued



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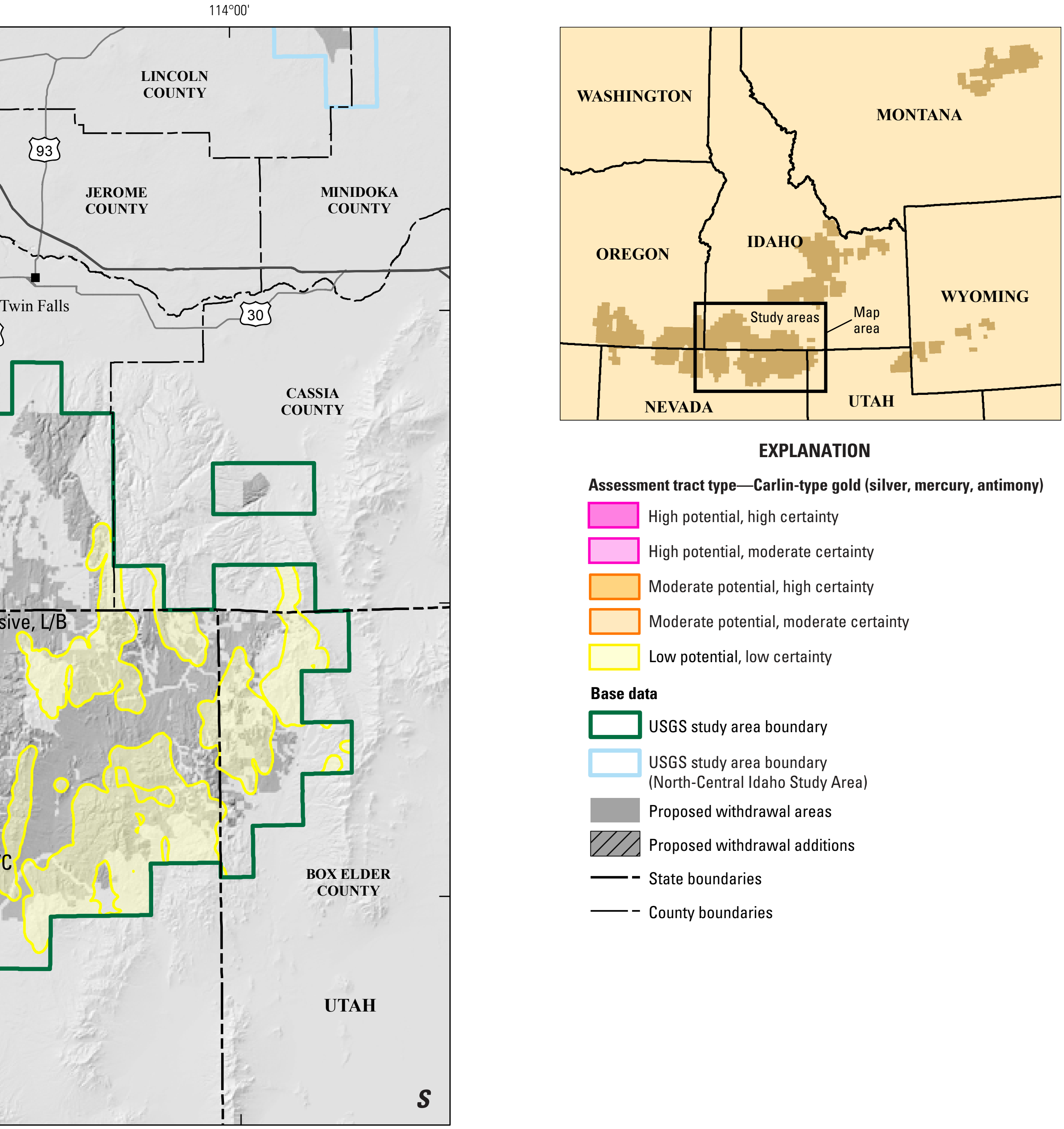
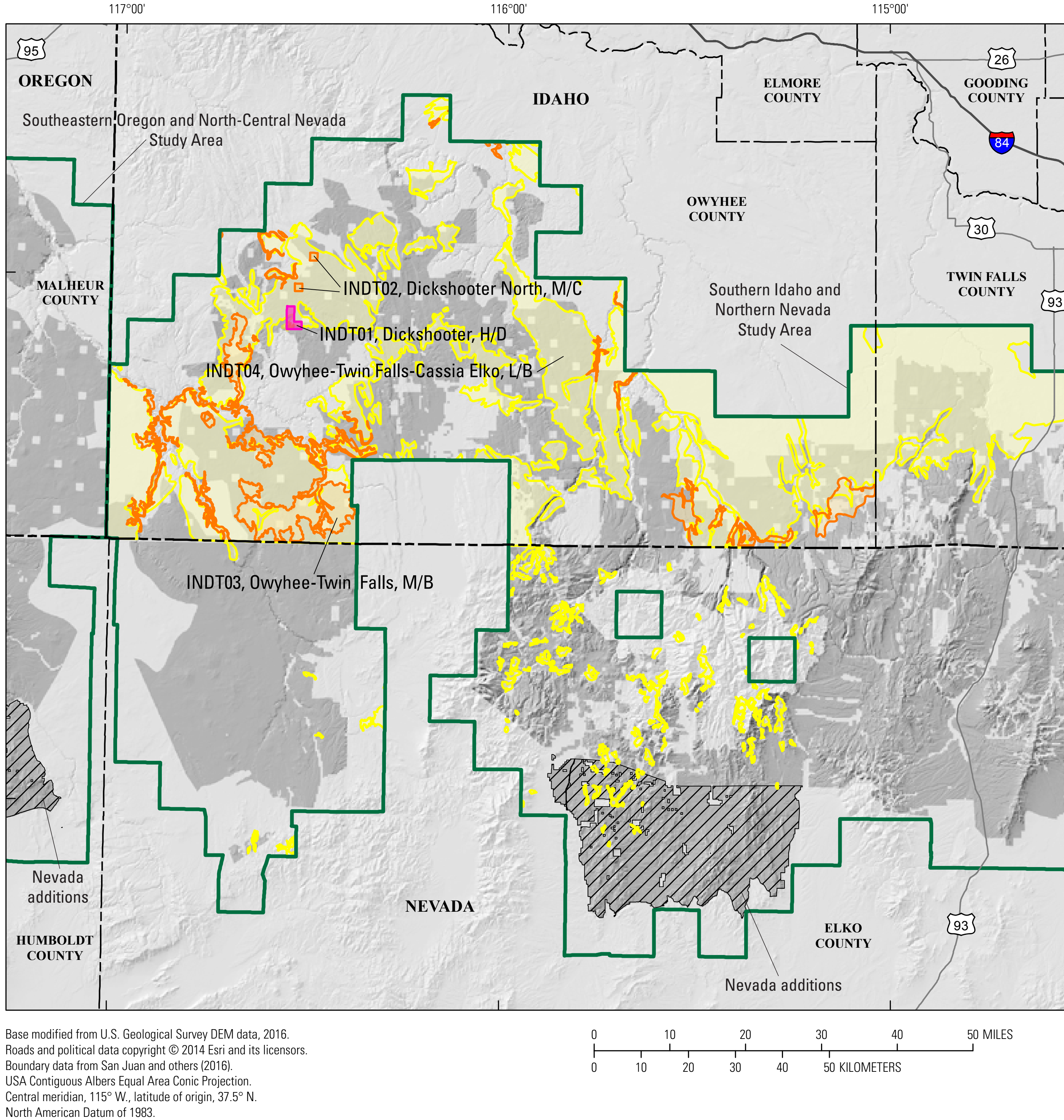
Central meridian, 115° W., latitude of origin, 37.5° N.
North American Datum of 1983.

Figure 31*A*–*U*. Maps showing assessment tracts for metallic locatable minerals and nonmetallic locatable minerals in the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, Nevada, Idaho, and Utah (San Juan and others, 2016); USGS, U.S. Geological Survey; *A*, Assessment tracts for epithermal gold-silver (mercury); *B*, Assessment tract for hydroallogenic volcanic-hosted uranium; *C*, Assessment tracts for polymetallic vein, porphyry copper, copper skarn, and arc-related porphyry molybdenum (low-fluorine); *D*, Assessment tract for distal disseminated gold-silver; *E*, Assessment tracts for polymetallic replacement, polymetallic vein, and tungsten vein; *F*, Assessment tracts for tungsten skarn and polymetallic vein; *G*, Assessment tracts for distal disseminated gold-silver, polymetallic vein and skarn; *H*, Assessment tract for polymetallic vein;



I, Assessment tracts for polymetallic vein, copper skarn, and tungsten skarn; *J*, Assessment tracts for porphyry copper, copper skarn, polymetallic vein, and tungsten skarn; *K*, Assessment tract for polymetallic replacement; *L*, Assessment tract for molybdenum-tungsten greisen; *M*, Assessment tract for polymetallic vein; *N*, Assessment tract for distal disseminated gold-silver and polymetallic vein; *O*, Assessment tract for Climax-type porphyry molybdenum; *P*, Assessment tracts for distal disseminated silver-gold, polymetallic replacement, and polymetallic vein; *Q*, Assessment tract for multiple intrusion-related deposit types; *R*, Assessment tracts for volcanogenic massive sulfide (Besshi-subtype); *S*, Assessment tracts for Carlin-type gold (silver, mercury, antimony); *T*, Assessment tracts for lacustrine diatomite; and *U*, Assessment tracts for bedded barite.—Continued



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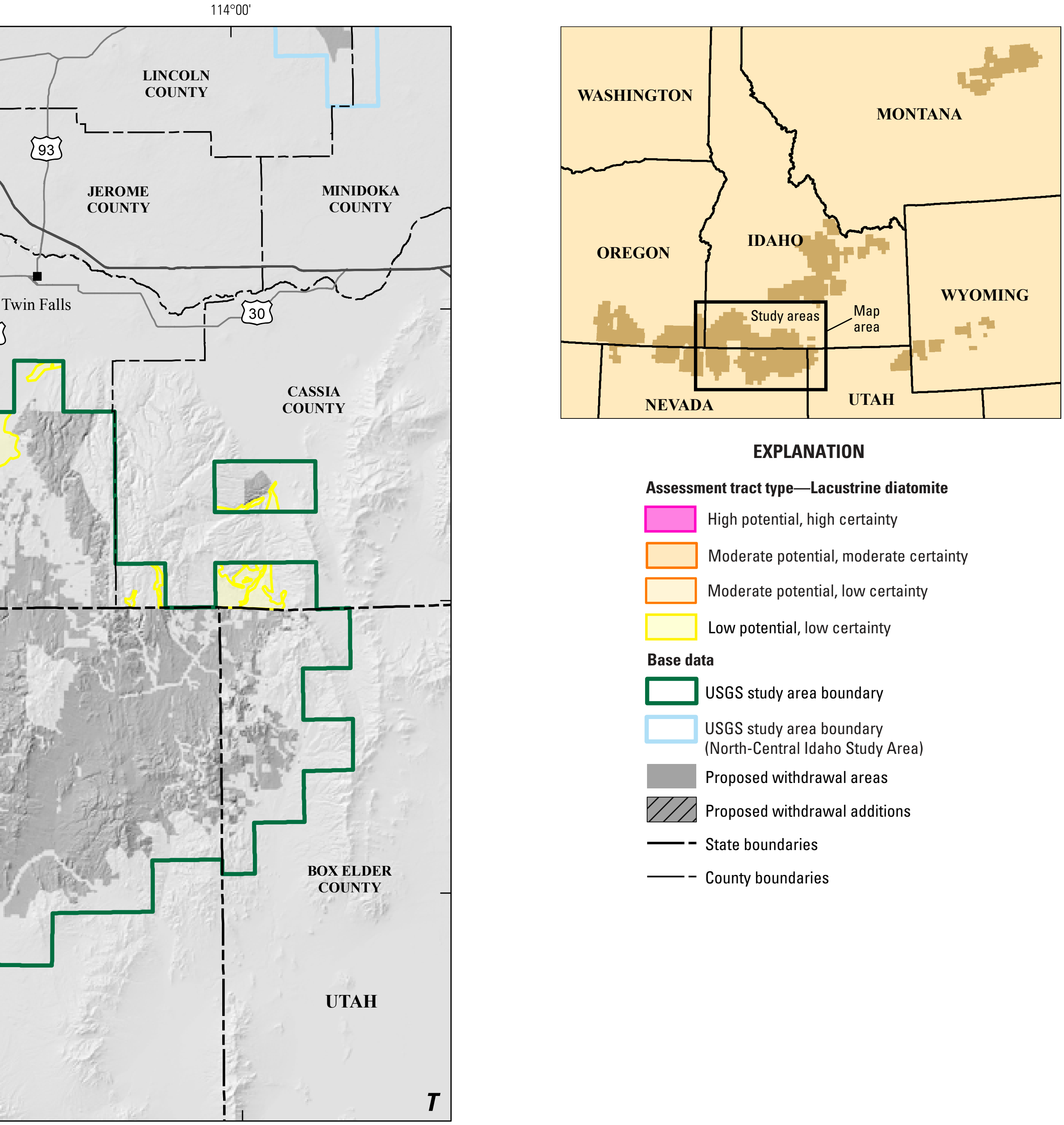
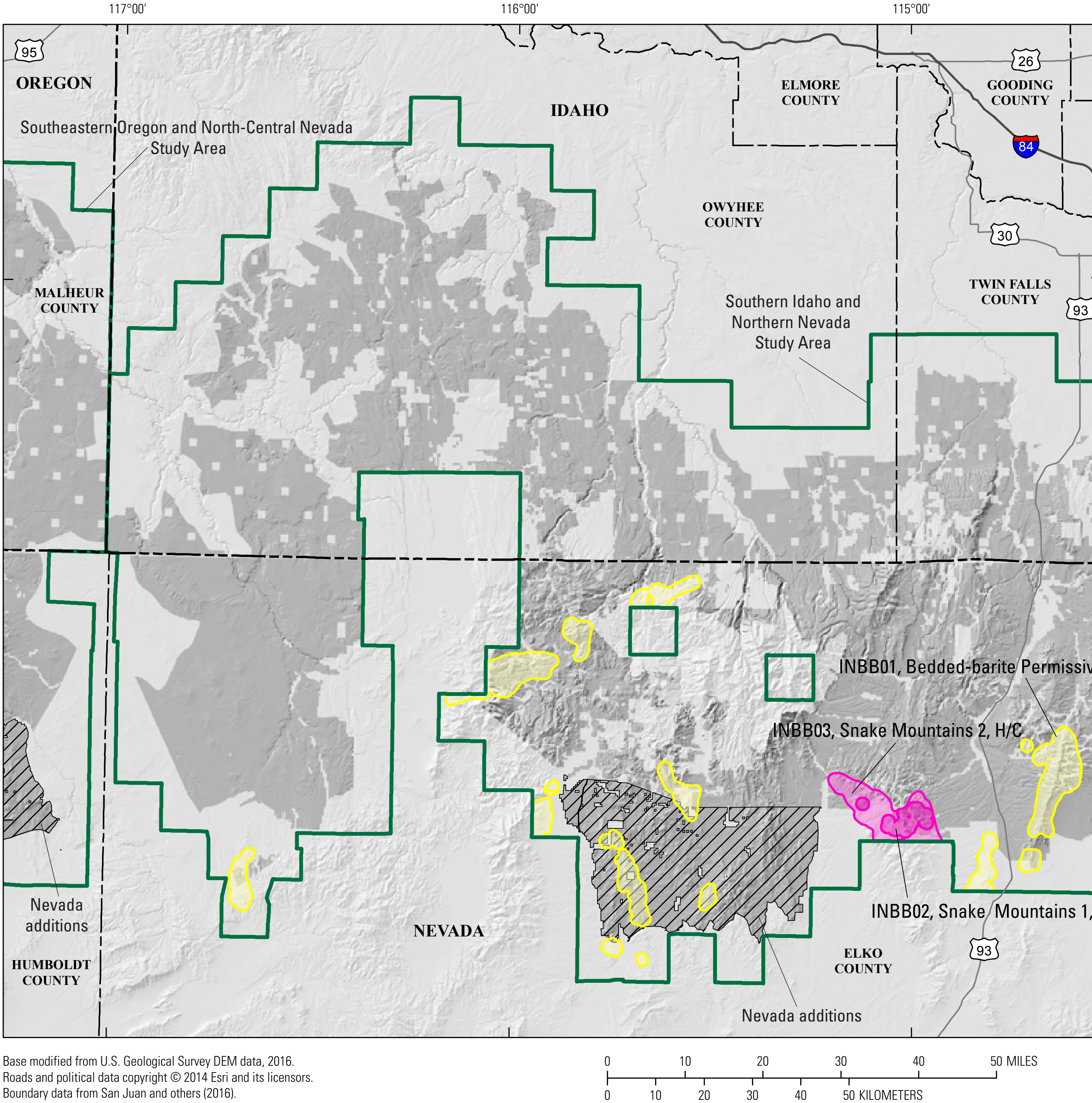


I, Assessment tracts for polymetallic vein, copper skarn, and tungsten skarn; *J*, Assessment tracts for porphyry copper, copper skarn, polymetallic vein, and tungsten skarn; *K*, Assessment tract for polymetallic replacement; *L*, Assessment tract for molybdenum-tungsten greisen; *M*, Assessment tract for polymetallic vein; *N*, Assessment tract for distal disseminated gold-silver and polymetallic vein; *O*, Assessment tract for Climax-type porphyry molybdenum; *P*, Assessment tracts for distal disseminated silver-gold, polymetallic replacement, and polymetallic vein; *Q*, Assessment tract for multiple intrusion-related deposit types; *R*, Assessment tracts for volcanogenic massive sulfide (Besshi-subtype); *S*, Assessment tracts for Carlin-type gold (silver, mercury, antimony); *T*, Assessment tracts for lacustrine diatomite; and *U*, Assessment tracts for bedded barite.—Continued



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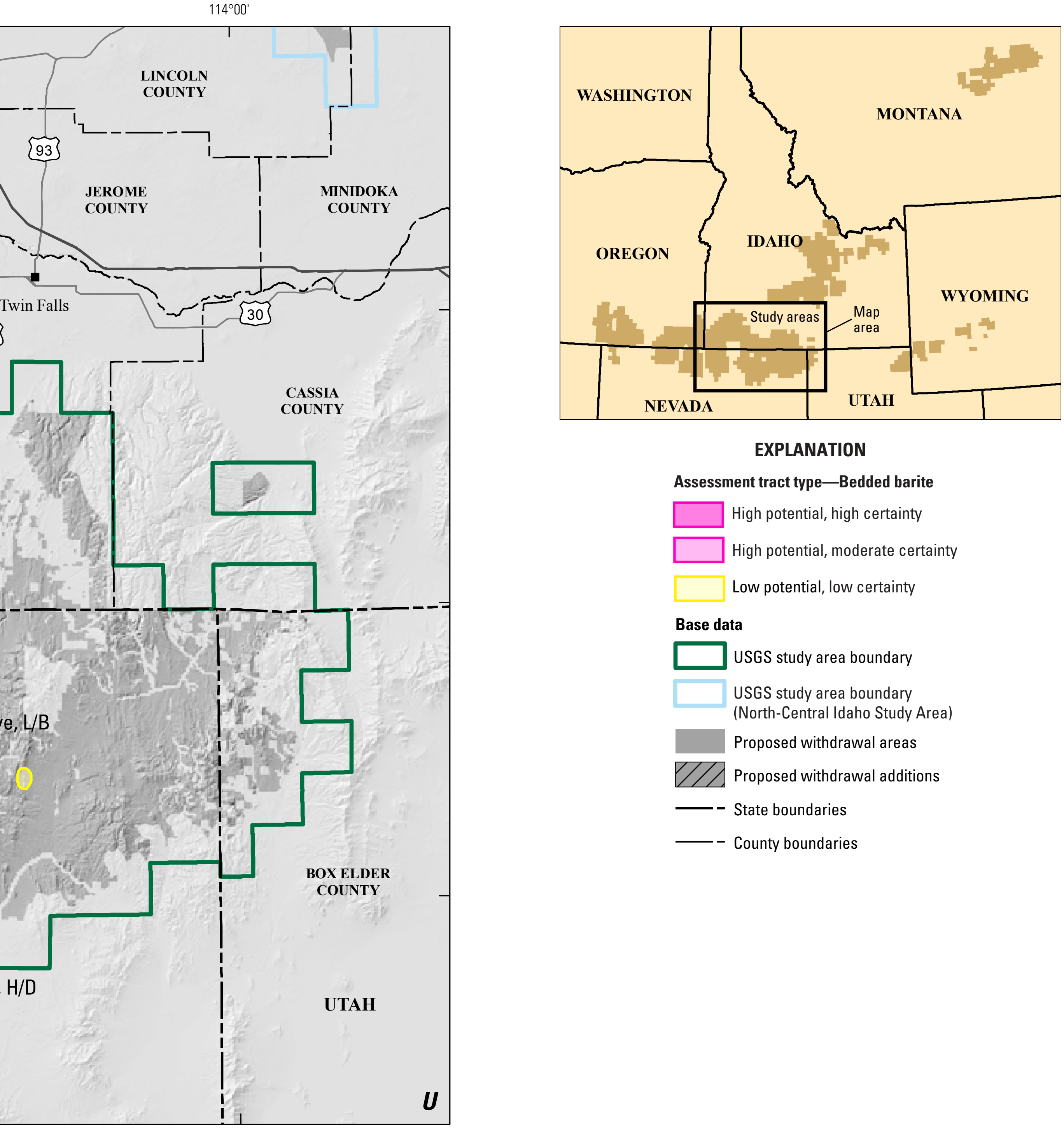
USA Contiguous Albers Equal Area Conic Projection.
Central meridian, 115° W., latitude of origin, 37.5° N.
North American Datum of 1983.

Figure 31*A*–*U*. Maps showing assessment tracts for metallic locatable minerals and nonmetallic locatable minerals in the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, Nevada, Idaho, and Utah (San Juan and others, 2016); USGS, U.S. Geological Survey; *A*, Assessment tracts for epithermal gold-silver (mercury); *B*, Assessment tract for hydroallogenic volcanic-hosted uranium; *C*, Assessment tracts for polymetallic vein, porphyry copper, copper skarn, and arc-related porphyry molybdenum (low-fluorine); *D*, Assessment tract for distal disseminated gold-silver; *E*, Assessment tracts for polymetallic replacement, polymetallic vein, and tungsten vein; *F*, Assessment tracts for tungsten skarn and polymetallic vein; *G*, Assessment tracts for distal disseminated gold-silver, polymetallic vein and skarn; *H*, Assessment tract for polymetallic vein;



I, Assessment tracts for polymetallic vein, copper skarn, and tungsten skarn; *J*, Assessment tracts for porphyry copper, copper skarn, polymetallic vein, and tungsten skarn; *K*, Assessment tract for polymetallic replacement; *L*, Assessment tract for molybdenum-tungsten greisen; *M*, Assessment tract for polymetallic vein; *N*, Assessment tract for distal disseminated gold-silver and polymetallic vein; *O*, Assessment tract for Climax-type porphyry molybdenum; *P*, Assessment tracts for distal disseminated silver-gold, polymetallic replacement, and polymetallic vein; *Q*, Assessment tract for multiple intrusion-related deposit types; *R*, Assessment tracts for volcanogenic massive sulfide (Besshi-subtype); *S*, Assessment tracts for Carlin-type gold (silver, mercury, antimony); *T*, Assessment tracts for lacustrine diatomite; and *U*, Assessment tracts for bedded barite.—Continued

consists of upper Paleozoic and Triassic limestone, siltstone, and chert overlain by Tertiary conglomerates and Miocene rhyolite tuffs. All of these rocks are intruded by Miocene rhyolites and dacites (Coats, 1987; Miller and others, 2012). Several types of gold and silver deposits occur in the tract, including epithermal quartz-carbonate veins that locally crop out in the pre-Tertiary limestones, disseminated deposits in Tertiary conglomerates and underlying calcareous sandstone and limestone, and breccia-hosted deposits along the margins of a Miocene rhyolite intrusion (Goodall, 2003; Kehmeier, 2009; Pilot Gold, 2011; Ramelius Resources Limited, 2012).

The tract was delineated using a 3-km buffer around the Angel Wing, Viper, and White Rock exploration projects (Fernette and others, 2016a). Surface samples and significant intervals in drill holes at the Viper and Angel Wing exploration projects locally contain highly anomalous concentrations of gold (more than 1 part per million [ppm]) and silver (more than 20 ppm) (Pilot Gold, 2011; Ramelius Resources Limited, 2012). The White Rock project has a resource (non-NI 43-101 compliant) of approximately 150,000 oz gold (Goodall, 2003; Kehmeier, 2009). Stream-sediment samples from the area have anomalous concentrations of mercury and selenium. Numerous active lode claims have been located and three active exploration areas are in the tract (Fernette and others, 2016a; tables 16, 17, 18, 19). Active notices, closed plans of operations, and numerous closed and historic lode claims are in the tract (figs. 28, 29; tables 16, 17; Causey, 2007, 2011).

Tract INEP07, Oakley—A high potential (H), at certainty level D, for epithermal gold and silver deposits is assigned to an area in the Goose Creek Basin on the west side of the Middle Mountain in southwestern Idaho just north of the Utah border (tract INEP07, Oakley; fig. 31*A*; appendix 2). The area consists of the late Miocene Salt Lake Formation that was deposited in Goose Creek Basin, a north-trending graben on the west side of Middle Mountain (Sturm, 2013). Middle Mountain is along the western edge of the Albion-Raft River-Grouse Creek metamorphic core complex, which is composed of ductilely deformed Precambrian through Mesozoic intrusive and metamorphic rocks that are structurally overlain by a series of brittle Paleozoic rocks, including quartzite, limestone, and minor phyllite (Sturm, 2013). The Goose Creek Basin is filled by the late Miocene Salt Lake Formation, which consists of tuffaceous siltstone, sandstone, conglomerate, and tuffs, and locally contains hot spring deposits. The Blue Hill Creek exploration project has a resource (NI 43-101 compliant) of approximately 230,400 oz of gold (appendix 2; Sturm, 2013).

The tract was delineated using a 3-km buffer around epithermal prospects in the late Miocene sedimentary rocks, including the drilled gold resource at Blue Hill Creek exploration project, prospects at Cold Creek with strongly anomalous gold values in drill holes, and active exploration areas (Sturm, 2013). Hot spring deposits, including sinter and silicified hydrothermal vent breccia, are preserved at the Blue Hill Creek exploration project in the Miocene sedimentary rocks (Sturm, 2013). A pronounced radiometric thorium/potassium (Th/K) low over the Miocene sedimentary rocks (Day and others, 2016) is suggestive of potassic alteration (see, for example, Morrell and others, 2011). The tract includes four active exploration projects, numerous active lode claims (tables 16, 17), and numerous closed and historic lode claims (figs. 28, 29; tables 16, 17; Causey, 2007, 2011).

Tract INEP08, Star Lake—A moderate (M) potential, with certainty B, for epithermal gold and silver deposits is assigned to an area of the Owyhee Plateau along the Humboldt-Elko County line, about 55 km northeast of the town of Paradise Valley (tract INEP08, Star Lake; fig. 31*A*; appendix 2). This area is characterized by subhorizontal Miocene ash-flow tuffs, overlain by slightly younger basalts and continental sediments. No mineral exploration activity was recorded prior to 2006 when a project was established to explore stream-sediment geochemical anomalies reported by the USGS (Coombs and others, 2002; Ludington and others, 2006).

The tract was delineated using a 3-km buffer around the project boundaries (Fernette and others, 2016a). The stream-sediment geochemical anomalies that led to discovery of the prospect are characterized by antimony values as high as 550 ppm, 5–7 ppm arsenic, and 50–75 ppm zinc. Detailed ground geochemical surveys have delineated arsenic anomalies of 100 to 600 ppm (Altan Nevada Minerals Ltd., 2016). A small positive residual Bouguer gravity anomaly that coincides with the central part of the project area has been interpreted to be similar to the signature of the northern part of the Carlin Trend (Altan Nevada Minerals Ltd., 2016). ASTER satellite imagery shows scattered pixels indicative of sericite (Rockwell and others, 2015). Modeling of the gravity data suggests that the Paleozoic basement is less than 1 km beneath the surface (Ponce, 2004); the original target was Carlin-type gold mineralization along the extension of the Carlin Trend. However, four widely spaced core holes (340–770 m in depth) in 2009 revealed a hydrothermal system in Miocene rhyolite at depths below 450 m that is characterized by quartz veining, argillization, and brecciation, with anomalous gold values of as much as 0.101 g/t (gram per metric ton; approximately equal to part per million; Altan Nevada Minerals Ltd., 2016). The tract includes closed and historic lode claims and an active exploration area (figs. 28, 29, 30; tables 16, 17; Causey, 2007, 2011)

Tract INEP09, Gollaher—A moderate potential (M), with certainty level C, for epithermal gold and silver deposits is assigned to an area centered on the Gollaher exploration project (Fernette and others, 2016a), which extends into the proposed withdrawal area (tract INEP09, Gollaher; fig. 31*A*; appendix 2). This tract is based on several prospects in Mississippian to Permian siliciclastic and carbonate rocks and Miocene tuffaceous volcanic and sedimentary rocks that locally are overlain by Miocene Jarbidge Rhyolite or Quaternary alluvium (Crafford, 2007). The tract includes these Paleozoic, Miocene, and Quaternary units and a 1-km buffer to account for volcanic rock and alluvial cover and uncertainty of mapped contacts. Although this active exploration area has potential for Carlin-type gold deposits and epithermal gold and silver deposits, according to company reports (West Kirkland Mining Inc., 2010, 2012), the area more closely resembles nearby epithermal tracts (for example, tract INEP06, Angel Wing) that include gold and silver vein mineralization in volcanic rocks, and disseminated gold and silver mineralization in underlying sedimentary rocks. The exploration projects derive from rock and soil geochemical surveys and drilling in the 1980s (West Kirkland Mining Inc., 2010, 2012). The tract encloses an active exploration area (Fernette and others, 2016a) with one drill intercept that contains 18.9 ppm gold over 60 cm (West Kirkland Mining Inc., 2010, 2012). Although little or no argillic or sericitic alteration is evident on interpreted ASTER imagery (Rockwell and others, 2016), quartz was mapped from interpretation of ASTER thermal emission data (Rockwell and Hofstra, 2008). There is one closed notice for gold on the east side of the tract (figs. 28, 29; tables 18, 19). The tract is largely on private land, which accounts for the paucity of published information on exploration activity.

Buffering Epithermal Gold and Silver Tracts

The epithermal gold and silver tracts described previously were delineated from characteristics of epithermal gold, silver, and mercury deposits on the basis of the deposit model, which was assembled from characteristics of well-documented epithermal gold, silver, and mercury deposits and the magmatic-hydrothermal systems that formed the deposits (Day and others, 2016; appendix 2). Some of these characteristics may be concealed (for example, altered rocks covered by younger rocks; drill-defined gold and silver resources; deposits identified by drill-hole intercepts with elevated gold and silver values) and do not appear on published maps (geologic; topographic) or in other publications. Gold and silver occurrences on published maps and in other publications were the first criterion used to delineate possible concealed and unmapped epithermal gold and silver deposits. Other criteria used include the alteration and geochemical signatures of the magmatic-hydrothermal systems that form epithermal gold and silver deposits. The approximate diameters of footprints (surface exposures) of well-exposed epithermal gold and silver systems, based largely on mapped gold and silver occurrences, alteration, and geochemistry, range from several hundred meters to about 10 km, and are mostly 10–20 km^2 in the study areas (appendix 5). If the areas of well-exposed systems are geometrically represented by circles concentric to mapped or published gold and silver occurrences, then circles enclosing systems that formed epithermal gold and silver deposits in the study areas have radii of 1.8–2.6 km. Based on the distribution and spatial density of gold and silver occurrences in the study areas, a circle with a radius of 3 km centered on occurrences was used to delineate tracts. Tract boundaries represent the merged circumferences of circles concentric to all gold and silver occurrences within the tract.

Mineral Potential Tract for Hydroallogenic Uranium Deposits

One mineral potential tract for hydroallogenic uranium deposits was delineated and rated in this study area: tract INHU01, Racetrack.

Tract INHU01, Racetrack—Nineteen uranium occurrences near Mountain City, Nevada, support delineation of the Racetrack permissive tract that has high potential (H) for uranium deposits, with certainty level D (tract INHU01, Racetrack; fig. 31*B*; appendix 2). The uranium occurrences, which fit the hydroallogenic uranium deposit type (Day and others, 2016), are near a Tertiary erosional surface represented by the contact between Cretaceous quartz monzonite and overlying Miocene volcanic rocks (Garside, 1973; Proffitt and others, 1982). The tract boundary is based on the distribution of the uranium occurrences, the presence of favorable host rocks, and anomalous uranium values (as much as 479 ppm uranium) in soil, rock, and talus samples (Proffitt and others, 1982; U.S. Geological Survey, 2005; Fernette and others, 2016a; Smith, 1997; Smith and others, 2016).

Cumulative production of 20,876 lbs U_3O_8 in the 1950s and 1960s is reported from three mines and claim groups in this tract; the Rim Rock Mine (4,240 lbs of U_3O_8), Race Track Mine (9,866 lbs of U_3O_8), Happy Joe Mine (2,259 lbs of U_3O_8), and the South Fork and Pixley Claims (4,511 lbs of U_3O_8; table 20; Garside, 1973; Proffitt and others, 1982). Rock samples collected near the uranium occurrences contain 6–3,745 ppm U_3O_8, and the average grade of ore ranged from 0.12 percent to 0.5 percent U_3O_8 (Garside, 1973; Proffitt and others, 1982).

The Race Track Mine and Autunite prospect were explored by Samba Gold (Samba Gold Inc., 2007a,b). Bayswater Uranium Corporation established a land position in the area and acquired a resource from Pathfinder Mines Corporation of 1.1 Mlbs of U_3O_8 defined by 359 holes drilled from 1967 to 1983 (Bayswater Uranium Corporation, 2007). The tract boundary was modified from Proffitt and others (1982) by adding a 2-km buffer to correct for an error in georeferencing the original NURE (National Uranium Resource Evaluation) tract. Uranium occurrences and geochemical anomalies are located in the southwestern part of the tract. The rest of the tract is delineated by the occurrence of permissive Tertiary sedimentary and volcanoclastic source and host rocks that were deposited on a Tertiary erosional surface.

Hydroallogenic deposits form when uranium-enriched fluids are released from volcanic source rocks, transported by aqueous solutions, and concentrated in the same or nearby rocks (Mickle and Mathews, 1978). Three types of hydroallogenic deposits are identified in the Racetrack tract: (1) secondary uranium minerals in paleochannels or lows that are filled with Tertiary conglomerate, sandstone, and volcanic ash-flow tuffs; (2) uranium concentrated in shear zones and joints within volcanic rocks; and (3) uranium in Cretaceous granite shear zones and grus that were originally overlain by Tertiary sedimentary and volcanic ash-flow tuffs (Proffitt and others, 1982). In this tract, the sources of uranium are likely weathered Eocene volcanic rocks with some contribution from weathered Cretaceous granites. The deposits formed between 40 and 20 million years ago where groundwater leached uranium from local ash-flow tuffs or granites and redeposited this uranium in zones of high porosity and permeability (faults or poorly consolidated sediments below ash-fall tuffs) (Proffitt and others, 1982). Uranium was chemically trapped and removed from groundwater by montmorillonite clay that is derived from alteration of volcanic rocks and by carbonaceous debris incorporated into the volcanic and sedimentary host rocks. Potential for significant uranium deposits may be limited by the disparate nature of these chemical traps within host sediments.

Stratigraphy Favorable for Uranium Deposits

In the easternmost portion of the study area, uranium-rich lignite and carbonaceous shale have been identified in the Goose Creek Basin (U.S. Department of Energy, 1980; Gallant, 1982; also see report section “Leasable Minerals; Coal”). Uranium produced in this area would likely be a byproduct of lignite mining, which is unlikely to occur based on the low quality of lignite as a solid fuel.

A number of uranium occurrences are described near Contact, Elko County, Nevada, including the Pink Horse, Contact occurrences, Texas Canyon project, and Podner and Prince Claims (U.S. Geological Survey, 2005; Fernette and others, 2016a). These occurrences may represent the hydroallogenic uranium deposit type similar to those in the Racetrack tract. In 2007, Gold Reef International evaluated a 0.50-square-mile (mi^2) area around the Prince Claim and reported anomalous radioactivity and rock samples that contained as much as 1 percent U_3O_8 within a mineralized fault breccia (Gold Reef International, 2007). However, no resources or production are reported for occurrences in this area; therefore, a uranium tract was not delineated.

Scattered uranium occurrences associated with polymetallic deposits and with volcanic domes, intrusions, and volcanoclastic sediments are reflected mainly by geochemical and geophysical anomalies, trenches, and prospect pits (Berry and others, 1982; Castor and others, 1982a,b; Gallant, 1982; Garside, 1982; Proffitt and others, 1982; Dayvault, 1983; U.S. Geological Survey, 2005; Fernette and others, 2016a). Castor and others (1982a,b) also note that Basin and Range faulting throughout the region has created basins that, coupled with abundant uranium-rich felsic volcanic and granitic source rocks, hold potential for hosting uranium deposits that has not been evaluated. However, no clear clustering of these anomalies occurs in the study area, nor is there reported production or reserves that would support delineation of higher potential tracts.

Mineral Potential Tracts for Intrusion-Related Deposits, Including Porphyry Copper, Porphyry Molybdenum, Polymetallic Skarn, Replacement, and Vein, Tungsten Greisen Deposits, and Distal Disseminated Silver-Gold Deposits

Fifteen tracts and tract groups were delineated and rated for various intrusion-related deposits, including porphyry copper and molybdenum deposits; polymetallic (copper-lead-zinc-tungsten-silver-gold) skarn, replacement, and vein deposits; and distal disseminated silver-gold deposits: tract INPR02, Pluton-related Permissive; tract INPR02_pCu, Mountain City Porphyry Copper, tract INPR02_pMo, Mountain City Porphyry Molybdenum, and tract INPR02_pmv, Mountain City Polymetallic Vein; tract INPR03, Cobb Creek; tract INPR04_pmr, Blue Jacket Polymetallic Replacement, tract INPR04_pmv, Blue Jacket Polymetallic Vein, and tract INPR04_Wv, Blue Jacket Tungsten Vein; tract INPR05_pmv, Alder Polymetallic Vein and tract INPR05_WMosk, Alder Tungsten-Molybdenum Skarn; tract INPR06_dd, Island Mountain Distal Disseminated Gold-Silver and tract INPR06_pmv, Island Mountain Polymetallic Vein and Skarn; tract INPR07, Charleston; tract INPR08_Cusk, Elk Mountain Copper Skarn, tract INPR08_WMosk, Elk Mountain Tungsten-Molybdenum Skarn, and tract INPR08_pmv, Elk Mountain Polymetallic Vein; tract INPR09_pCu, Contact Porphyry Copper, tract INPR09_Cusk, Contact Copper Skarn, tract INPR09_Wsk, Contact Tungsten Skarn, and tract INPR09_pmv, Contact Polymetallic Vein; tract INPR10, Delano; tract INPR11, Indian Springs; tract INPR12, Gold Basin; tract INPR13, Texas Canyon; tract INPR14, Scraper Springs; tract INPR15_pmr, Ashbrook Polymetallic Replacement, tract INPR15_dd, Ashbrook Distal Disseminated Silver-Gold, and tract INPR15_pmv, Ashbrook Polymetallic Vein (San Juan and others, 2016).

Tract INPR02_pCu, Mountain City Porphyry Copper—There is moderate (M) potential, with certainty level B, for porphyry copper deposits in the Mountain City and Hicks Mining Districts near Mountain City, Elko County, Nevada (LaPointe and others, 1991; fig. 31*C*; appendix 2). The geology of the area is characterized by Paleozoic sedimentary and metavolcanic formations that are intruded by the Late Cretaceous Mountain City, Enright Hill, McDonald Creek, and Summit Creek plutons (Coats and McKee, 1972; Crafford, 2007; du Bray and Crafford, 2007). Eocene volcanic and volcaniclastic rocks rest unconformably on Mesozoic and older strata. Miocene volcanic and volcaniclastic rocks cover older strata and are most widespread to the north and east of the Mountain City district. Paleozoic formations are tilted moderately to steeply northward and are cut by reverse faults. Younger, steep normal faults cut the quartz monzonite and older rocks. Miocene and older rocks are in turn cut by younger north- and east-trending normal faults (Coats, 1987; LaPointe and others, 1991).

In the Mountain City district, silver-gold lode and associated placer deposits were discovered in 1869 causing a rush that led to the founding of the town of Mountain City. Mining from polymetallic veins in the district continued into the early 1900s. After a period of low activity, mining in the district resumed in 1931 with the discovery of the Rio Tinto volcanogenic massive sulfide and the redevelopment of Van Duzer placer deposits (Coats and Stephens, 1968; Smith, 1976; LaPointe and others, 1991). Mining activity in the Hicks district, 15 km east of Mountain City, started around 1880; however, no production was recorded during this period.

Polymetallic veins around the Enright Hill pluton produced small quantities of lead-zinc-silver ore with minor gold and copper as byproducts from 1950 to 1952. The Enright Hill area was explored in the 1970s and 1980s for precious metals (Smith, 1976; LaPointe and others, 1991).

The tract was delineated by aggregating 3-km buffers around the Mountain City and Summit Creek plutons, and mines around the Enright Hill pluton in the Hicks district (Crawford, 2007; Fernette and others, 2016a). In the Mountain City district, soil and stream-sediment geochemistry is characterized by moderately high to high concentrations (8 to 15 times background) of arsenic and moderately high concentrations (4 to 7 times background) of silver and molybdenum. In the Hicks district, soil and stream-sediment geochemistry is characterized by moderately high to high concentrations (8 to 15 times background) of cadmium and moderately high concentrations (4 to 7 times background) of silver, beryllium, molybdenum, and tin (U.S. Geological Survey, 2016b).

The Mountain City district is located over a magnetic high that images the Mountain City pluton. Mines and prospects in the district are also cospatial with elevated uranium concentrations reflected by radiometric measurements. The uranium/thorium (U/Th) map around these mines is high. In contrast, the Hicks district occurs over a magnetic low that is cospatial with elevated northeast-trending uranium concentrations best reflected by the uranium/thorium (U/Th) map (Day and others, 2016).

Alteration is weakly-developed over the Golden Ensign, Nelson, and New Yorkey's Claim based on interpretation of ASTER satellite imagery of (Rockwell and others, 2015). In contrast, a northeast trend of advanced argillic alteration minerals and ferric iron occurs along the Bieroth, Enright Hill, and Never Sweat Mines in the Hicks district. Advanced argillic alteration minerals and ferric iron are relatively well-developed on the McDonald Creek stock to the north, where the Copper Mountain copper occurrence is located.

Previous assessments estimate that all or parts of this tract are permissive for distal disseminated, polymetallic replacement, skarn, and porphyry copper deposits (U.S. Geological Survey, 2001; Wallace and others, 2004; Parks and others, 2016). There are 92 active lode claims in the tract area (Dicken and San Juan, 2016).

One porphyry-related occurrence is known in the Hicks district. About 1.5 km east of the Enright Hill diorite-granodiorite pluton, the Never Sweat Ag-(Au-Cu-Pb-Zn) quartz vein is associated with an altered porphyry dike emplaced in metamorphosed siltstone and shale units. The Never Sweat Mine is controlled by a 300-m-long northeast structure on which the Bieroth Au-Ag-(Pb-Zn), Enright Hill Au veins are also located (Smith, 1976; LaPointe and others, 1991). From 1950 to 1952, mines on Enright Hill produced a small quantity of lead-zinc-silver ore with minor gold and copper as byproducts. The area was explored throughout the 1970s and 1980s for porphyry and precious metals deposits, and a drilling project in 1989 delineated a small gold resource at the Enright Hill Mine. Another copper occurrence is found at the Copper Mountain site to the north in the McDonald Creek pluton (U.S. Geological Survey, 2016a).

No porphyry copper deposits are known in the Mountain City district. However, along the southern contact between the Mountain City intrusion and Paleozoic rocks, mineralized rock exhibits characteristics that contrast with those of the more typical precious and base metal veins in the district. The Golden Ensign Ag-Au-W-(Cu-Mo-Pb-Zn) and Nelson Ag-(Au-Cu-Zn-Pb-As) skarns formed at the contact of a quartz monzonite intrusion with limestone. Mineralization is associated with dikes and irregular masses of altered aplite (Emmons, 1910). Sulfides include pyrite, chalcopyrite, galena, sphalerite, chalcocite, silver sulfosalts, and arsenopyrite. Scheelite and molybdenite are also present, but there is no recorded production of these metals. At the New Yorkey's Claim, copper and gold occurs in sheeted veins that contain pyrite, copper minerals, and iron oxides (Smith, 1976; LaPointe and others, 1991). The Golden Ensign (Silver Banner) and Nelson Mines were among the largest producers in the district. They were active in the 1870s, in the early 1900s, and in the 1920s.

Tract INPR02_pMo, Mountain City Porphyry Molybdenum—There is moderate (M) potential, with certainty level B, for intrusion-related low-fluorine porphyry molybdenum deposits in the Mountain City district near Mountain City, Elko County, Nevada (LaPointe and others, 1991; fig. 31C; appendix 2). The geology, regional geochemical, geophysical, and remote-sensing data that characterize the tract are described in report section "Tract INPR02_pCu, Mountain City Porphyry Copper."

Low-fluorine porphyry molybdenum is represented by the Huber Hill (Granite Ridge) prospect located in the Mountain City pluton 3 km east-southeast of Mountain City (Smith, 1976; LaPointe and others, 1991; Sherlock and others, 1996). In the Mountain City district, however, molybdenite also occurs at the Golden Ensign Ag-Au-W-(Cu-Mo Pb-Zn) skarn deposit. Molybdenum mineralization at Huber Hill consists of quartz-pyrite-molybdenite veins in quartz monzonite near the contact with a granite porphyry. Molybdenite also occurs disseminated and in veins throughout the larger Granite Ridge area around Huber Hill (Smith, 1976; LaPointe and others, 1991).

Molybdenum at Huber Hill was first identified in 1969. The prospect was drilled in the 1970s and early 1980s, but results did not indicate sufficient tonnage and grade to support an economically viable operation (LaPointe and others, 1991). Processed ASTER satellite imagery shows a well-developed 1,000- by 300-m northeast-trending zone of advanced argillic alteration minerals and lesser sericite in this area.

Tract INPR02_pmv, Mountain City Polymetallic Vein—There is high (H) potential, with certainty level C, for intrusion-related silver-gold-(copper-lead-zinc) polymetallic vein deposits in the Mountain City and Hicks districts, Elko County, Nevada (LaPointe and others, 1991; fig. 31*C*; appendix 2). The geology, regional geochemical, geophysical, and remote-sensing data that characterize the tract are described in report section "Tract INPR02_pCu, Mountain City Porphyry Copper."

Polymetallic veins in the Mountain City district with reported production include the Independent, Mariposa, Mountain City, Protection, and Resurrection Mines. These mines produced precious metals and small quantities of copper, lead, and zinc from veins that occur mainly in the Late Cretaceous Mountain City quartz monzonite. Near the southern margin of the pluton, veins also cut Paleozoic rocks. The veins commonly occupy northwest-trending faults. Ore minerals in the quartz-pyrite-arsenopyrite veins consist of chalcopyrite, galena, sphalerite, tetrahedrite, argentite, and free gold (Coats and Stephens, 1968; Smith, 1976; LaPointe and others, 1991).

The Protection Au-Ag-(Cu-Pb-Zn), Resurrection Ag-(Cu-Pb), and Mountain City Ag-(Au-Cu-Pb) polymetallic veins were the district's major producers into the early 20th century, but small and sporadic production continued until the early 1980s. In the early 1980s, a silver leach plant operated at the old Protection Mine (Smith, 1976; LaPointe and others, 1991). In the mid to late 1980s, exploration activity for precious metals increased. One exploration project (the Mountain City property) is active in the district (Fernette and others, 2016a). On the Mountain City property, sampling by First American Siver Corp. obtained silver values of as much as 84.9 opt, and gold values of as much as 0.218 opt from quartz veins (First American Silver Corp., 2011).

Tract INPR03, Cobb Creek—There is high (H) potential, with certainty level D, for intrusion-related, distal disseminated gold-silver deposits in the Mountain City and Aura districts near Mountain City, Elko County, Nevada (LaPointe and others, 1991; fig. 31*D*; appendix 2). The geology of the area is characterized by Paleozoic sedimentary and metavolcanic formations that are intruded by Late Cretaceous continental margin arc intrusions. Eocene volcanic and volcaniclastic rocks rest unconformably on Mesozoic plutons and older strata. Miocene volcanic and volcaniclastic rocks occur mostly outside the district to the northwest and southeast (Coats, 1987; Crafford, 2007).

The Cobb Creek-McCall deposit was discovered in 1983, and geophysical and geochemical surveys and drilling identified the Beaver Creek oxide gold target in the early 1990s. Active exploration has continued to the present. In 2004, the Cobb Creek-McCall near-surface oxide gold inferred mineral resource was estimated at 1.36 million short tons at 0.040 opt gold, and the sulfide gold inferred mineral resource was estimated at 2.38 million short tons at 0.050 opt gold (Pawlowski, 2006).

The tract was delineated by aggregating 3-km buffers around the Cobb Creek, McCall, and Beaver Creek active exploration projects, and the antimony-precious metal vein at the Blue Ribbon-Boyce Mine (LaPointe and others, 1991; Fernette and others, 2016a). Regional stream-sediment geochemical samples do not cover the tract area. Surrounding the tract, stream-sediment data show the area to be characterized by high concentrations (more than 16 times background) of antimony, moderately high to high concentrations (8 to 15 times background) of silver, arsenic, cadmium, and molybdenum, and moderately high concentrations (4 to 7 times background) of copper (U.S. Geological Survey, 2016b). The tract is located at the northern margin of a broad gravity anomaly. A magnetic high to the north dips into the tract area imaging the continuation of a probable intrusion at depth. Uranium/thorium (U/Th) is also moderately high in the area of the Cobb Creek resource, as reflected by radiometric measurements (Day and others, 2016). Interpretation of ASTER satellite imagery shows minor ferric iron zones over the Cobb Creek-McCall and Beaver Creek areas, and small carbonate-propylitic and ferric iron zones over the Silver Creek intrusion west, and 2 km north of the Blue Ribbon-Boyce Mine (Rockwell and others, 2015).

Previous assessments estimate that all or parts of this tract are permissive for distal disseminated, polymetallic replacement, skarn, and porphyry copper deposits (U.S. Geological Survey, 2001; Wallace and others, 2004; Parks and others, 2016). There are 42 active lode claims and 1 placer claim in the tract (Dicken and San Juan, 2016).

The gold-silver mineralization at the Cobb Creek project is considered similar to Carlin-type gold deposits by the deposit owners. However, proximity to intrusions and association of base metal-silver vein and skarn deposits with those intrusions suggests that the gold-silver deposit type is distal disseminated (Cox and Singer, 1990). The intrusion-related Mountain Laurel Ag-(Au-Cu-Pb) and the Silver King Ag-Pb-(Au-Cu-Zn) mines are located in the vicinity of the Cobb Creek project. In the early 1980s, a small silver mining operation was still active at the Silver King Mine (LaPointe and others, 1991).

Antimony-bearing gold-silver distal disseminated deposits are surrounded by the Late Cretaceous Silver Creek and Winter Creek granitic intrusions to the south and west, and by the Mountain City granitic pluton to the north (U.S. Geological Survey, 2016a). The 100 Ma age of mineralization obtained from fuchsite at Cobb Creek is consistent with ages obtained from these nearby intrusions (Pawlowski, 2006). Three periods of structural deformation have been identified in the area. Late Paleozoic deformation produced N. 40°–70° E. asymmetrical folds with steep dips to the northwest, and low-angle N. 70° E.-striking shear zones. This event was followed by pre-Late Cretaceous N. 60°–70° W. and Late Cretaceous high-angle N. 30° E.- and N. 30° W.-trending faults. The ore zone at the Cobb Creek project is imaged by distinctive resistivity highs with no associated aeromagnetic response. Geochemical surveys show anomalous gold, silver, arsenic, antimony, copper, and molybdenum, with a strong correlation between gold and arsenic. Most of the Cobb Creek area is covered by alluvium. However, drilling has shown that deposits consist of bull quartz-calcite-pyrite-arsenopyrite stockworks, veins, and breccias that are hosted by argillized, potassium-metasomatized, and weakly silicified greenstone and argillite units of the Ordovician Valmy Formation. Probable similar antimony-gold deposits also occur at the historic Blue Ribbon-Boyce Mine, which has produced antimony from stibnite-bearing quartz stringers and disseminations. The Blue Ribbon-Boyce Mine is located at the margin of the Silver Creek biotite granite stock, about 4 km southwest of the Cobb Creek deposit (LaPointe and others, 1991).

Tract INPR04_pmr, Blue Jacket Polymetallic Replacement—There is high (H) potential, with certainty level D, for intrusion-related silver-lead-(gold-copper-antimony-zinc) polymetallic replacement deposits in the Aura, Centennial, and Edgemont districts 20 km southwest of Mountain City, Elko County, Nevada (LaPointe and others, 1991; fig. 31*E*; appendix 2). The geology of the area is characterized by deformed lower Paleozoic sedimentary rocks. These rocks are intruded by the Late Jurassic Columbia, Trail Creek, and White Rock dioritic to granodioritic stocks, dikes, and sills (LaPointe and others, 1991; du Bray and Crafford, 2007). Intrusive and sedimentary rocks are displaced as much as 600 m by north- to northeast-trending normal faults. Eocene volcanic and volcaniclastic rocks rest unconformably on older strata. These rocks are covered by Miocene volcanic and volcaniclastic rocks and Quaternary alluvial deposits (Coats, 1987; LaPointe and others, 1991; Crafford, 2007).

The Aura district was organized in 1869, and ten lode mines and several placer claims were active in the 1870s. Placer mining declined between the 1880s and early part of the 20th century, but silver-rich ores in lode deposits were produced until the late 1940s. Production continued intermittently from a few mines into the 1980s (Smith, 1976; LaPointe and others, 1991). Significant production was derived from the Blue Jacket Mine, which in 1989 contained an estimated resource of 2 million short tons at 0.01 opt gold, 2.2 opt silver, 0.25 percent copper, 2 percent lead, and 1.8 percent zinc (Long and others, 1998). Blue Jacket is an exploration project that is currently active (Fernette and others, 2016a). In contrast to the Aura district, lode deposits in the Edgemont district to the west were not discovered until the 1890s. Most gold and silver production occurred between 1900 and 1909. Mining revived in the 1930s through the early 1970s. During this period, lead was the major commodity produced, with lesser gold and silver, and minor copper, zinc, and tungsten. Exploration in the 1980s focused on Carlin-type gold deposits in the area (Smith, 1976; LaPointe and others, 1991).

The tract was delineated by aggregating 3-km buffers around the mines and prospects (Fernette and others, 2016a; U.S. Geological Survey, 2016a). It encompasses the Mesozoic intrusions. Soil and stream-sediment geochemistry in the tract is characterized by high concentrations (more than 16 times background) of antimony; moderately high to high concentrations (8 to 15 times background) of arsenic, cadmium, and magnesium; and moderately high concentrations (4 to 7 times background) of silver, copper, molybdenum, lead, and silver (U.S. Geological Survey, 2016b). The tract occurs over a local low-intensity magnetic high and at the northern margin of a broad gravity low. The tract area is located at the margin of a local thorium high as reflected by radiometric measurements (Day and others, 2016). Prominent argillic alteration and ferric iron zones occur in quartzite along the 6-km east-northeast-trending range where the Bull Run Mine is located, and along the range where the Lucky Girl Mine is situated, based on interpretation of ASTER satellite imagery (Rockwell and others, 2015). Previous assessments estimate that the tract area is favorable and prospective for intrusion-related deposits (Wallace and others, 2004; Parks and others, 2016). There are 169 active lode claims and 2 placer claims in the tract (Dicken and San Juan, 2016).

Polymetallic replacement deposits occur mostly in the eastern part of the tract and formed proximal to intrusive stocks and dikes. The deposits developed in recrystallized, bleached, and silicified dolomitic limestone along faults and bedding planes at the Aura King Ag-Pb-(Au-Cu-Zn), Aura Queen Au-(Ag-Cu-Pb-Zn), Big Four Pb-Ag-(Cu-Au-Sb-Zn), Blue Jacket Ag-Pb-Zn-(Au-Cu-Sb-As), Burns Pb-Zn-Ag-(Au-Sb), California Ag-Pb-(Zn-Au), Columbia Ag-Au-Pb-(Zn), and Infidel Ag-Pb replacement deposits, and at the Golden Eagle Au-Pb skarn. Sulfide, silicate, carbonate, and oxide minerals in replacement deposits include pyrite, galena, chalcopyrite, sphalerite, tetrahedrite, quartz, calcite, silica, and iron oxides. At the Golden Eagle skarn, calc-silicates with disseminated pyrite and chalcopyrite are cut by barren white quartz veins. A medium-grained strongly propylitized (epidote-chlorite-albite) diorite is associated with skarn mineralization (Smith, 1976; LaPointe and others, 1991).

Tract INPR04_pmv, Blue Jacket Polymetallic Vein—There is high (H) potential, with certainty level C, for intrusion-related silver-lead-(gold-copper-antimony-zinc) and gold-silver-(lead-copper) polymetallic vein deposits in the Aura and Edgemont districts 20 km southwest of Mountain City, Elko County, Nevada (LaPointe and others, 1991; fig. 31*E*; appendix 2). The geology, regional geochemical, geophysical, and remote-sensing data that characterize the tract are described in report section “Tract INPR04_pmr, Blue Jacket Polymetallic Replacement.”

Polymetallic vein deposits occur in association with polymetallic carbonate replacement deposits where proximal to intrusive stocks and dikes. Polymetallic vein deposits in the Aura district are commonly hosted by faults in silicified dolomitic limestone at the Aura King Ag-Pb-(Au-Cu-Zn), Big Four Pb-Ag-(Cu-Au-Sb-Zn), Blue Jacket Ag-Pb-Zn-(Au-Cu-Sb-As), California Ag-Pb-(Zn-Au), Columbia Ag-Au-Pb-(Zn), Infidel Ag-Pb, and Tiger Lode Ag-(Pb-Zn-Cu) veins and associated replacement systems, and the Polaris Ag-(Au-Cu-Pb) vein (LaPointe and others, 1991; Sherlock and others, 1996).

In contrast to the silver-rich carbonate-hosted veins in the Aura district, quartzite- and shale-hosted veins in the Edgemont district are gold rich. Polymetallic vein deposits include the Big Bob Au-(Ag), Bull Run Au-Ag-(Pb), Echo Canyon Au-Pb-(Ag-Cu-Zn), Lucky Boy Au-(Ag-Pb), and Lucky Girl Au-(Ag-Cu-Pb) vein systems. Alteration selvages around these quartz veins consist of sericite and pyrite. Sulfides include pyrite, arsenopyrite, galena, and minor chalcopyrite. Polymetallic vein deposits in this district that are hosted by carbonate instead of quartzite and shale exhibit contrasting silver-rich mineralogy similar to that found in the Aura district. The Burns Pb-Zn-Ag-(Au-Sb) vein occurs in limestone, and the Nevada Zn-(Pb-Ag) vein occurs in the White Rock diorite stock near the contact with Ordovician limestone (Smith, 1976; LaPointe and others, 1991).

Tract INPR04_Wv, Blue Jacket Tungsten Vein—There is moderate (M) potential, with certainty level B, for intrusion-related tungsten vein deposits in the Aura and Edgemont districts 20 km southwest of Mountain City, Elko County, Nevada (LaPointe and others, 1991; fig. 31*E*; appendix 2). The geology, regional geochemical, geophysical, and remote-sensing data that characterize the tract are described in report section “Tract INPR04_pmr, Blue Jacket Polymetallic Replacement.”

A tungsten vein deposit and associated skarn occurrences are located close to the contact with one of the smaller White Rock stocks in the northwestern part of the tract. Here, a fault-vein is hosted by limestone at the Burns Scheelite Mine. Scheelite occurs in seams and disseminated in the quartz vein. A single shipment of 6 short tons of ore in 1953 averaged 0.73 percent tungsten trioxide (WO_3) (Smith, 1976; LaPointe and others, 1991).

Tract INPR05_pmv, Alder Polymetallic Vein—There is moderate (M) potential, with certainty level C, for polymetallic gold-silver vein deposits in the Alder district 20 km west of Jarbidge, Elko County, Nevada (LaPointe and others, 1991; fig. 31*F*; appendix 2). The geology of the area is characterized by a deformed sequence of Lower Paleozoic carbonate and argillaceous rocks that have been intruded by the middle Cretaceous (120 Ma) granodiorite to quartz monzonite Coffeepot pluton (du Bray and Crafford, 2007). The Coffeepot pluton is cut by normal faults and is partly overlain by Miocene volcanic rocks (Coats, 1987; LaPointe and others, 1991; Crafford, 2007).

The first discoveries in the Alder district were made in 1869. Lode mining of silver-gold vein deposits continued intermittently from the early 1870s through the 1930s. Lode mining from 1916 through 1939 from the Clipper Alder, Pittsburg Silver, and Mohawk Mines yielded 53 oz of gold and 1,219 oz of silver. Precious-metal production has not been recorded from vein deposits since 1939 (Smith, 1976; LaPointe and others, 1991).

The tract was delineated by a 3-km buffer around the Coffeepot pluton (Crawford, 2007). Soil and stream-sediment geochemistry in the tract is characterized by local moderately high to high concentrations (8 to 15 times background) of antimony, molybdenum, and uranium, and moderately high concentrations (4 to 7 times background) of silver, arsenic, beryllium, cadmium, iron, phosphorus, strontium, thorium, and vanadium (U.S. Geological Survey, 2016b). The Coffeepot pluton is well-imaged by magnetic high, and located over a gravity low (Day and others, 2016). Mines in the tract occur in association with a distinct U/Th high, as reflected by radiometric measurements (Day and others, 2016). A north-south-trending, 4-km long zone of advanced argillic and ferric iron in the Coffeepot pluton between the Garnet and Little Joe Mines is interpreted from ASTER satellite imagery (Rockwell and others, 2015). South of the pluton, well-developed advanced argillic, ferric iron, and argillic alteration occurs in Proterozoic quartzite-dominated units and Quaternary glacial deposits. In the northern part of the pluton, an argillic and widespread sericite and ferric iron alteration zone occurs 2 km west-southwest and around the Red Ledge Claims prospect. An additional 500- by 200-m zone of advanced argillic, argillic, sericitic, and hydrous silica alteration is located at the Clipper Alder Mine. Previous assessments estimate that all or parts of this tract are favorable and prospective for intrusion-related polymetallic deposits (Wallace and others, 2004; Parks and others, 2016). There are 74 active lode claims in the tract (Dicken and San Juan, 2016).

Precious metal-bearing polymetallic vein deposits occur at the Clipper Alder Au-(Ag-Pb-Cu-Fe), Mohawk Au-(Ag), Pittsburg Silver Ag-(Au), and Tennessee Gulch Au mines, and the Johnson Group Au prospect. Quartz-calcite veins with gold, pyrite, and minor argentiferous galena and other sulfides are common near and within the contact zone of the Coffeepot pluton, where they cut the Paleozoic rocks and the quartz monzonite. In several places, veins are adjacent to altered aplite and porphyry dikes and associated skarn (Smith, 1976; LaPointe and others, 1991).

Previous assessments that include all or parts of this tract assign favorable and prospective favorability for intrusion-related polymetallic deposits (Wallace and others, 2004; Parks and others, 2016).

Tract INPR05_WMosk, Alder Tungsten-Molybdenum Skarn—There is high (H) potential, with certainty level D, for tungsten-molybdenum skarn deposits in the Alder district 20 km west of Jarbidge, Elko County, Nevada (LaPointe and others, 1991; fig. 31*F*; appendix 2). The geology, regional geochemical, geophysical, and remote-sensing data that characterize the tract are described in report section “Tract INPR05_pmv, Alder Polymetallic Vein.”

Following discovery of tungsten in 1949, exploration in the district focused on scheelite- and molybdenite-bearing skarns. The Garnet Mine is the best developed and most productive skarn deposit in the district. Reserves in the 1950s were estimated at 224,000 short tons at 0.5 percent tungsten trioxide (WO_3), and 540,000 short tons at 0.4 percent tungsten trioxide (WO_3) (LaPointe and others, 1991). However, only small quantities of tungsten were produced in 1970 and 1977. Between 1954 and 1956, the Batholith Mine produced 1,000 short tons of tungsten ore averaging 0.5 percent to 1.0 percent tungsten trioxide (WO_3). Tungsten ore was also shipped from the Coon Creek (Rowland) Mine in 1943 and from 1954 to 1956, yielding a total of 608 units of tungsten trioxide (WO_3) (Stager and Tingley, 1988). The Little Joe Mine may have produced a few tons of sorted tungsten ore that contained 3 percent tungsten trioxide (WO_3) from a narrow quartz vein (Smith, 1976).

Tungsten-molybdenum deposits in the Alder district occurs along the contact between deformed Paleozoic limestone and argillaceous rocks and the Coffeepot pluton. Dikes and sills intrude the sedimentary wall rocks along the contact. The principal tungsten-molybdenum skarns in the district occur at the Garnet, Little Joe, and Mohawk-Pittsburg Mines on the southwestern margin, and at the Batholith and Coon Creek Mines on the southeastern margin of the pluton (Smith, 1976; Sherlock and others, 1996; LaPointe and others, 1991). At the Garnet W-Mo-(U-Cu-Bi) mine, garnet-epidote skarn is cut by an east-trending and clay-altered quartz monzonite dike. The skarn contains scheelite and molybdenite, and lesser amount of powellite, bismuthinite, and chalcopyrite. The skarn is cut by gray to white gold-, scheelite-, and molybdenite-bearing quartz veins. Uraninite (pitchblende) occurs in fault gouge. At the Little Joe W-(Mo-Cu) mine, skarn is cut by aplite dikes and veinlets of quartz and calcite. Scheelite occurs in the skarn and in tungsten-bearing quartz veinlets near the dikes. At the Batholith W-Mo and Conn Creek (Rowland) Cu-W-(Mo) mines, scheelite occurs with powellite and molybdenite in skarn at the contact between a quartz monzonite stock and limestone interbedded with shale and quartzite. At Coon Creek, chalcopyrite is more abundant. Garnet, epidote, calcite, and magnetite skarn is cut by quartz veins. Other tungsten skarns are located at the Apex W-(Mo), Chapin group W-(Mo), Copper Queen W-(Cu-Pb-Ag), Hot Springs Claims W, and Red Ledge Claims W prospects (Smith, 1976; LaPointe and others, 1991).

Tract INPR06_dd, Island Mountain Distal Disseminated Gold-Silver—There is high (H) potential, with certainty level D, for intrusion-related gold-silver, distal disseminated silver-gold deposits in the Island Mountain District southeast of Mountain City, Elko County, Nevada (LaPointe and others, 1991; fig. 31*G*; appendix 2). The geology of the area is characterized by deformed and faulted Paleozoic sedimentary rocks that are intruded by the Jurassic Island Mountain (Hammond Canyon) stock and Cretaceous Coffeepot quartz monzonite pluton on the west and north, respectively. These Paleozoic rocks and Mesozoic plutons are overlain by Eocene and Miocene volcanic and volcaniclastic strata. Northeast-striking faults cut the sedimentary and volcanic rocks and are displaced by younger northwest-striking faults. Quaternary alluvium covers parts of the area (Smith, 1976; Coats, 1987; LaPointe and others, 1991; Crafford, 2007).

The tract was delineated by aggregating 3-km buffers around the centers of the Island Mountain and St. Elmo active exploration projects (Peatfield, 2004; Broili and others, 2007; Fernette and others, 2016a). It excludes the contrasting mineralization style along the contact with the Coffeepot pluton in the northernmost part of the St. Elmo active exploration claim block, which is included in report section "Tract INPR05_WMosk, Alder Tungsten-Molybdenum Skarn."

In the Island Mountain project, soil and stream-sediment geochemistry in the tract is characterized by high concentrations (more than 16 times background) of cadmium; moderately high to high concentrations (8 to 15 times background) of antimony, arsenic, and uranium; and moderately high concentrations (4 to 7 times background) of gold and molybdenum (U.S. Geological Survey, 2016b). The Island Mountain stock coincides with a local magnetic high that reflects the exposed intrusion as well as an internal gravity high. The area is cospatial with elevated potassium, uranium, and thorium concentrations, as reflected by thorium/potassium (Th/K) from radiometric measurements (Day and others, 2016). Advanced argillic alteration, argillic alteration, and ferric iron mainly along faults in Lower Paleozoic quartzite-dominated rocks is interpreted from ASTER satellite imagery (Rockwell and others, 2015). Also, small alteration zones occur in Paleozoic clastic and carbonate rocks and in the Island Mountain stock.

In the St. Elmo project, soil and stream-sediment geochemistry is characterized by moderately high concentrations (4 to 7 times background) of silver and cadmium (U.S. Geological Survey, 2016b). The St. Elmo project area is cospatial with elevated potassium, uranium, and thorium concentrations, as reflected by thorium/potassium (Th/K) from radiometric measurements, like those noted at the Island Mountain stock (Day and others, 2016). Well-developed advanced argillic, and argillic and ferric iron alteration northeast of the St. Elmo Mine and between the Diamond Jim and Rosebud Claims Mines is interpreted from ASTER satellite imagery (Rockwell and others, 2015). The alteration zones occur mainly in Lower Paleozoic quartzite.

Previous assessments estimate that all or parts of this tract are permissive for intrusion-related polymetallic replacement, porphyry copper, and skarn deposits (U.S. Geological Survey, 2001; Wallace and others, 2004; Parks and others, 2016). There are 186 active lode claims and 2 placer claims in the tract (Dicken and San Juan, 2016).

Distal disseminated gold-silver deposits in the Island Mountain district have been identified in two areas. The first gold-silver project occurs near the southwest contact of the Island Mountain stock (Peatfield, 2004), and the second project is located near the Diamond Jim and Rosebud Mines about 7 km to the east (Broili and others, 2007). The sediment-hosted style of gold-silver deposit is considered similar to Carlin-type gold deposits by the deposit owners. However, proximity to intrusions and association of base metal vein and skarn deposits with those intrusions suggests that the gold-silver deposit type is distal disseminated.

Deposits at the Island Mountain active exploration project are hosted by interbedded limestone and limy siltstone units of Permian age. These units are replaced by fault-controlled limonitic bodies of jasperoid or massive silica. Disseminated gold and sulfide minerals occur mainly in some of these bodies, but is also found away from faults in favorable stratigraphy. Sedimentary units have been altered to skarn along the contact with the intrusion 100 to 200 m to the east. Contrasting bismuth-bearing silver and base-metal prospects occur in skarn and intrusion-hosted veins along the contact (Peatfield, 2004).

Geochemical surveys at the Island Mountain project indicate anomalous gold, arsenic, antimony, and mercury concentrations. Magnetic surveys image the Island Mountain intrusion well, but also show a 500- by 1,000-m north-south-trending magnetic high over the distal disseminated gold target. Electrical surveys are roughly coincident but open to the north (Peatfield, 2004). Drill holes from several drilling programs estimate a current resource of 26.3 million short tons at 0.019 opt gold (Juhas and Hollenbeck, 2012).

Mineralization at the St. Elmo active exploration project is hosted by Cambrian to Ordovician quartzite, shale, and limestone rock succession that has been complexly faulted by Mesozoic (and possibly Paleozoic) thrust faults and northeast, north, and northwest-trending normal faults. These rocks have been intruded by the small Cretaceous Gold Creek hornblende-biotite quartz diorite intrusion exposed about 3 km west of the polymetallic vein at the St. Elmo Mine. Northeast of the St. Elmo Mine, fracture-controlled silica and jasperoid replacements are surrounded by strong bleaching, clay-sericite alteration, and iron-oxide staining. Jasperoids contain fine-grained pyrite, and select samples contain as much as 5 g/t gold. A magnetic survey over the project area indicates two weak magnetic highs that may reflect buried intrusive bodies. At present, there are no available mineral-resource estimates for this early-stage exploration project (Broili and others, 2007).

Tract INPR06_pmv, Island Mountain Polymetallic Vein and Skarn—There is high (H) potential, with certainty level C, for intrusion-related silver-lead (zinc-copper-antimony-tungsten-gold) polymetallic veins and associated skarn deposits in the Island Mountain District southeast of Mountain City, Elko County, Nevada (LaPointe and others, 1991; fig. 31*G*; appendix 2). The geology, regional geochemical, geophysical, and remote-sensing data that characterize the tract are described in report section “Tract INPR06_dd, Island Mountain Distal Disseminated Gold-Silver.”

Silver-lead-copper-zinc-antimony veins in the Island Mountain district were discovered in 1869; however, mining in the area focused on placer gold between 1873 and 1901. About 40,000 oz of gold are reported to have been recovered from placers. Production from lode deposits was first recorded in 1934 from the Rosebud and Diamond Jim lead-(gold-silver-copper-zinc) vein deposits, but lead, silver, zinc, and copper production in the district occurred mostly between the 1950s and 1970s. Sporadic small-scale mining continued into the 1980s. The Diamond Jim open-pit mine produced most of the ore in the district from 1954 and 1985 (Smith, 1976; LaPointe and others, 1991).

Deposits in the Island Mountain district include Ag-Pb-(Zn-Cu-Sb)-bearing polymetallic vein, and subordinate Sb-(W)-dominated skarn deposits. Gold is variably present in both types of deposits. Quartz-calcite veins and local replacement bodies contain argentiferous galena, argentite, and minor stibnite, sphalerite, tetrahedrite, and tennantite (Smith, 1976; LaPointe and others, 1991). These veins also carry elevated concentrations of bismuth (Peatfield, 2004). Vein deposits in the district are represented by the Coleman Au-(Ag-Cu) and the Diamond Jim and Rosebud Pb-(Au-Ag-Cu-Zn) mines. The latter are located about 7 km east of the Island Mountain stock.

Ore in skarns commonly consists of pyrite, chalcopyrite, scheelite, and minor molybdenite. Skarns are closely associated with aplite dikes and cut by quartz-calcite veins. Skarn deposits include several occurrences along the edge of the Island Mountain stock, and the Gribble Sb-W-(Pb-Zn) mine located approximately 5 km northeast of the stock. Antimony was shipped in 1941 and 1951 from the Sb-W-(Pb-Zn) vein and skarn deposit at the Gribble Mine. Between 1952 and 1955, the Gribble Mine also produced tungsten trioxide (WO_3) (Smith, 1976; LaPointe and others, 1991).

Tract INPR07, Charleston—There is moderate (M) potential, with certainty level C, for intrusion-related copper-antimony-(gold-silver-zinc-lead) polymetallic vein deposits, in the Charleston District of Elko County, Nevada (LaPointe and others, 1991; fig. 31*H*; appendix 2). The geology of the area is characterized by highly deformed and locally recrystallized and hornfelsed Paleozoic sedimentary rocks that are intruded by the Jurassic Seventy Six Creek quartz monzonite stock (du Bray and Crafford, 2007). The stock and sedimentary rocks are cut by granitic, monzonitic, and dioritic dikes. These rocks are overlain by Eocene and Miocene volcanic and volcaniclastic strata, which are dissected by high-angle normal faults (Smith, 1976; Coats, 1987; LaPointe and others, 1991; Ketner, 2005; Crafford, 2007).

Placer gold was discovered along Seventy Six Creek in 1876. Mining activity continued into the 1930s, but placer production was limited. The most extensive workings along polymetallic veins in the district are those of the Prunty and Slattery Mines, which were most active between 1905 and 1920. The Prunty Mine continued to be mined intermittently for its precious metals into the early 1980s. Production is also reported from the Black Warrior Au-Sb-(Ag-Cu-Pb), Carleton Tunnel Cu, Prunty Antimony Sb-Ag-(Cu-Au), Prunty Cu-Sb-(Zn-Au-Ag-Pb-Bi), Rescue Cu-(Ag-Zn-Au-Sb-Bi), and Slattery Cu-(Ag-Pb) mines (Smith, 1976; LaPointe and others, 1991).

The tract was delineated by aggregating 3-km buffers around the Black Warrior, Carlton Tunnel, Prunty Antimony, Prunty, Rescue, and Slattery Mines (Fernette and others, 2016a). The tract encompasses these mines and the Seventy Six Creek stock. Soil and stream-sediment geochemistry in the tract is characterized by high concentrations (more than 16 times background) of cadmium, and moderately high concentrations (4 to 7 times background) of arsenic, barium, molybdenum, and strontium (U.S. Geological Survey, 2016b). The Seventy Six Creek stock is imaged by a magnetic high and located over a pronounced gravity low (Day and others, 2016). The Charleston district is cospatial with elevated thorium/potassium (Th/K), as reflected by radiometric measurements (Day and others, 2016).

Well-developed advanced argillic, argillic, ferric iron and lesser sericite alteration in Proterozoic and in Paleozoic quartzite-dominated rocks is interpreted from ASTER satellite imagery (Rockwell and others, 2015). A 500- by 500- m advanced argillic, argillic, and ferric iron alteration zone is also present about 1 km north of the Charleston Tunnel Mine. Smaller advanced argillic and ferric iron alteration zones, based on interpretation of ASTER imagery, occur in the Seventy Six Creek intrusion.

Previous assessments estimate that all or parts of this tract are permissive for intrusion-related polymetallic replacement, porphyry copper, and skarn deposits (U.S. Geological Survey, 2001; Wallace and others, 2004; Parks and others, 2016). There are 122 active lode claims and 3 placer claims in the tract (Dicken and San Juan, 2016).

Polymetallic veins in the Charleston district are associated with hydrothermally altered and sulfide-bearing granitic, monzonitic, and dioritic dikes that intrude quartzite, shale, and limestone units. Quartz-calcite-(barite) veins contain pyrite, arsenopyrite, pyrrhotite, chalcopyrite, sphalerite, galena, and stibnite. Silver and gold, and elevated concentrations of bismuth and selenium are also present (Smith, 1976; LaPointe and others, 1991).

Tract INPR08_WMosk, Elk Mountain Tungsten-Molybdenum Skarn—There is moderate (M) potential, with certainty level C, for intrusion-related tungsten-molybdenum skarn deposits in the Elk Mountain district 30 km northwest of Contact, Elko County, Nevada (LaPointe and others, 1991; fig. 31*I*; appendix 2). The geology of the area is characterized by lower Paleozoic sedimentary rocks that are intruded by Late Cretaceous White Elephant Butte (Elk Mountain) granodiorite to quartz monzonite stock and associated late dikes. Paleozoic carbonate rocks near the contact have been locally altered to skarn. Paleozoic rocks are partly covered by Eocene tuffs and Miocene rhyolites that are cut by northeast- and younger northwest-trending normal faults (Smith, 1976; Coats, 1987; LaPointe and others, 1991; Crafford, 2007).

The tract was delineated by placing a 3-km buffer around mines and prospects, and by clipping the buffer to the west and south where the intrusion is in fault contact with thick Miocene and younger volcanic and volcaniclastic units (Fernette and others, 2016a). The tract encompasses the intrusion.

Soil and stream-sediment geochemistry in the tract is characterized by local, moderately high to high concentrations (8 to 15 times background) of molybdenum, and moderately high concentrations (4 to 7 times background) of cadmium, magnesium, and strontium (U.S. Geological Survey, 2016b). The granodiorite stock is prominently reflected by an isolated magnetic high and is cospatial with a gravity high and elevated concentrations of thorium and potassium (high thorium-potassium ratios) as reflected by radiometric measurements (Day and others, 2016). A small northeast-trending zone of advanced argillic alteration, ferric iron, and argillic alteration in postmineralization Eocene rhyolitic strata is interpreted from ASTER satellite imagery (Rockwell and others, 2015). Previous assessments estimate that all or parts of this tract are permissive for intrusion-related polymetallic replacement deposits and porphyry copper deposits (U.S. Geological Survey, 2001; Wallace and others, 2004; Parks and others, 2016). There are no active lode claims or placer claims in the tract (Dicken and San Juan, 2016).

Tungsten-molybdenum skarn deposits in the district are represented by the Pyramid (Robinette) W-Mo-(Au-Cu) mine and other tungsten-bearing occurrences around the southern contact of the intrusion. Garnet-dominated skarns are proximal to late intrusive dikes that cut granodiorite, limestone, and quartzite. The Pyramid Mine was the only productive skarn in the district. Scheelite and molybdenite ores locally contained as much as 0.25 percent tungsten trioxided (WO_3) and 0.2 percent MoS_2. About 400 short tons of tungsten ore averaging 0.5 percent tungsten trioxide (WO_3) were mined and milled from the property in 1957 and 1958 (Sherlock and others, 1996; Smith, 1976; Stager and Tingley, 1988; La Pointe and others, 1991).

Tract INPR08_Cusk, Elk Mountain Copper Skarn—There is moderate (M) potential, with certainty level C, for intrusion-related copper skarn deposits in the Elk Mountain district 30 km northwest of Contact, Elko County, Nevada (LaPointe and others, 1991; fig. 31*I*; appendix 2). The geology, regional geochemical, geophysical, and remote-sensing data that characterize the tract are described in report section "Tract INPR08_WMosk, Elk Mountain Tungsten-Molybdenum Skarn."

Copper mineralization was first noted in the district as early as 1890, and little mining occurred until the 1940s and 1950s. During the late 1960s, several companies explored for copper (Smith, 1976; LaPointe and others, 1991).

Copper skarn mineralization in the district is represented by the Valdez Au-Cu-(Ag-Pb) mine, and the Red Elephant, Estes Cu, and Jim Claims Cu-(Zn) prospects located along the eastern contact of the intrusion. The Valdez Mine consists of copper- and scheelite-bearing epidote skarn, fault-controlled jasperoid after limestone, and a quartz vein. The Red Elephant skarn consists of a 4.5-meter-thick ore body containing malachite, azurite, chrysocolla, chalcopyrite, and bornite in a gangue of silicified or garnetized limestone. Skarn mineralization at the Jim Claims prospect is associated with a porphyritic quartz monzonite (Schrader, 1912; Smith, 1976; LaPointe and others, 1991).

Tract INPR08_pmv, Elk Mountain Polymetallic Vein—There is moderate (M) potential, with certainty level C, for intrusion-related polymetallic vein deposits in the Elk Mountain district 30 km northwest of Contact, Elko County, Nevada (LaPointe and others, 1991; fig. 31*I*; appendix 2). The geology, regional geochemical, geophysical, and remote-sensing data that characterize the tract are described in report section "Tract INPR08_WMosk, Elk Mountain Tungsten-Molybdenum Skarn."

Polymetallic vein deposits in the district are represented by the Austean Cu-Au mine and the O'Neil Cu prospect located respectively along the northern and southern contacts of the intrusion. Quartz-calcite veins are commonly associated with steep brecciated and silicified fault zones. The veins are as much as 2 m wide and contain copper oxide minerals, native copper, stibnite, argentite, and gold (Schrader, 1912; Smith, 1976; LaPointe and others, 1991).

Tract INPR09_pCu, Contact Porphyry Copper—There is high (H) potential, with certainty level D, for copper-(molybdenum-gold) porphyry and associated porphyry-related skarn deposits in the Contact district centered on the town of Contact, Elko County, Nevada (LaPointe and others, 1991; fig. 31*J*; appendix 2). The geology of the area is characterized by a deformed sequence of Carboniferous quartzite, shale, and limestone units that have been intruded by the Jurassic Contact allanite-bearing biotite-hornblende granodioritic pluton (156 Ma; du Bray and Crafford, 2007). The Contact pluton consists of three main intrusions that are exposed just west and east, and 15 km east of the town of Contact. Sedimentary rocks are variably altered to hornfels and skarn within 600 m of the contact with these intrusions. Steeply dipping northeast, northwest, and contact-parallel faults cut intrusive and sedimentary rocks. Faults trending N. 40°–70° E. and N. 40° W. commonly host potassically altered and mineralized quartz monzonite, quartz syenite, syenite, and alaskite porphyry dikes. The dikes are as wide as 60 m and as long as 8 km. Paleozoic and Mesozoic rocks are unconformably overlain by Miocene volcanic and volcaniclastic strata and Pliocene lacustrine deposits (Schrader, 1937; Coats, 1987; LaPointe and others, 1991; Crafford, 2007).

Copper mining in the Contact district started in the late 1870s. Largely unsuccessful efforts in consolidating and developing mining operations occurred between the 1880s and 1905. Mining activity in the district revived after 1905, and production from several mines, most notably from the Nevada Belleview, peaked during the first and second world wars. Operations continued through to 1957. Little production was recorded in the district from 1958 to 1969, but interest was renewed in the 1970s with several exploration projects for porphyry copper-molybdenum targets (Smith, 1976; LaPointe and others, 1991). Exploration efforts have continued until present, with the last drilling campaign occurring in 2012 (Choquette and others, 2013).

The most productive deposits of the district have been along the northern contact zone of the western intrusion, where the Contact porphyry copper active exploration project is located (Long and others, 1998; Fernette and others, 2016a). The deposit has an estimated resource of 429 million short tons at 0.19 percent copper (0.07 percent copper cutoff grade; Choquette and others, 2013). Active exploration projects are also evaluating copper oxide targets around the Copper Shield Cu-(Mo) and New York Cu mines within the intrusion about 1 km south of the contact (Choquette and others, 2013; Fernette and others, 2016a).

The tract was delineated by aggregating 3-km buffers around mines and exploration projects (Fernette and others, 2016a). Soil and stream-sediment geochemistry in the tract is characterized by high concentrations (more than 16 times background) of bismuth, copper, and lead, moderately high to high concentrations (8 to 15 times background) of antimony, calcium, and molybdenum, and moderately high concentrations (4 to 7 times background) of arsenic, cadmium, gold, magnesium, nickel, phosphorus, strontium, thorium, and zinc (U.S. Geological Survey, 2016b). The Contact pluton is prominently reflected by isolated magnetic and gravity highs, and by elevated concentrations of thorium and potassium, as reflected by radiometric measurements (Day and others, 2016). A broad area of sericite and ferric iron alteration on the western intrusion is interpreted from ASTER satellite imagery (Rockwell and others, 2015). Previous assessments estimate that all or parts of this tract are permissive for intrusion-related polymetallic replacement, skarn, and porphyry copper deposits (U.S. Geological Survey, 2001; Wallace and others, 2004; Parks and others, 2016). There are 567 active lode claims and 8 placer claims in the tract (Dicken and San Juan, 2016).

Copper deposits along the contact (skarn) and within the intrusion (vein) are associated with alaskite, quartz monzonite, and quartz syenite porphyry dikes that have been recognized in all three intrusions. In the northern part of the west intrusion, copper-molybdenum-precious metal porphyry-related deposits are reported from the Contact and Copper Ridge active exploration projects; the Bonanza, Copper King, Copper Shield, Ivy Wilson, Junction, and Nevada-Bellevue Mines; and the Archie, Florence, Salt Lake, Yellow Girl, and White Elephant prospects. Cu-(Au-Ag-Mo) quartz veins adjacent to porphyry dikes are as large as 3-m wide and 3-km long. They consist of vitreous quartz with chalcopyrite and bornite, and lesser galena, sphalerite, molybdenite, argentite, and gold. Where hosted by the intrusion, veins exhibit potassic and sericitic alteration halos and disseminated copper minerals that extend hundreds of feet into the wall rock (Smith, 1976; LaPointe and others, 1991). Where hosted by carbonate units, copper sulfides and oxides occur in a gangue of garnet, axinite, epidote, calcite, quartz, actinolite, diopside, iron oxides, and chloropal (Schrader, 1937; LaPointe and others, 1991). Carbonate replacement deposits associated with porphyry dikes include the Hickey Pb-Ag-(Cu-Zn-Au) and Lena Shaft Cu mines, and Detweiler Cu prospect. The most distal Hickey replacement deposit is located about 1 km north of the intrusion contact.

Porphyry-related vein and skarn systems around the northern contact of the east intrusion occur at the O’Connell Group Ag-(Mo-Cu) skarn mine and the Clark Group Cu-(Au-Ag) vein prospect. Along the southern contact zone of the east intrusion, veins and skarns associated with porphyry dikes include the Chinaman Cu, High Ore Cu-(Ag), Johnson Cu-Ag-(Au-Mo), and Silk Worm Pb-Zn-(Cu-Mo-Au) vein, and the Blanchard Cu-(Au-Ag-Mo) skarn and War Eagle Cu-Ag-(Au-Pb-Zn-Mo) replacement mines (Schrader, 1937; Smith, 1976; LaPointe and others, 1991). The Silk Worm vein is located about 9 km south of the exposed intrusion contact. Four parallel veins associated with pervasively altered porphyry dikes also occur at the Toano Cu-(Fe) prospect. This prospect is located on the intrusion 15 km east of the town of Contact (LaPointe and others, 1991).

Tract INPR09_Cusk, Contact Copper Skarn—There is high (H) potential, with certainty level D, for intrusion-related copper-(gold-silver) skarn deposits in the Contact district centered on the town of Contact, Elko County, Nevada (LaPointe and others, 1991; fig. 31*J*; appendix 2). The geology, regional geochemical, geophysical, and remote-sensing data that characterize the tract are described in report section “Tract INPR09_pCu, Contact Porphyry Copper.”

In the northern part of the western intrusion, copper skarn deposits occur along the contact with equigranular granodiorite and associated dikes. Deposits include the Alice Cu-(Au-Ag-Mo-Fe), Brooklin Cu-(Au-Ag), Green Monster Cu-(Au-Ag), Old Abe Cu, Rattler Cu-(Ag-Au), and Silver Circle Cu-Ag-(Pb-Au) mines, and Bryan Cu-(Ag-Au) and Standard Group Cu prospects. The Boston Cu-(Au-Ag) skarn is the only one reported in the northern part of the eastern intrusion (LaPointe and others, 1991). Production from these skarns was small (Smith, 1976).

Tract INPR09_Wsk, Contact Tungsten Skarn—There is moderate (M) potential, with certainty level C, for intrusion-related tungsten skarn deposits in the Contact district centered on the town of Contact, Elko County, Nevada (LaPointe and others, 1991; fig. 31*J*; appendix 2). The geology, regional geochemical, geophysical, and remote-sensing data that characterize the tract are described in report section "Tract INPR09_pCu, Contact Porphyry Copper."

Tungsten skarn mineralization occurs only in the southern part of the eastern intrusion. At the Tunnel Mine, scheelite-bearing skarn occurs at the contact of the granodioritic intrusion with limestone, dolomite, and shale. The mine produced 210 short tons of ore at 0.6 percent tungsten trioxide (WO_3) in 1954 and 1955 (Smith, 1976; Sherlock and others, 1996). At the Hice W-Pb-Ag-(Au-barite) prospect located about 3 km south of the contact with the intrusion, a breccia composed of Paleozoic wall rock clasts is cemented by jasper, barite, and quartz. Ore consists of lead, gold, and silver (LaPointe and others, 1991).

Tract INPR09_pmv, Contact Polymetallic Vein—There is moderate (M) potential, with certainty level C, for intrusion-related polymetallic vein deposits in the Contact district centered on the town of Contact, Elko County, Nevada (LaPointe and others, 1991; fig. 31*J*; appendix 2). The geology, regional geochemical, geophysical, and remote-sensing data that characterize the tract are described in report section "Tract INPR09_pCu, Contact Porphyry Copper."

In the northern part of the western intrusion, Cu-(Au-Ag) veins are hosted by the intrusion and sedimentary wall rocks around the contact. Vein deposits are represented in the Allen, Antelope, Blue Bird, Empire, Jules Verne, Mammoth, Marshall, New York, and Palo Alto Mines. In the southern part of the eastern intrusion, polymetallic veins occur at the Arizona Cu-Au-(Ag), Hanks-Miller Cu-(Au-Ag-Ba), Silver King Pb-Ag-Cu-Zn-(Au-Mn), Silver Star Pb-Ag-(Au-Cu), and Vulcan Ag-(Cu-Pb-Zn-Ba-Au) mines. The Arizona and Hanks Miller veins are located at the contact, whereas the Silver King and Silver Star Mines are located 5 km south of the exposed contact of the pluton. The Vulcan Mine is located about 2 km south of the contact. The Copper Button Cu-(Au-Ag) prospect is the only prospect in the northern part of the eastern intrusion (Smith, 1976; LaPointe and others, 1991).

Tract INPR10, Delano—There is high (H) potential, with certainty level D, for intrusion-related lead-silver-zinc polymetallic replacement deposits in the northern part of the Delano district, Elko County, Nevada (LaPointe and others, 1991; fig. 31*K*; appendix 2). The geology of the area is characterized by west-dipping Permian sedimentary rocks that are cut by faults with attitudes parallel and at high angles to bedding (LaPointe and others, 1991). Paleozoic rocks are overlain unconformably by Miocene volcanic and Pliocene volcaniclastic strata (Crafford, 2007).

The Delano district was first identified in 1872, and production was first recorded from the Cleveland Mine in 1908. Production in the district was mainly from the Delano and Cleveland Mines every year from 1917 through 1966 (Smith, 1976). During that time period, 1.5 million oz of silver, 333 oz of gold, 22 million lbs of lead, 1.3 million lbs of zinc, and 168,000 lbs of copper were produced (Long and others, 1998). Since then, production has been intermittent. Exploration at the Delano and Cleveland Mines in the 1980s identified a resource of approximately 240,000 short tons averaging 6.43 opt silver, 5.6 percent lead, and 3.8 percent zinc with minor values in copper and gold (LaPointe and others, 1991).

The tract was delineated by aggregating 3-km buffers around the Cleveland, Delano, Gold Note, and 86 Mines. Soil and stream-sediment geochemistry in the area is characterized by moderately high concentrations (4 to 7 times background) of cadmium and molybdenum (U.S. Geological Survey, 2016b). The tract is located along the margin of a gravity low. As reflected by radiometric measurements, the tract occurs on the margin of a thorium/potassium (Th/K) high (Day and others, 2016). Small, isolated zones of advanced argillic and minor ferric iron alteration in Paleozoic sedimentary rocks around the Delano and Cleveland Mines are interpreted from ASTER satellite imagery (Rockwell and others, 2015).

Previous assessments estimate that all or parts of this tract are permissive for intrusion-related polymetallic replacement, skarn, and porphyry copper deposits (U.S. Geological Survey, 2001; Parks and others, 2016). The mines are inactive at present (Fernette and others, 2016a). However, there are 105 active lode claims in the tract (Dicken and San Juan, 2016).

Polymetallic replacement deposits are represented by the Delano Pb-Ag-Zn-(Cu-Au-Sb), Cleveland Zn-Pb-Cu-Ag-(Sb-Au), Gold Note Pb-Zn-Ag-(Au-Cu-Sb), and 86 Ag-Pb mines. At these mines, mixed oxide-sulfide cerussite, galena, bindheimite, and minor anglesite, sphalerite, argentite, tetrahedrite, and malachite occur in a gangue of silica-jasper. At the Cleveland and Delano Mines, replacement mantos occur along two parallel limestone beds that are separated by a partly silicified dolomite. The upper manto is located along a limestone-dolomite contact, and the lower manto occurs along a limestone-sandstone contact. In the larger upper manto, ore shoots were as much as 6-ft thick, 125-ft long, and were mined 450 ft downdip in the Cleveland Mine, and 1,700 ft downdip in the Delano Mine (LaPointe and others, 1991).

Subeconomic cassiterite quartz veins healed with chalcedony occur alongside replacement mineralization at some mines. Their relationship to the polymetallic replacement deposits in the district is unclear. Tin mineralization is likely associated with Miocene rhyolite porphyry dikes exposed in the area (Slack, 1972; Smith, 1976; LaPointe and others, 1991).

Tract INPR11, Indian Springs—There is high (H) potential, with certainty level D, for intrusion-related tungsten (molybdenum) greisen deposits in the southern part of the Delano district, 45 km north of Montello, Elko County, Nevada (LaPointe and others, 1991; fig. 31*L*; appendix 2). The geology of the area is characterized by folded and thrust-faulted Permian sedimentary rocks that are intruded by the Lower Cretaceous Indian Springs quartz monzonite stock. Rocks at the contact are locally altered to garnet-diopside-epidote skarn and cut by quartz monzonite and granite porphyry dikes (Slack, 1972). Paleozoic rocks surrounding the stock are unconformably covered by Miocene volcanic and Pliocene volcaniclastic strata (Coats, 1987; LaPointe and others, 1991; Crafford, 2007).

Tungsten exploration in the area resulted in discovery of the Indian Springs deposit in 1969. By the 1980s, 12,500 short tons of ore averaging 0.25 percent tungsten trioxide (WO_3) had been mined at Indian Springs (LaPointe and others, 1991). The current indicated and inferred resource stands at 19 million short tons at 0.17 percent tungsten trioxide (WO_3) (0.10 percent WO_3 cutoff grade; SRK Consulting, 2007).

The tract was delineated by aggregating 3-km buffers around the Indian Springs deposit and Mitchell mine (Fernette and others, 2016a). The tract encompasses the Indian Springs stock. Soil and stream-sediment geochemistry in the tract is characterized by moderately high concentrations (4 to 7 times background) of cadmium and molybdenum (U.S. Geological Survey, 2016b). The tract is located along the margin of a broad gravity high, and elevated thorium and potassium concentrations as reflected by radiometric measurements (Day and others, 2016). Interpreted ASTER satellite imagery (Rockwell and others, 2015) shows an area of advanced argillic alteration and ferric iron about 1 km north of Indian Springs.

Previous assessments estimate that all or parts of this tract are permissive for intrusion-related polymetallic replacement, skarn, and porphyry copper deposits (U.S. Geological Survey, 2001; Parks and others, 2016). There are 45 active lode claims in the tract (Dicken and San Juan, 2016).

The Indian Springs W-Mo deposit consists of quartz-topaz-muscovite-fluorite greisen veins and stockworks that are related to northeast-trending late quartz monzonite and granite porphyry dikes on the eastern edge of the 135 Ma Indian Springs stock (Slack, 1972). Ore minerals include scheelite, powellite, pyrite, magnetite, molybdenite, and minor chalcopyrite. Greisen veins exhibit potassium-silicate and intense sericite and clay alteration envelopes that spread out over a 2,000- by 3,000-ft surface area (LaPointe and others, 1991; SRK Consulting, 2007). Scheelite also occurs in associated W-(Mo-Cu-Zn) skarn on the southeastern edge of the stock, and in an Ag-Cu-W quartz vein at the Mitchell Mine on the northwestern edge of the stock. A newly-identified zone of anomalous gold values in rock chip and soil samples occurs about 500 m to the east of the Indian Springs deposit (Fernette and others, 2016a).

Tract INPR12, Gold Basin—There is moderate (M) potential, with certainty level B, for intrusion-related gold-(silver-copper) polymetallic veins in the Gold Basin (Rowland) district, Elko County, Nevada (LaPointe and others, 1991; fig. 31*M*; appendix 2). The geology of the area is characterized by steeply dipping Cambrian to Pennsylvanian limestone, schist, argillite, and phyllite. These rocks are cut by several northeast-trending thrust faults which generally parallel the strike of the beds, and by steeply dipping north-northwest and northeast-striking normal faults. To the south, Paleozoic rocks are intruded by the Cretaceous (73 Ma; du Bray and Crafford, 2007) Deep Creek quartz monzonite stock. Contact metamorphism developed adjacent to the stock and produced hornfels and marble, but no significant skarn. These Paleozoic and Mesozoic rocks are partially overlain by Eocene andesite flows and are more extensively covered by Miocene rhyolite tuffs (Smith, 1976; Coats, 1987; LaPointe and others, 1991; Crafford, 2007).

Small amounts of gold-silver ore with byproduct copper were produced intermittently from 1930 through 1940, mainly from the Bruneau Mine. Ore from the Bruneau and Mendive veins is reported to have had grades of 0.30 opt gold and 0.68 opt silver. No production has been reported from the district since 1941 (Smith, 1976; LaPointe and others, 1991).

The tract was delineated by aggregating 3-km buffers around mines and prospects (Fernette and others, 2016a). Soil and stream-sediment geochemistry in the tract is characterized by high concentrations (more than 16 times background) of tin, and moderate to high concentrations (8 to 15 times background) of antimony, cadmium, and molybdenum (U.S. Geological Survey, 2016b). The tract is, in part, cospatial with an isolated magnetic low, and at the tract northern margin, a broad gravity low. Elevated uranium, thorium, and potassium concentrations, as reflected by radiometric measurements, occur in the tract (Day and others, 2016). An east-northeast-trending zone of advanced argillic alteration and ferric iron, and argillic alteration along the western margin of the Deer Creek stock is interpreted from ASTER satellite imagery (Rockwell and others, 2015). No prospects are known in this area.

Previous assessments estimate that all or parts of this tract are permissive for intrusion-related polymetallic replacement, skarn, and porphyry copper deposits (U.S. Geological Survey, 2001; Wallace and others, 2004; Parks and others, 2016). There are 5 active lode claims in the tract (Dicken and San Juan, 2016).

Deposits in the area are represented by fissure veins. These occur at the Bruneau (Elko) Au-(Ag-Cu) and Deep Creek Au mines, and the Bearpaw Mountain Au, Mendive Au-(Ag-Cu), and Taylor Creek Au-(Ag) prospects. The Deep Creek Mine and Bearpaw Mountain prospect are located closest to the Deep Creek stock, but their relation to the intrusion is not documented (Smith, 1976; LaPointe and others, 1991; Fernette and others, 2016a).

Tract INPR13, Texas Canyon—There is moderate (M) potential, with certainty level C, for distal disseminated gold-silver deposits and associated silver-gold-bearing polymetallic vein deposits located about 80 km northeast of Wells in Elko County, Nevada (LaPointe and others, 1991; fig. 31*N*; appendix 2). The geology of the area is characterized by Permian carbonate and clastic rocks that were deformed and mildly metamorphosed in Mesozoic time. Both Jurassic and Cretaceous granitic rocks intrude the sedimentary rocks in nearby areas. Much of the area is covered by relatively thin sequences of Miocene volcanic rocks, some of which are reported to include quartz-latite subvolcanic intrusions (Coats, 1987; Crawford, 2007).

The tract was delineated by aggregating 3-km buffers around the Rock Springs, Golden Trail, and Texas Canyon (including the Prince mine) active exploration projects (Fernette and others, 2016a). Soil and stream-sediment geochemistry around the Texas Canyon and Golden Trail projects is characterized by moderately high to high concentrations (8 to 15 times background) of molybdenum and moderately high concentrations (4 to 7 times background) of gold and cadmium. Soil and stream-sediment geochemistry around the Rock Springs project is characterized by moderately high concentrations (8 to 15 times background) of molybdenum (U.S. Geological Survey, 2016b). Weak positive regional magnetic anomalies occur east of the Texas Canyon and south of the Golden Trail projects. The tract area is otherwise cospatial with a regional gravity low (Day and others, 2016), and elevated concentrations of uranium and thorium (Texas Canyon) and potassium and thorium (Golden Trail), as reflected by radiometric measurements (Day and others, 2016).

A 100- by 500-m advanced argillic and ferric iron alteration zone in Paleozoic rocks 500 m south of the Prince Mine is interpreted from ASTER satellite imagery (Rockwell and others, 2015). Ferrous or coarse-grained ferric iron is well developed in Miocene volcanic rocks to the west. Argillic and ferric iron alteration are also present in Paleozoic rocks at Golden Trail.

Previous assessments estimate that all or parts of this tract are permissive for intrusion-related polymetallic deposits (Wallace and others, 2004; Parks and others, 2016). There are 164 active lode claims in the tract (Dicken and San Juan, 2016).

Gold occurs at the Golden Trail project, the Texas Canyon project, and the Rock Springs property (Capps, 2012; Capps and others, 2015; Western Pacific Resources Corp., 2016). Although the companies that have explored these properties since the 1970s often characterize the mineralization as “Carlin-type,” we believe the geology, alteration, and mineralogy of the veins indicate they are they are related to nearby but largely unexposed Mesozoic intrusions.

At the Golden Trail project, gold occurs in fault-controlled quartz-carbonate-clay-white mica veins, and adjacent silica replacements, iron oxide-rich breccias, and jasperoids. These are hosted within a broad zone of hornfels and Zn-(Pb-Cu)-bearing skarn, and more distally in decalcified and dolomitized limestone. Results from geochemical rock-chip sampling indicate that anomalous gold is associated with elevated silver, arsenic, antimony, and thallium values. Gold values above 20 part per billion (ppb) are common with several samples assaying above 9 ppm gold. Part of the Golden Trail project was explored and drilled as a porphyry molybdenum target in the 1970s (Capps, 2012). Several granitic/monzonitic hypabyssal intrusive intercepts are reported in drill logs (Capps and others, 2015).

The characteristics of gold mineralization at the Texas Canyon project are comparable to those at the Golden Trail project. At Texas Canyon, however, a sulfide-bearing coarse-grained granitic intrusion is exposed at the surface. Gold in veins and adjacent breccia and silica replacement zones is associated with elevated antimony, arsenic, lead, silver, zinc, and local mercury, molybdenum, and copper values. At the Prince Mine, parallel veins extend northeasterly to the central Texas Canyon claim area. Vein gangue mineralogy includes several generations of quartz, sericite, calcite, and dolomite. Pseudomorphs after sulfides suggest the former presence of pyrite, chalcopyrite, and stibnite. The Prince Mine is reported to also contain anomalous uranium values (Capps, 2012).

At the Rock Springs property, the main area of gold deposits occur along two parallel ridges that trend N. 60° E. Surface sampling in 1987–89 of structurally controlled jasperoids in both ridges returned values as high as 0.055 opt (1.88 g/t) gold and 16.1 opt (551 g/t) silver, 750 ppm arsenic, 0.99 percent antimony, and 32 ppm mercury. Recent surface rock chip samples returned values as high as 0.04 opt (1.38 g/t) gold, 8.7 opt (300 g/t) silver, 1.7 percent lead, and 2.0 percent zinc. Quartz veins along these ridges contain stibnite, stibiconite, and local pyrite and barite (Western Pacific Resources Corp., 2016).

An additional exploration project is reported at Gold Jackpot less than 1 km northeast of the Texas Canyon project. Here, 1988–1990 drill-hole data and geochemical samples are reported to show structurally controlled near-surface anomalous gold and elevated silver, arsenic, and tellurium values (Mexivada Mining Corp., 2012, 2013).

Tract INPR14, Scraper Springs—There is moderate (M) potential, with certainty level C, for high-fluorine, porphyry-molybdenum-associated gold-bearing polymetallic skarn and quartz-alunite epithermal gold-silver deposits in the Scraper Springs area, 15 km northeast of Midas, Elko County, Nevada (LaPointe and others, 1991; fig. 31*O*; appendix 2). The geology of the area is characterized by an exposure of Paleozoic rocks in a window of Eocene and Miocene volcanic rocks. Paleozoic and Eocene volcanic rocks have been intruded by 39 Ma porphyritic diorite and quartz syenite intrusions. Skarn developed in Paleozoic rocks around the intrusion, and Tertiary volcanic rocks have been silicified and pervasively argillized (Coats, 1987; LaPointe and others, 1991; Crafford, 2007; Cantor, 2012)

The tract was delineated by aggregating 3-km buffers around a several-square-kilometer area of hydrothermally altered volcanic rocks and drill holes (Cantor, 2012). The tract encloses the Scraper Springs property, the Rebel Claims prospect, and a zunyite locality. Soil and stream-sediment geochemistry in the tract is characterized by high concentrations (more than 16 times background) of bismuth, moderately high to high concentrations (8 to 15 times background) of molybdenum, and moderately high concentrations (4 to 7 times background) of cadmium. Local, elevated concentrations of gold, selenium, and tin occur in stream sediments (U.S. Geological Survey, 2016b). The tract is cospatial with a modest magnetic high and near a northwest-trending moderate gravity high (Day and others, 2016). A northwest-trending zone of elevated potassium concentrations, as reflected by radiometric measurements, coincides with much of the tract (Day and others, 2016). Well-developed advanced argillic, ferric iron, and argillic alteration in the tract are interpreted from ASTER satellite imagery (Rockwell and others, 2015).

Previous assessments estimate that all or parts of this tract are permissive for polymetallic replacement, skarn, and porphyry copper deposits (U.S. Geological Survey, 2001), hot spring gold-silver deposits, quartz-adularia vein deposits, quartz-alunite gold deposits, and epithermal deposits of mercury, antimony, manganese, and tin (U.S. Geological Survey, 2001; Wallace and others, 2004; Parks and others, 2016). There are 75 active lode claims in the tract (Dicken and San Juan, 2016).

Mineral occurrences in the district include the zunyite locality, the Rebel and Willow epithermal silver-barium-manganese prospects, and the Scraper Springs molybdenum-(fluorine) exploration project. The zunyite locality was identified and studied in the late 1970s (Coats and others, 1979). This occurrence generated exploration interest for quartz-alunite epithermal gold-silver deposits in the area. In the 1980s and 1990s, exploration efforts resulted in the identification of the porphyry molybdenum-(fluorine) and associated gold-bearing polymetallic skarn target at Scraper Springs (Cantor, 2012). At Scraper Springs, alteration minerals in breccias and stockwork veins in Eocene volcanic rocks and intrusions include K-feldspar, sericite, and quartz, and advanced argillic associations (quartz, alunite, pyrophyllite, pyrite, topaz, kaolinite, and zunyite; Coats and others, 1979). Skarn minerals occur in Paleozoic sedimentary rocks adjacent to intrusions. Based on drill-hole logs and cuttings analyses, altered rocks contain 3 to more than 8 percent pyrite and elevated concentrations of gold, silver, molybdenum, fluorine, copper, zinc, and lead, and lesser bismuth, tellurium, selenium, and tin (Cantor, 2012). Notwithstanding some encouraging drill intercepts, a resource estimate has not been published. Exposed mineralization at nearby prospects is characterized by small silver-barite-manganese quartz veins and breccia zones (Rebel claims), and fault-controlled jasperoid (Willow claims) in altered volcanic rocks (LaPointe and others, 1991).

Tract INPR15_pmr, Ashbrook Polymetallic Replacement—There is moderate potential (M), with certainty level C, for porphyry-related Ag-Au-Pb-(Cu-Zn) polymetallic replacement deposits in the Ashbrook district of northwestern Box Elder County, 13 km northwest of Lynn, Utah (fig. 31*P*; appendix 2). The geology of the area is characterized by folded and faulted Proterozoic metasedimentary and Paleozoic sedimentary rocks that are intruded by ~13 Ma granite and rhyolite porphyry plugs, dikes, and sills that are possibly related to the Jarbidge volcanic suite. Eocene to early Miocene east-dipping faults resulted in top-to-west block rotation followed by Miocene to Pliocene faults associated with denudation of the Raft River-Grouse Creek-Albion metamorphic core complex adjacent to the east. Quaternary alluvium covers parts of the district (Compton and others, 1977; Hintze and others, 2000; Gloyn and Krahulec, 2006).

The Ashbrook district was staked in 1873, and through 1920 had intermittent production. Mining was most active between 1920 and 1923, and halted because of a drop in silver prices. Mining in the district revived between 1934 and 1941, but was closed by the federal precious metal mine closure act of 1941. Past production in the district is estimated at 180,000 short tons of ore which yielded 3,440,000 oz of silver. In the 1950s, an exploration drilling program was conducted by the U.S. Bureau of Mines, and the Vipont tailings were re-processed between 1978 and 1984 (Gloyn and Krahulec, 2006).

The tract was delineated by aggregating 3-km buffers around projects, mines, and prospects. Moderate to strong (8 to 15 times and more than 16 times background) selenium and tin, and moderate (4 to 7 times background) silver geochemical anomalies occur in the tract (U.S. Geological Survey, 2016b). The district is located approximately 8 km north of a reduced-to-pole magnetic high that images the Grouse Creek Pluton, and a moderate-intensity, north-south Bouguer gravity ridge (Day and others, 2016). The radiometric thorium/potassium (Th/K) map shows that the district is located on a north-northwest-trending low. A northwest-trending zone indicating advanced argillic plus ferric iron, argillic, and lesser sericite alteration is interpreted from ASTER satellite imagery (Rockwell and others, 2015).

Previous assessments estimate that this area is permissive for quartz-adularia and quartz-alunite, and hot spring epithermal, and polymetallic replacement, porphyry, and skarn deposits (U.S. Geological Survey, 2001; Parks and others, 2016). There are 9 active lode claims in the tract (Dicken and San Juan, 2016).

The Ashbrook district includes the Vipont, Lexinton-Argenta, Sentinell, and Skoro Ag-Au-Pb-(Cu-Zn) carbonate replacement deposits and other prospects. Replacement gangue and ore minerals were deposited from oldest to youngest in three stages: (1) rhodochrosite; (2) quartz, pyrite, arsenopyrite, sphalerite, and chalcopyrite; and (3) galena, argyrodite, pyrargyrite, pearceite, tennantite, and other silver sulfosalts. Oxidized and enriched ore includes argentite, covellite, chalcocite, cerussite, and native silver (Peterson, 1942; Doelling and others, 1980; Gloyn and Krahulec, 2006).

Tract INPR15_dd, Ashbrook Distal Disseminated Silver-Gold—There is high (H) potential, with certainty level D, for intrusion-related distal disseminated silver-gold deposits in the Ashbrook district of northwestern Box Elder County, 13 km northwest of Lynn, Utah (fig. 31*P*; appendix 2). The geology, regional geochemical, geophysical, and remote-sensing data that characterize the tract are described in report section "Tract INPR15_pmr, Ashbrook Polymetallic Replacement."

A distal disseminated gold-silver deposit in the Ashbrook district is exposed at the Vipont Mine. Stratiform disseminated mineralization is associated with silver-rich polymetallic veins and replacements. The mineralogy and sequence of deposition of gangue and ore is the same as that reported for replacement deposits in the district. The Vipont Ag-Au deposit is reported to contain an open-pit-mineable mineral resource of approximately 430,000 short tons at an average grade of 5.06 opt silver and 0.01 opt gold (Peterson, 1942; Doelling and others, 1980; Gloyn and Krahulec, 2006).

Tract INPR15_pmv, Ashbrook Polymetallic Vein—There is moderate (M) potential, with certainty level C, for intrusion-related Ag-Au-(Pb-Cu-Zn) polymetallic vein deposits in the Ashbrook district of northwestern Box Elder County, 13 km northwest of Lynn, Utah (fig. 31*P*; appendix 2). The geology of the area is described in report section "Tract INPR15_pmr, Ashbrook Polymetallic Replacement."

Au-Ag-(Pb-Cu-Zn) polymetallic veins in the Ashbrook district include the Peg Leg, Dolly Clark, and Midway tunnel Mines. These veins exhibit ore mineral associations that are similar to those in related replacement deposits (see report section “Tract INPR15_pmr, Ashbrook Polymetallic Replacement”). These veins have been classified as epithermal (U.S. Geological Survey, 2016a; Fernette and others, 2016a).

Rock Units Favorable for Intrusion-Related Deposits

There is low potential (L), with certainty level B for intrusion-related mineral deposits in large areas within the four study areas. A tract that encloses these areas consists of numerous separate enclosures in each study area (tract INPR01, Pluton-related Permissive, Jurassic to Holocene intrusion-related deposits; fig. 31*Q*; appendix 2). The boundaries of the tract are based on the Oregon, Idaho, Nevada, and Utah state geologic maps (fig. 3*A*; Walker and MacLeod, 1991; Hintze and others, 2000; Miller and others, 2002; Crafford, 2007; Lewis and others, 2012). The boundaries enclose autochthonous and allochthonous Paleozoic and Mesozoic stratigraphy that has been superpositioned by crustal compression in the Paleozoic and Mesozoic, and Eocene to Holocene volcanic rocks and intrusions that have been distended by crustal extension during the late Tertiary (see report section “Introduction; Description of Geology”).

Appropriate units were selected from digital geologic maps of Nevada, Oregon, Idaho, and Utah; permissive intrusive map units were buffered by 10 km, permissive volcanic map units were buffered by 2 km, and those buffered units were merged into tracts. Mineral-resource occurrences (U.S. Geological Survey, 2005) that correspond to intrusion-related deposits in permissive igneous rock map units were buffered by 10 km and those buffered units were merged into the permissive map unit-based tracts. The composited tracts were aggregated, using a 5-km aggregation distance, and a 2,000-km^2 minimum hole size. The aggregated tracts were smoothed, using a 5-km tolerance. Areas within the aggregated tracts where the depth to basement rocks is interpreted to exceed 1 km (Day and others, 2016) were excluded. The resulting tracts enclose stratigraphy favorable for intrusion-related deposits similar to deposits within assessed tracts described above, and include several assessed tracts.

Early-stage exploration projects for which there is limited information and for which no work has been reported in the past 5 to 10 years are included in tract INPR01, Pluton-related Permissive. One area was identified in PLSS ID080080S0010W0 and PLSS ID080080S0010E0. The identified area includes the Silver Rock and Clover Mountain gold-silver-(base metal) vein systems (Fernette and others, 2016a). These veins are associated with Oligocene rhyolite dikes hosted in Cretaceous granite. A soil geochemical survey was conducted in 2008 at the Clover Mountain active exploration project, but the results of this survey have not been published (Thunder Mountain Gold, 2013, 2016). The Silver Rock Mine had historic production; however, no lode claims are currently active (Bennett and others, 2010).

Buffering Intrusion-Related Tracts

The intrusion-related tracts described previously represent numerous deposit types, including polymetallic vein, skarn, replacement gold-silver-copper-lead-zinc deposits, porphyry copper deposits, porphyry molybdenum deposits, tungsten greisen deposits, and distal disseminated gold-silver deposits. All intrusion-related tracts were delineated from characteristics of deposit models for these deposit types, which were assembled from characteristics of well-documented intrusion-related deposits and the magmatic-hydrothermal systems that formed the deposits (Day and others, 2016; appendix 2). Some of these characteristics may be concealed (for example, altered rocks covered by younger rocks; drill-defined polymetallic resources; deposits identified by drill-hole intercepts with elevated metal values) whereas others are detectable only by instrumentation (for example, gravimetric, magnetic, and radiometric surveys) and do not appear on published maps (geologic; topographic) or may not appear in other publications.

Metal occurrences and intrusions on published maps and in other publications were the initial criteria used to delineate tracts for possible concealed and unmapped intrusion-related deposits. Other criteria used included the alteration, geochemical, and geophysical signatures of the magmatic-hydrothermal systems that form intrusion-related deposits. The approximate diameters of “footprints” (surface exposures) of well-exposed intrusion-related systems range from hundreds of meters to tens of kilometers for very large to “giant” systems (Sillitoe, 2010; Richards, 2013). Since no evidence for very large to giant intrusion-related systems has been found in the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, radii less than 10 km from intrusion-related metal occurrences broadly represent the uncertainty associated with the location of an intrusion-related occurrence within concealed to partly concealed, small to large, intrusion-related systems (those with diameters of hundreds of meters to about 10 km). Additional footprint refinement of intrusion-related systems was derived from the median and 90th-percentile radii, about 0.6 km and 2.6 km, respectively, of porphyry copper systems (Singer and others, 2008). These radii are minima because many porphyry systems used in their calculation are partly covered. For tract delineation in the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, a 3-km buffer radius centered on intrusion-related metal occurrences was selected to represent the uncertainty associated with the surface projection of concealed to partly concealed intrusion-related systems. Tract boundaries represent the merged circumferences of circles (with 3-km radii) concentric to all intrusion-related metal occurrences within the tract.

Mineral Potential Tracts for Volcanogenic Massive Sulfide Copper Deposits

One low potential tract and two nested high potential tracts with different certainty levels were delineated for VMS deposits: tract INMS01, VMS Permissive; tract INMS02, Rio Tinto 1; and INMS03, Rio Tinto 2.

Tract INMS01, VMS Permissive—There is low potential (L), with certainty level B, for VMS copper-zinc-lead-silver-gold deposits in the study area (tract INMS01, VMS Permissive; fig. 31*R*; appendix 2). In VMS systems, sulfide minerals precipitate near seafloor vents where circulating hydrothermal fluids driven by magmatic heat mix with cool seawater (Shanks and Thurston, 2010). In Nevada, submarine volcanic rocks and VMS deposits and occurrences (Sherlock and others, 1996) occur in the following geologic map units: Black Rock/Pueblo terrane (unit Mzbr), Golconda allochthon (unit Pzh), and Roberts Mountains allochthon (unit Pzrm) (fig. 27). The tract encloses these units plus a 1-km buffer to account for cover and uncertainty of mapped contacts.

Tract INMS02, Rio Tinto 1; Tract INMS03, Rio Tinto 2—There is high potential (H), with certainty levels D (Rio Tinto 1) and C (Rio Tinto 2), for volcanogenic massive sulfide copper-zinc-lead-silver-gold deposits (VMS) in an area centered on the Rio Tinto Mine, which is largely within the proposed withdrawal area within the study area (tract INMS02, Rio Tinto 1; tract INMS03, Rio Tinto 2; fig. 31*R*; appendix 2; Coats and Stephens, 1968; LaPointe and others, 1991). From 1932 to 1949, this mine produced 1,110,000 million short tons of ore from the Ordovician Valmy Formation with an average grade of 9.7 percent copper (Coats and Stephens, 1968; LaPointe and others, 1991). Because VMS deposits are known to occur in clusters (Shanks and Thurston, 2010), two buffers, 1.8 km and 6.7 km in width, were applied to the Rio Tinto Mine, which correspond to the 50th- and 90th-percentile spacing between VMS deposits in five well-described VMS districts (Galley and others, 2007). Deposit buffers were trimmed to map units of the Roberts Mountains allochthon and a 1-km-wide buffer was added to account for cover and uncertain contacts. There is high potential with certainty level D within the 1.8-km-wide buffer (dark magenta) and high potential with certainty level C within the 6.7-km-wide buffer (light magenta; fig. 31*R*). Within the tract, anomalous concentrations of copper, silver, gold, and arsenic are present in stream sediments (Day and others, 2016; Smith and others, 2016). Supergene weathering and oxidation of associated pyrite in enclosing rocks (Coats and Stephens, 1968; LaPointe and others, 1991) are evident in the distribution of ferric and ferrous iron, and argillic alteration, based on interpretation of Landsat and ASTER imagery (Rockwell and others, 2015). The tract includes numerous patented, active, and historic lode claims (fig. 29; tables 16, 17; Causey, 2007, 2011) but no exploration activity (Fernette and others, 2016a).

Mineral Potential Tracts for Carlin-Type Gold Deposits

One low potential tract, four moderate potential tracts, and four nested high potential tracts were delineated for Carlin-type gold deposits: tract INCT01, Carlin Permissive; tract INCT02, Willow 1; tract INCT03, Willow 2; tract INCT04, Big Springs 1; tract INCT05, Big Springs 2; tract INCT06, Doby George 1; tract INCT07, Doby George 2; tract INCT08, North Star 1; and tract INCT09, North Star 2.

Tract INCT01, Carlin Permissive—There is low potential (L), with certainty level B, for Carlin-type gold deposits over much of the eastern part the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area (tract INCT01, Carlin Permissive; fig. 31*S*; appendix 2). In Eocene Carlin-type systems, gold-bearing disseminated pyrite precipitates where hydrogen sulfide-bearing hydrothermal fluids react with iron-bearing minerals or fluids in sedimentary rocks (Hofstra and Cline, 2000). In areas of Nevada adjacent to the tract, most production and resources of Carlin-type gold deposits occur in Paleozoic sedimentary rocks deposited near the platform margin in slope environments, although gold deposits also are present in marginal basin, shelf, foreland basin, and overlap sequences (Cline and others, 2005; Berger and others, 2014; Cook, 2015). These sedimentary rocks correspond to the following geologic map units: sedimentary rock units of the North American Continental Shelf, Roberts Mountains allochthon, and Golconda allochthon (fig. 27). The low potential tract includes these units and a 1-km buffer to account for cover and uncertainty of contacts.

Tract INCT02, Willow 1; Tract INCT03, Willow 2—There is moderate potential (M), with certainty levels D (Willow 1) and C (Willow 2), for Carlin-type gold deposits in an area centered on the Willow active exploration project (Carlin Gold Company, 2016; Fernette and others, 2016a), which extends into the proposed withdrawal area (tract INCT02, Willow 1; tract INCT03, Willow 2; fig. 31*S*; appendix 2).

Because Carlin-type gold deposits occur in clusters (Hofstra and Cline, 2000), two buffers, 4.2 km and 2.0 km in width, were applied to the active exploration area and three prospects (Fernette and others, 2016a), which correspond to the 50th- and 90th-percentile spacing, respectively, between Carlin-type gold deposits in Nevada (Berger and others, 2014). The west side of the resulting tract was trimmed to stratigraphy favorable for Carlin-type gold deposits (sedimentary rock units of the North American Continental Shelf, Roberts Mountains allochthon, and Golconda allochthon; fig. 27). The tract boundary was extended to the southeast to include an area with moderately anomalous gold in stream sediments (Day and others, 2016; Smith and others, 2016). There is moderate potential with certainty level D within the 2.0-km-wide buffer and moderate potential with certainty level C in the rest of the tract (fig. 31*S*).

The geology of the tract is typical of Carlin-type gold districts in Nevada (Carlin Gold Company, 2016). Alteration, including silicification (jasperoid), decalcification, and argillization, and gold, occur along northeast-striking, high-angle faults in the Ordovician and Silurian Hanson Creek Formation and Silurian and Devonian Roberts Mountains Formation. An Eocene felsic dike is phyllically altered. These formations are exposed between a northwest-striking range front fault and the Roberts Mountains thrust fault. Drilling of the Hot Creek prospect in the 1980s was based on gold, arsenic, and mercury anomalies near jasperoid (LaPointe and others, 1991); two additional holes were drilled in 2008 (Carlin Gold Company, 2016). Rock samples contain as much as 368 ppb gold at Currant Creek, as much as 159 ppb gold at Badger Creek, and anomalous concentrations of arsenic, antimony, mercury, and thallium (Carlin Gold Company, 2016).

The tract encloses several PLSS sections with plans of operations and notices for gold as well as numerous active, closed, and historic lode claims (figs. 28, 29; tables 16, 17, 18, 19; Causey, 2007, 2011).

Tract INCT04, Big Springs 1; Tract INCT05, Big Springs 2—There is high potential (H), with certainty levels D (Big Springs 1) and C (Big Springs 2), for Carlin-type gold deposits in an area centered on the Big Springs Mine, which is outside the proposed withdrawal area but is adjacent to the Nevada additions study area (tract INCT04, Big Springs 1; tract INCT05, Big Springs 2; fig. 31*S*; appendix 2). From 1987 to 1993, the Big Springs Mine produced 386,000 oz of gold at 0.12 opt gold. The mine is within an active exploration area that includes seven discrete deposits with an inferred total resource defined by 2,400 drill holes of 14.8 million metric tons at 2 g/t gold (table 20; 16.3 million short tons at 0.06 opt gold; Anova Metals Limited, 2016; fig. 30).

Because Carlin-type gold deposits occur in clusters (Hofstra and Cline, 2000), two buffers, 4.2 km and 2.0 km in width, were applied to deposits, resources, and prospects in the mining district (U.S. Geological Survey 2005; Western Exploration and Development Ltd., 2008; Anova Metals Ltd., 2016; Fernette and others, 2016a), which correspond to the 50th- and 90th-percentile spacing between Carlin-type gold deposits in Nevada (Berger and others, 2014). The southwest side of the buffer was trimmed to the study area boundary, and the southeast side was trimmed to stratigraphy favorable for Carlin-type gold deposits (sedimentary rock units of the North American Continental Shelf, Roberts Mountains allochthon, and Golconda allochthon; fig. 27). There is high potential with certainty level D within the 2.0-km-wide buffer and high potential with certainty level C within the 4.2-km-wide buffer (fig. 31*S*).

In this tract, gold deposits and resources mainly occur along high-angle faults in the Devonian to Pennsylvanian Dorsey Creek and Mikes Creek Members of the Schoonover Formation (Adams, 1996), which is part of the Golconda allochthon (fig. 27). Alteration, mineralization, and geochemical values in nearby prospects in the Schoonover Formation, in the Ordovician Valmy Formation of the Roberts Mountains allochthon, and in underlying Ordovician to Devonian carbonate rocks, are consistent with Carlin-type gold deposits. These rocks are partially covered by Tertiary volcanic rocks and Quaternary alluvium. Gold is associated with carbonate dissolution and silicification (Youngerman, 1992; Adams, 1996). The deposits contain in addition to gold, anomalous concentrations of arsenic, antimony, mercury, thallium, and cadmium (Youngerman, 1992). Ferric and ferrous iron occurs in the vicinity of deposits, based on interpretation of Landsat imagery (Rockwell and others, 2015). The tract includes one section with a closed plan of operations for gold as well as numerous active closed and historic lode claims (figs. 28, 29; tables 16, 17, 18, 19; Causey, 2007, 2011).

Tract INCT06, Doby George 1; Tract INCT07, Doby George 2—There is high potential (H), with certainty levels D (Doby George 1) and C (Doby George 2), for Carlin-type gold deposits in an area centered on the Doby George deposit (Western Exploration and Development, Ltd., 2008; Fernette and others, 2016a), which extends into the proposed withdrawal area (tract INCT06, Doby George 1; tract INCT07, Doby George 2; fig. 31*S*; appendix 2; Western Exploration and Development Ltd., 2008). The Doby George deposit, which is part of an active exploration area (map and cross section in LaPointe and others, 1991), has a NI 43-101 compliant gold resource, defined by 577 drill holes, of 27.1 million short tons at 0.028 opt gold (table 20; Western Exploration and Development Ltd., 2008).

Because Carlin-type gold deposits occur in clusters (Hofstra and Cline, 2000), two buffers, 4.2 km and 2.0 km in width, were applied to the gold resource and a nearby gold prospect (Western Exploration and Development Ltd., 2008; Fernette and others, 2016a), which correspond to the 50th- and 90th-percentile spacing between Carlin-type gold deposits in Nevada (Berger and others, 2014). The buffers were trimmed to stratigraphy favorable for Carlin-type gold deposits (sedimentary rock units of the North American Continental Shelf, Roberts Mountains allochthon, and Golconda allochthon; fig. 27). There is high potential with certainty level D within the 2.0-km-wide buffer and high potential with certainty level C within the 4.2-km-wide buffer (fig. 31*S*).

Based on the Western Exploration and Development Ltd. (2008) report, gold-mineralized rocks are localized along northeast- and northwest-striking, high-angle faults in calcareous siltstones and sandstones of the Schoonover sequence, which is part of the Golconda allochthon (fig. 27). Other potential host rocks include hornfels and skarn adjacent to a Cretaceous stock, and the Pennsylvanian Van Duzer Limestone, which occurs at a depth of about 1,500 ft in the deposit area. Gold resources are associated with silicified fault zones, decalcification, argillic alteration, and, in deep drill holes, carbon remobilization. Supergene oxidation extends about 400 ft below the surface. Sericitic alteration occurs with high-grade gold- mineralized rock along fractures in Mesozoic granodiorite. Drill intercepts contain as much as 0.719 opt gold. Soils are anomalous in gold, arsenic, and antimony. Stream sediments are anomalous in arsenic (Day and others, 2016; Smith and others, 2016). Ferric iron and clay minerals, and minor phyllic alteration, occur in the vicinity of deposits, based on interpretation of Landsat and ASTER imagery (Rockwell and others, 2015).

The tract includes two sections with closed notices for gold as well as numerous active, closed, and historic lode claims (figs. 28, 29; tables 16, 17, 18, 19; Causey, 2007, 2011).

Tract INCT08, North Star 1; Tract INCT09, North Star 2—There is moderate potential (M), with certainty level D (North Star 1) and C (North Star 2), for Carlin-type gold deposits in an area centered on the North Star active exploration area, which covers a small proposed withdrawal area (tract INCT08, North Star 1; tract INCT09, North Star 2; fig. 31*S*; appendix 2; Altan Nevada Minerals Ltd., 2015; Fernette and others, 2016a).

Because Carlin-type gold deposits occur in clusters (Hofstra and Cline, 2000), two buffers, 4.2 km and 2.0 km in width, were applied to the exploration area, which correspond to the 50th- and 90th-percentile spacing between Carlin-type gold deposits in Nevada (Berger and others, 2014). The buffers were trimmed to stratigraphy favorable for Carlin-type gold deposits (sedimentary rock units of the North American Continental Shelf, Roberts Mountains allochthon, and Golconda allochthon; fig. 27). There is moderate potential with certainty level D within the 2.0-km-wide buffer and moderate potential with certainty level C within the 4.2-km-wide buffer (fig. 31*S*).

Based on the Altan Nevada Minerals Ltd. (2015) report, jasperoid along a north-northeast-striking, high-angle fault in the Ordovician Vinini Formation contains as much as 1.059 ppm gold, 457 ppm arsenic, 14 ppm antimony, and 3.6 ppm mercury, and is enveloped by a 2-km-long gold, arsenic, and antimony soil anomaly. A drill hole encountered decalcification and silicification in the Vinini Formation and anomalous mercury in strata that resemble the Devonian Rodeo Creek unit, which is an important host rock for Carlin-type gold deposits (Cline and others, 2005). Ferric and ferrous iron minerals, phyllic alteration, and hydrous silica occur in the vicinity of deposits, based on interpretation of Landsat and ASTER imagery (Rockwell and others, 2015).

There were 163 lode claims in the exploration area in 2015 (Altan Nevada Minerals Ltd., 2015). The tract includes two sections with active and numerous closed notices for gold, as well as numerous active, closed, and historic lode claims (figs. 28, 29; tables 16, 17, 18, 19; Causey, 2007, 2011).

Stratigraphy Favorable for Black Shale Vanadium Deposits

There is low potential (L), with certainty level B, for vanadium deposits in Paleozoic, organic-rich, black shales in the study area. Vanadium in seawater is concentrated in organic matter that accumulates in euxinic basins with high organic productivity and low clastic sedimentation rates (Breit and Wanty, 1991; Lehmann and others, 2007). The resulting organic-rich black shales are petroleum source rocks (Poole and Claypoole, 1984; Anna and others, 2007) and typically contain anomalous concentrations of metals and trace elements (Desborough and Poole, 1983; Lehmann and others, 2007). In some basins, they occur with phosphorite (McKelvey and others, 1986), bedded barite (Papke, 1984), or SEDEX zinc-lead-silver-gold deposits (Emsbo, 2000, 2009). Some of these black shales have been proposed to be potential sources for gold and minor elements in Carlin-type gold deposits (Emsbo and others, 2003; Large and others, 2011). In neighboring areas of Nevada and Idaho, black shales with potentially extractable concentrations of vanadium (more than or equal to 1,500 ppm vanadium; American Vanadium, 2011) are present in the following stratigraphic units: Permian Phosphoria Formation, Mississippian Chainman Shale, Devonian and Mississippian Pilot Shale, Devonian Popovich Formation, Devonian Woodruff Formation, Ordovician Vinini Formation, and correlative formations (Desborough and Poole, 1983; Maughan, 1984; McKelvey and others, 1986; Poole and others, 1992; Emsbo and others, 2003; Hofstra and others, 2011; American Vanadium, 2011; Poole and Sandberg, 2015; American Vanadium, 2015; National Geochemical Database, U.S. Geological Survey, 2016b; Stina Resources Ltd., 2016). Although black shale vanadium resources may be present in these formations in the study area, there is little or no evidence of exploration, detailed mapping, or analyses for vanadium. Consequently, no permissive tracts were delineated and no tracts with moderate or high potential were identified.

Stratigraphy Favorable for Sedimentary Exhalative (SEDEX) Zinc-Lead-Silver-Gold Deposits

There is low potential (L), with certainty level B, for SEDEX zinc-lead-silver-gold deposits in Ordovician and Devonian, organic-rich, black shales in the study area. In SEDEX systems, ore minerals precipitate in organic-rich, black shales when metal-laden basinal brines vent into euxinic seawater in bathymetric lows (Emsbo, 2009). In areas of Nevada adjacent to the study area, SEDEX deposits with potentially extractable concentrations of metals occur in the following stratigraphic units: Devonian Popovich Formation (Upper Zone of the Rodeo deposit; Emsbo, 2000), Devonian Rodeo Creek unit (Mike deposit; Bawden and others, 2003), Ordovician Vinini Formation (Blue Basin prospect and LAJ claims; LaPointe and others, 1991), and perhaps in other formations. Although SEDEX zinc-lead-silver-gold resources may be present in the study area, there is little or no evidence of exploration for, or descriptions of, SEDEX occurrences. Consequently, no tracts were delineated and no tracts with moderate or high potential were identified.

Stratigraphy Favorable for Mississippi Valley-Type (MVT) Lead and Zinc Deposits

There is low potential (L), with certainty level B, for MVT lead and zinc deposits in the study area. In MVT systems, ore minerals precipitate in sedimentary rocks deposited in shelf sequences where metal-laden basinal brines mix with contrasting aqueous fluids, or natural gas, containing hydrogen sulfide (Leach and others, 2010). Geologic map unit PzMzs (sedimentary rock units of the North American Continental Shelf; fig. 27) is a permissive host unit for MVT deposits. In areas of Nevada adjacent to the study area, dolomitized limestones and hydrothermal dolomite represent brine migration pathways; MVT deposits and occurrences with potentially extractable concentrations of zinc, lead, silver, and barite have been identified at several locations (Papke, 1984; LaPointe and others, 1991; Diehl and others, 2005, 2010), including Black Mountain which is an active exploration project (Firestone Ventures, 2016). Although MVT lead and zinc deposits may be present in the study area, there is little or no evidence of exploration for, or descriptions of, MVT deposits or occurrences. Consequently, no permissive tracts were drawn.

Market Analyses of Gold, Silver, Uranium, Copper, Molybdenum, Lead, Zinc, and Tungsten

Market analyses of gold, silver, uranium, copper, molybdenum, lead, zinc, and tungsten is provided in appendix 5 and section I of Day and others (2016).

Mineral Potential Tracts for Lacustrine Diatomite Deposits

Four tracts were delineated and rated for lacustrine diatomite deposits: tract INDT01, Dickshooter; tract INDT02, Dickshooter North; tract INDT03, Owyhee-Twin Falls; and tract INDT04, Owyhee-Twin Falls-Cassia-Elko.

Tract INDT01, Dickshooter—High potential (H), at certainty level D, for lacustrine diatomite deposits is assigned to an area in western Owyhee County, Idaho (tract INDT01, Dickshooter; fig. 31*T*; appendix 2). The Dickshooter tract is based on (1) two sites of past diatomite production (U.S. Geological Survey, 2016a); (2) an active plan of operations, apparently for diatomite (table 19) in sec. 27, T. 11 S., R. 2 W. and sec. 3, T. 12 S., R. 2 W.; (3) active millsites in sec. 2, T. 12 S., R. 2 W. and sec. 34, T. 11 S., R. 2 W., and active placer claims in sec. 3, T. 12 S., R. 2 W. (tables 16, 17); and (4) a published account of the diatomite deposit describing historic claims in sec. 34 and 35, south half of sec. 36, T. 11 S., R. 2 W., and all of sec. 2 and 3, T. 12 S., R. 2 W. (Powers, 1947); and (5) the Owyhee County geologic map (1:125,000 scale) unit Tbs sediments that locally contain diatomite interbedded within the Miocene Banbury Basalt of the Idaho Group (Ekren and others, 1981).

On the Idaho state map (1:500,000 scale), the generalized host lithologic unit for Dickshooter tract is depicted as the broadly extensive unit Tpb that consists of Pliocene basalt flows, pyroclastic debris, clastic sediments, and diatomite (Bond and others, 1978). According to Malde and Powers (1962), this unit might include Miocene, Pliocene, or Pleistocene “Lake Idaho” sediments—units that are semiequivalent to Succor Creek unit, Banbury Basalt, Bruneau, Chalk Hills, Glenns Ferry, and Poison Creek formations. The more specific host unit for the Dickshooter past producing mine is mapped on the Owyhee County geologic map (1:125,000 scale) as unit Tbs sediments that locally contain diatomite interbedded within the Miocene Banbury Basalt (Ekren and others, 1981). In Powers (1947), this diatomite exposure corresponds with a drainage that has eroded through the capping basalt.

No previous mineral-resource assessments have been conducted in the tract area.

Tract INDT02, Dickshooter North—Moderate potential (M), at certainty level C, for lacustrine diatomite deposits is assigned to an area north-northeast of tract INDT01, Dickshooter, in Owyhee County, Idaho (tract INDT02, Dickshooter North; fig. 31*T*; appendix 2). No current or past production and no identified prospects or occurrences were recorded within the two sections that comprise the Dickshooter North tract (sec. 11, T. 11 S., R. 2 W. and sec. 19, T. 10 S., R. 1 W.). Tract delineation and rating are based on (1) BLM-authorized surface-management plans, apparently for diatomite; and (2) the location of the two sections being within the generalized lithologic unit on the Idaho state map (1:500,000 scale) depicted as the broadly extensive unit Tpb Pliocene basalt flows, pyroclastic debris, clastic sediments, and diatomite (Bond and others, 1978), which corresponds with the unit Tb Miocene Banbury Basalt (Ekren and others, 1981).

Two previous mineral assessments were conducted at Pole Creek just to the west and inside the margin of the tract. In a report prepared for the BLM, Mathews and Blackburn (1983) determined that the Pole Creek area (Gem Resources Area ID-010-10), which includes T. 11 S., R. 2 W., has high favorability for diatomite resources with a confidence level equivalent to a certainty of the current rating of D; they further stated that the probability of diatomite deposits within the Tbs map unit (Banbury Basalt) is excellent. Subsequently, the mineral assessment of the Pole Creek Wilderness Study Area (U.S. Geological Survey and U.S. Bureau of Mines, 1989) recognized a high favorability for diatomite, but did not rate the mineral potential.

Tract INDT03, Owyhee-Twin Falls—Moderate potential (M) for lacustrine diatomite deposits, at certainty level B, is assigned to an area of Owyhee and Twin Falls Counties, Idaho (tract INDT03, Owyhee-Twin Falls; fig. 31*T*; appendix 2). The tract is delineated on the basis of lithologic units (1) from the Owyhee County Geologic Map (1:125,000 scale) that include unit Tbs Miocene sediments with lacustrine diatomite interbeds within the Banbury Basalt and unit Tch Miocene and Pliocene Chalk Hills Formation lake and stream deposits with diatomite in the Idaho Group (Ekren and others, 1981); and (2) the Twin Falls Quadrangle Geologic Map (1:250,000 scale) that include unit Qbs Pleistocene sediments with lacustrine diatomite within the Bruneau Formation and unit Tbs Pliocene sediments with lacustrine diatomite within the Banbury Basalt (Rember and Bennett, 1979). The tract is partially equivalent to the Miocene to Pleistocene stratigraphic unit Tpd from the Idaho state map (1:500,000 scale) (Bond and others, 1978) that includes diatomite as a minor or incidental lithology among sedimentary units associated with volcanic strata. The more detailed maps of Rember and Bennett (1979) and Ekren and others (1981) used to delineate the tract were georeferenced from .pdf files and digitized to bring them into a geographic information system (GIS), which enabled a higher resolution of areas where diatomite is exposed at the surface and along stream drainages.

The diatomite potential from previous mineral assessments conducted in the tract area was low and of C and D certainty (U.S. Geological Survey and U.S. Bureau of Mines, 1989). The Pole Creek Wilderness Study Area has high potential for lacustrine diatomite, with the equivalent of a certainty level of D. No current production is recorded in the tract. The only past production or active claims, plans of operations, or notices in the tract area are those indicated for tract INDT01, Dickshooter, and the adjacent tract INDT02, Dickshooter North.

Tract INDT04, Owyhee-Twin Falls-Cassia-Elko—This tract is rated as low potential (L) for lacustrine diatomite deposits at certainty level B (fig. 31*T*). It is located in Owyhee, Twin Falls, and Cassia Counties of southwestern Idaho, and Elko County, Nevada. The tract is delineated on the basis of permissive geology from (1) Idaho state map (1:500,000 scale) unit Tpb Pliocene basalt flows, pyroclastic debris, clastic sediments, and diatomite, and the coeval unit Tpd-Tpv Pliocene sandstone, conglomerate, siltstone, tuff, claystone, limestone, and diatomite (Bond and others, 1978); and (2) Nevada state map (1:250,000) unit QTls Holocene to Pliocene landslide deposits, colluvium, and talus mixed with basalt, tuff, diatomite, and tuffaceous sediments (Crafford, 2007).

Although this type of lithology extends across the state border into Nevada, no state-scale maps indicate diatomite among the lithologic units in Elko and Humboldt Counties (Stewart and Carlson, 1978; Crafford, 2007). As a result, a system of Miocene to Pleistocene lake beds in northern Nevada, represented as unit Ts3 (Crafford, 2007) and equivalent units Ts3 and Tts (Stewart and Carlson, 1978) that include the Humboldt and Carlin Formations, which are known to variably host diatomite or diatomaceous sediments (Wallace, 2003), are not included in this tract.

The diatomite potential from previous mineral assessments conducted in areas within the tract was low and ranged from B, C, to D certainty (U.S. Geological Survey and U.S. Bureau of Mines, 1989). The Pole Creek Wilderness Study Area has high potential with the equivalent of a certainty level of D. In a single location within the proposed withdrawal area, but adjacent to (outside) the tract boundaries, the Imperial Mercury Prospect contains diatomite associated with gold and mercury mineralization (U.S. Geological Survey, 2016a). No current or past production, active claims, plans of operations, or notices for diatomite in the tract area are on record other than those indicated for tract INDT01, Dickshooter, and the adjacent tract INDT02, Dickshooter North.

Mineral Potential Tracts for Bedded Barite Deposits

A low potential tract and two nested high potential tracts were delineated for bedded barite deposits: tract INBB01, Bedded-barite; tract INBB02, Snake Mountains 1; and tract INBB03, Snake Mountains 2.

Tract INBB01, Bedded-barite Permissive—There is low potential (L), with certainty level B, for bedded barite deposits in the study area (tract INBB01, Bedded-barite Permissive; fig. 31*U*). In sedimentary basins, barite precipitates from reduced basinal fluids that vent into oxygenated seawater containing sulfate (Johnson and others, 2009). In areas of Nevada adjacent to the study area, the vast majority of barite production is from bedded deposits in the Devonian Slaven Chert and Ordovician Vinini, Valmy, or Comus Formations (Papke, 1984; Poole, 1988; Koski and Hein, 2003; Papke and Castor, 2003). These formations occur within the geologic map unit comprising the Roberts Mountains allochthon (unit Pzrm; fig. 27). The tract includes this unit and a 1-km-wide buffer to account for cover and uncertainty of mapped contacts.

Tract INBB02, Snake Mountains 1; Tract INBB03, Snake Mountains 2—There is high potential (H), with certainty level D (Snake Mountains 1) and C (Snake Mountains 2), for bedded barite deposits in an area centered on the Snake Mountains, which extends into the proposed withdrawal area (tract INBB02, Snake Mountains 1; tract INBB03, Snake Mountains 2; fig. 31*U*; appendix 2). The tract is based on stratigraphy (Ordovician Valmy Formation) that hosts 7 bedded barite mines and 17 prospects from which more than 1 million short tons of barite has been produced (table 20; Papke, 1984; LaPointe and others, 1991; Fernette and others, 2016a). The tract includes anomalous concentrations of barium in stream sediments (Day and others, 2016; Smith and others 2016). Supergene weathering and oxidation of associated pyrite in enclosing siliciclastic rocks (Papke, 1984) are evident in the distribution of ferric and ferrous iron based on interpretation of Landsat imagery (Rockwell and others, 2015).

Because bedded barite deposits occur in clusters (Papke, 1984), two buffers, 2.7 km and 1.3 km in width, were applied to the deposits and prospects, which correspond to the 75th- and 90th-percentile spacing between bedded barite deposits in the Roberts Mountains allochthon in Nevada (Fernette and others, 2016a). There is high potential (H) with certainty level D within the 1.3-km-wide buffer and high potential with certainty level C in the rest of the tract (figs. 31*A*–31*U*).

The tract includes several PLSS sections with active and closed plans of operations and notices for barite as well as numerous active, closed, and historic lode claims (figs. 28, 29; tables 16, 17, 18, 19; Causey, 2007, 2011).

Market Analyses of Diatomite and Barite

Market analyses of diatomite and barite is provided in appendix 5 and section I of Day and others (2016).

Occurrence of Leasable Minerals

Leasable mineral commodities (leasable solid and fluid minerals) include oil and gas, geothermal, coal, and non-energy solid minerals, including phosphate and potash. These commodities were not evaluated for assessment, but were qualitatively appraised for exploration and mining activity, lease status, and potential for deposits within the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area. No production of leasable solid minerals (coal, phosphate, and potash) or production of leasable fluid minerals (oil and gas, and geothermal) is recorded for this study area. Based on comparison to deposits of these commodities elsewhere in the western United States with past or present production (including oil and gas fields, and geothermal fields), and current market conditions, neither concealed or exposed deposits of these commodities are likely to be explored for, or produced, in coming decades.

The leasable solid and fluid mineral commodities coal, geothermal, oil and gas, and phosphate have been explored for or occur in the study area. Although there is no recorded production of these commodities, authorized, pending, and closed leases for oil and gas (1,029 leases) and geothermal (7 leases; table 16; figs. 32, 33) indicate that exploration for these commodities has occurred in recent years. Oil and gas exploration, leases, dry wells, and geothermal leases and sites, are described for all four study areas in report section "Introduction; Leasable Minerals."

There are no records of coal and phosphate leases. However, two coal fields, phosphorite beds (containing elevated concentrations of phosphate), and favorable stratigraphy for coal and phosphate deposits, are exposed in the eastern part of the study area. Insufficient quantity and (or) unmarketable quality of the coal fields and phosphorite beds have precluded production. The coal fields and phosphate occurrences are described in the following paragraphs.

Coal

A coal resource is a naturally occurring concentration or deposit of coal in the Earth's crust in such forms and amounts that economic extraction is currently or potentially feasible (Wood and others, 1983). Part of the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area is within the Goose Creek coal field (East, 2013) and Grouse Creek coal field (Tabet, 2010; fig. 34). Both coal fields contain lignite of Paleogene age (Tabet, 2010; East, 2013). No other coal fields or coal regions are within the 25-km buffer zone. The USGS drilled six reconnaissance holes in the Goose Creek coal field but did not conduct a coal resource assessment. There is no known mining of the lignite beds in the Goose Creek and Grouse Creek coal fields in Utah (Doelling, 1972). A report by the State of Utah (2004) makes a reference to nine small coal fields (including the Goose Creek and Grouse Creek coal fields) stating that they "contain very small amounts of coal and will not likely be mined in the next 50 years."

The Goose Creek and Grouse Creek coal fields are situated in narrow structural basins in the northeastern part of the Basin and Range Province. Coal in the fields occurs within gently folded and significantly faulted sedimentary and volcanic beds that comprise the Salt Lake Formation and Payette Formation(?) (Doelling, 1972). North-trending normal faults with displacements as large as 900 ft are observed in both coal fields (Mapel and Hail, 1959).

Paleogene lignite beds in the Goose Creek and Grouse Creek coal fields are present in the lower member of the Salt Lake Formation and in the underlying Payette Formation(?) (Doelling, 1972). Two principal lignite beds, the Barrett and Worthington beds, have been reported along with numerous thin, impure beds (Bowen, 1913). The correlation of the Payette Formation(?) (within the Goose Creek and Grouse Creek coal fields) to that of the Payette Formation(?) (of the Snake River Valley) is tenuous due to possible age discrepancies and differences in the association of volcanic rocks between the two areas. The Payette Formation(?) in the Snake River Valley is associated with basalts, whereas the Payette Formation(?) in the Goose Creek and Grouse Creek coal fields is associated with rhyolites (Bowen, 1913); but, in this report, both occurrences are referred to as the Payette Formation(?).

The lower member of the Salt Lake Formation is composed of shale, sandstone, conglomerate, and lignite interbedded with white volcanic ash. Conspicuous beds of black- to dark-reddish-brown welded tuff are present in the upper half of the lower member (Doelling, 1972). The thickness of the lower member ranges from 1,200 to 1,600 ft. Carbonaceous shale zones are common in the lower 600 ft (Doelling, 1972). The Barrett lignite is the thickest and most laterally continuous lignite bed in the Salt Lake Formation and has reported thicknesses ranging from 14 in. to 9 ft. It is described as being very dirty and impure, with thick carbonaceous shale partings (Bowen, 1913). The Barrett lignite lies about 500 ft below the top of the lower member of the Salt Lake Formation (Mapel and Hail, 1959). Three additional lignite zones, described as Zones A, B, and C, from top to bottom, are noted in the lower member of the Salt Lake Formation. All three zones are composed mainly of carbonaceous shale with impure lignite interbedded (Doelling, 1972). Zone A is approximately 250 ft above the Barrett lignite, Zone B is about 160 ft below the Barrett lignite, and Zone C is about 70 ft below Zone B (Mapel and Hail, 1959).

The Payette Formation (?) is composed of interbedded shale and volcanic ash, with occasional beds of sandstone and conglomerates, as well as discontinuous beds of carbonaceous shale and lignite (Doelling, 1972). Total thickness of the formation reaches 900 ft. The Worthington lignite bed lies about 500 ft below the top of the formation (Mapel and Hail, 1959). In the Goose Creek field, the Worthington lignite bed crops out to the west of the Salt Lake Formation lignites. The Worthington lignite bed ranges in thickness from 3 to 5 ft. One mine was reported to have operated in Idaho in the Worthington lignite bed during 1911, after which it closed due to the high moisture and ash content of the lignite (Bowen, 1913). Reported analysis of the Worthington lignite bed on an "as received" (AR) basis

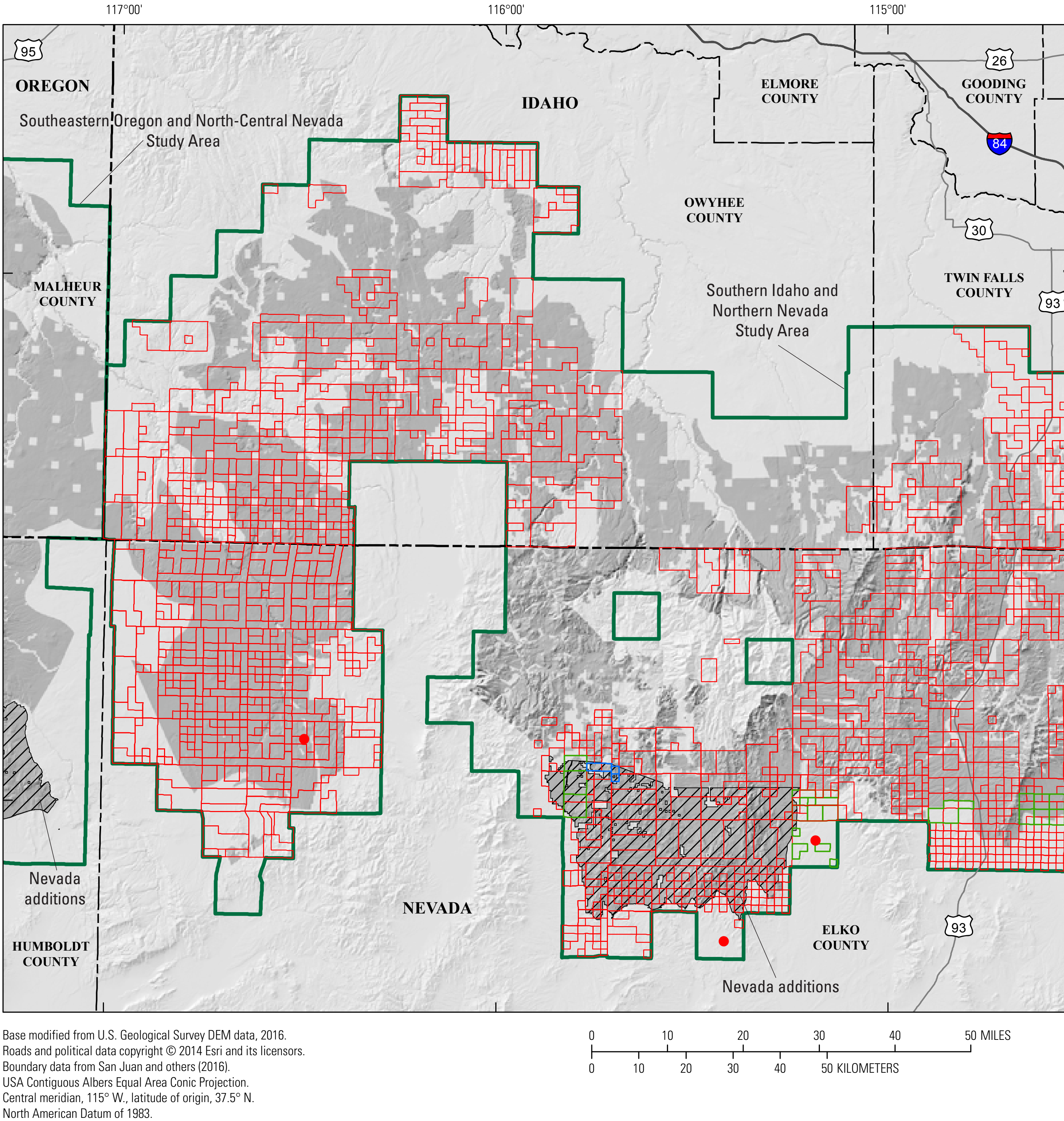
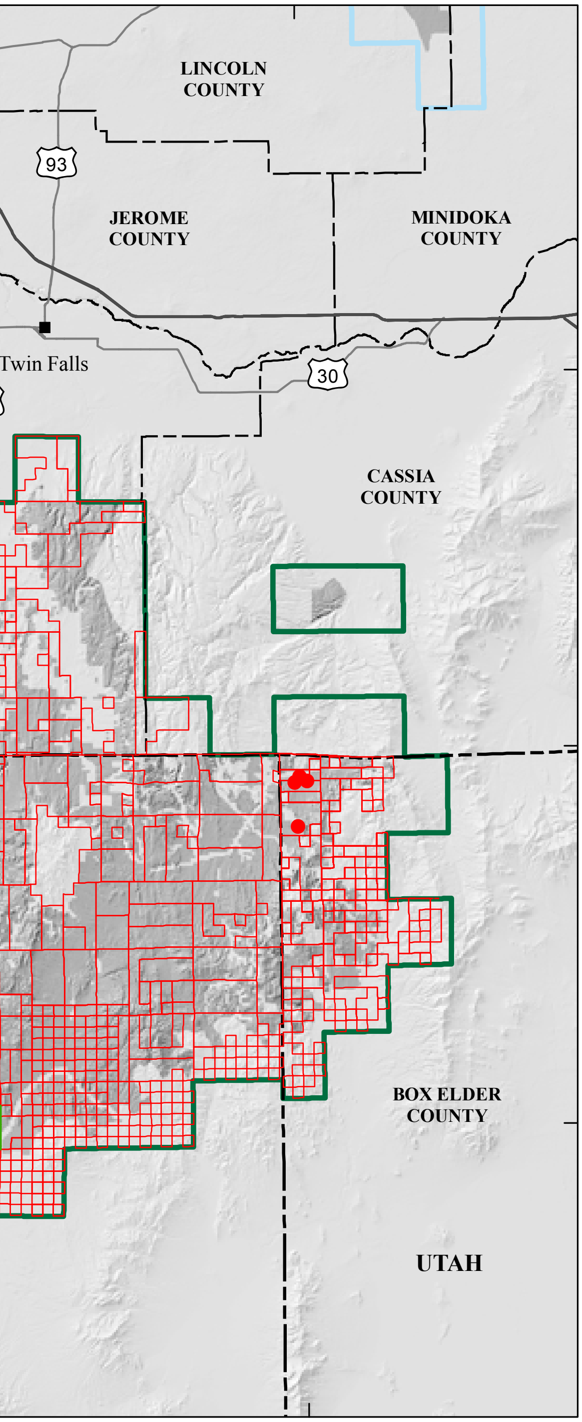
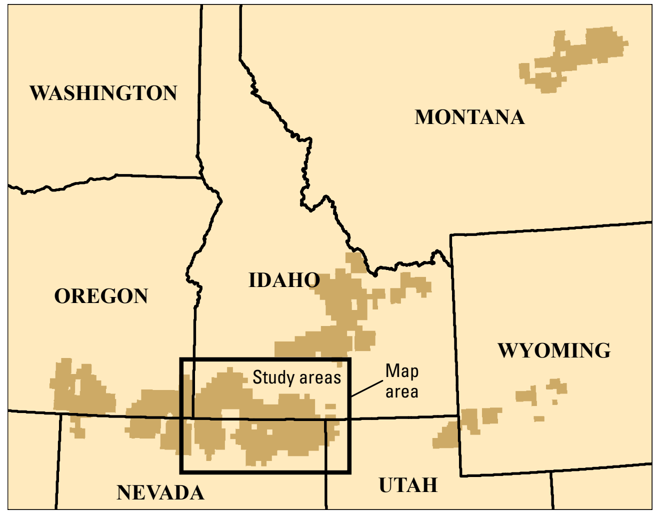


Figure 32. Map showing Bureau of Land Management (BLM) oil and gas leases and gas exploration (dry) in the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, Nevada, Idaho, and Utah (Dicken and San Juan, 2016; Gunther and others, 2016a,b; IHS Energy Group, 2016). USGS, U.S. Geological Survey.





EXPLANATION

BLM—Leasable commodities, energy: commodity; case disposition

- Oil and gas; closed
- Oil and gas; authorized
- Oil and gas; pending

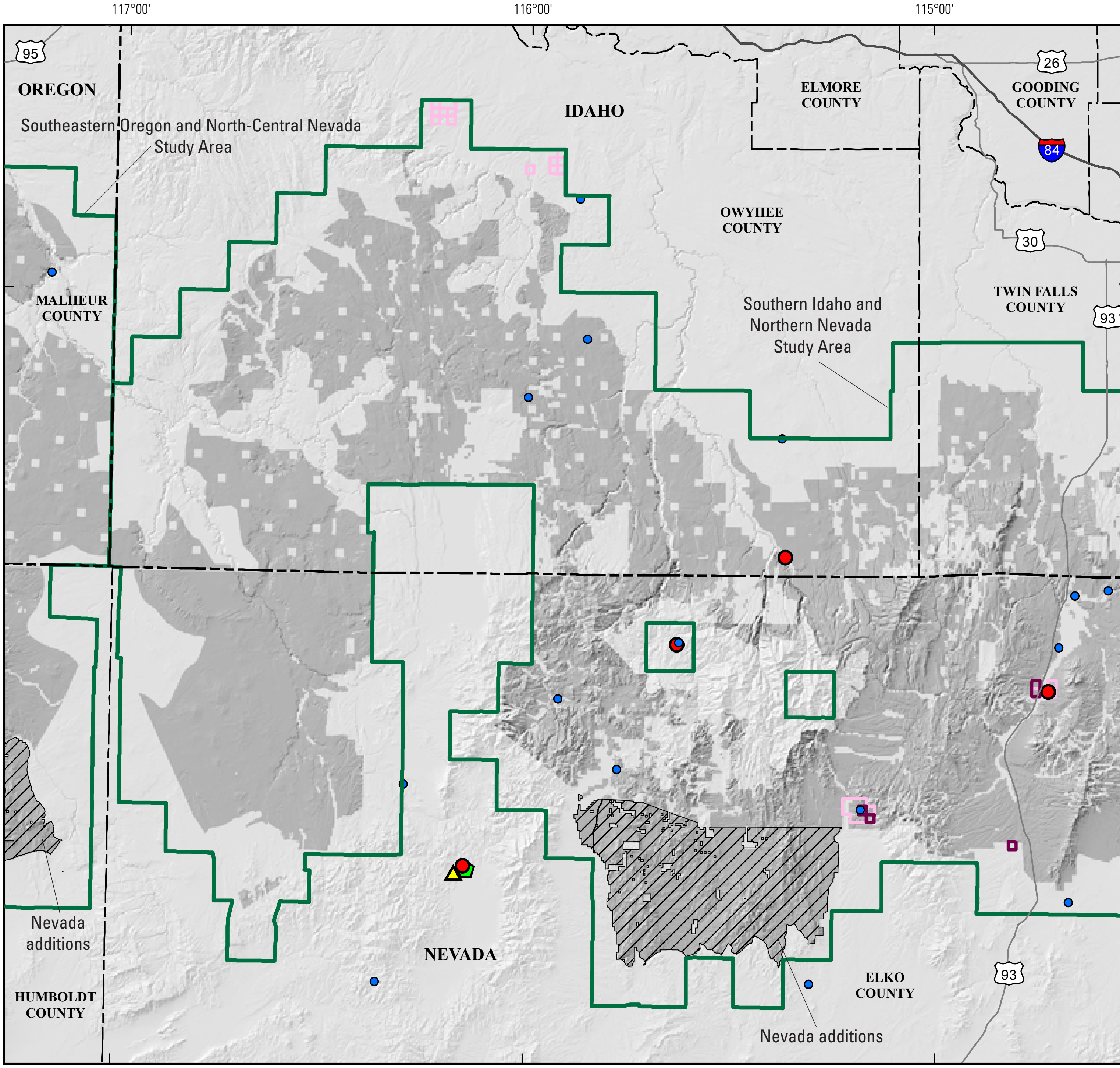
Base data

- USGS study area boundary
- USGS study area boundary (North-Central Idaho Study Area)
- Proposed withdrawal areas
- Proposed withdrawal additions
- State boundaries
- County boundaries

Oil and gas exploration

- Oil and gas exploration (dry)

Figure 32.—Continued



Base modified from U.S. Geological Survey DEM data, 2016.
Roads and political data copyright © 2014 Esri and its licensors.
Boundary data from San Juan and others (2016).
USA Contiguous Albers Equal Area Conic Projection.
Central meridian, 115° W., latitude of origin, 37.5° N.
North American Datum of 1983.

Figure 33. Map showing Bureau of Land Management (BLM) geothermal leases and sites in the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, Nevada, Idaho, and Utah (Dicken and San Juan, 2016; Williams and others 2008a,b). USGS, U.S. Geological Survey.

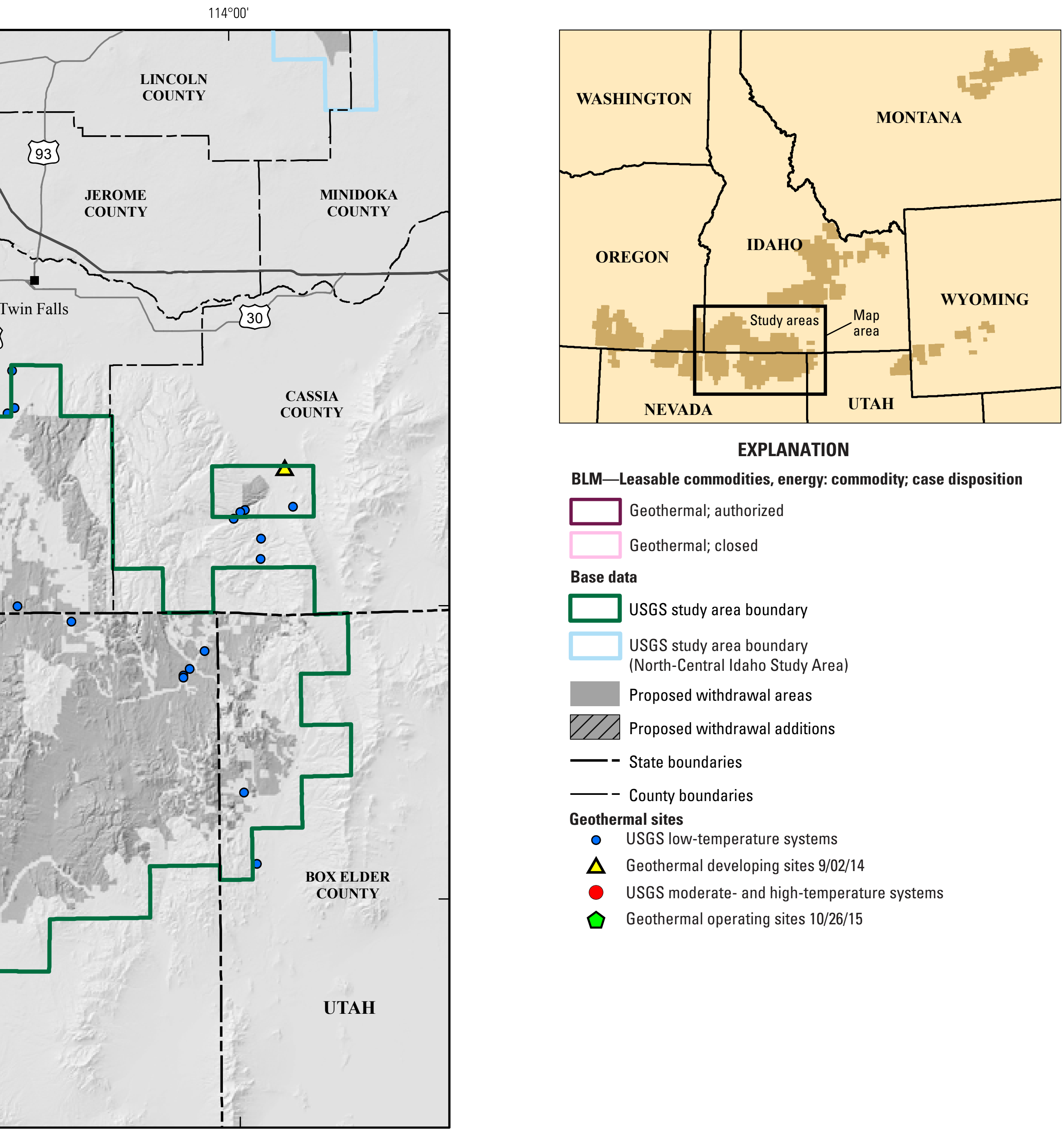


Figure 33.—Continued

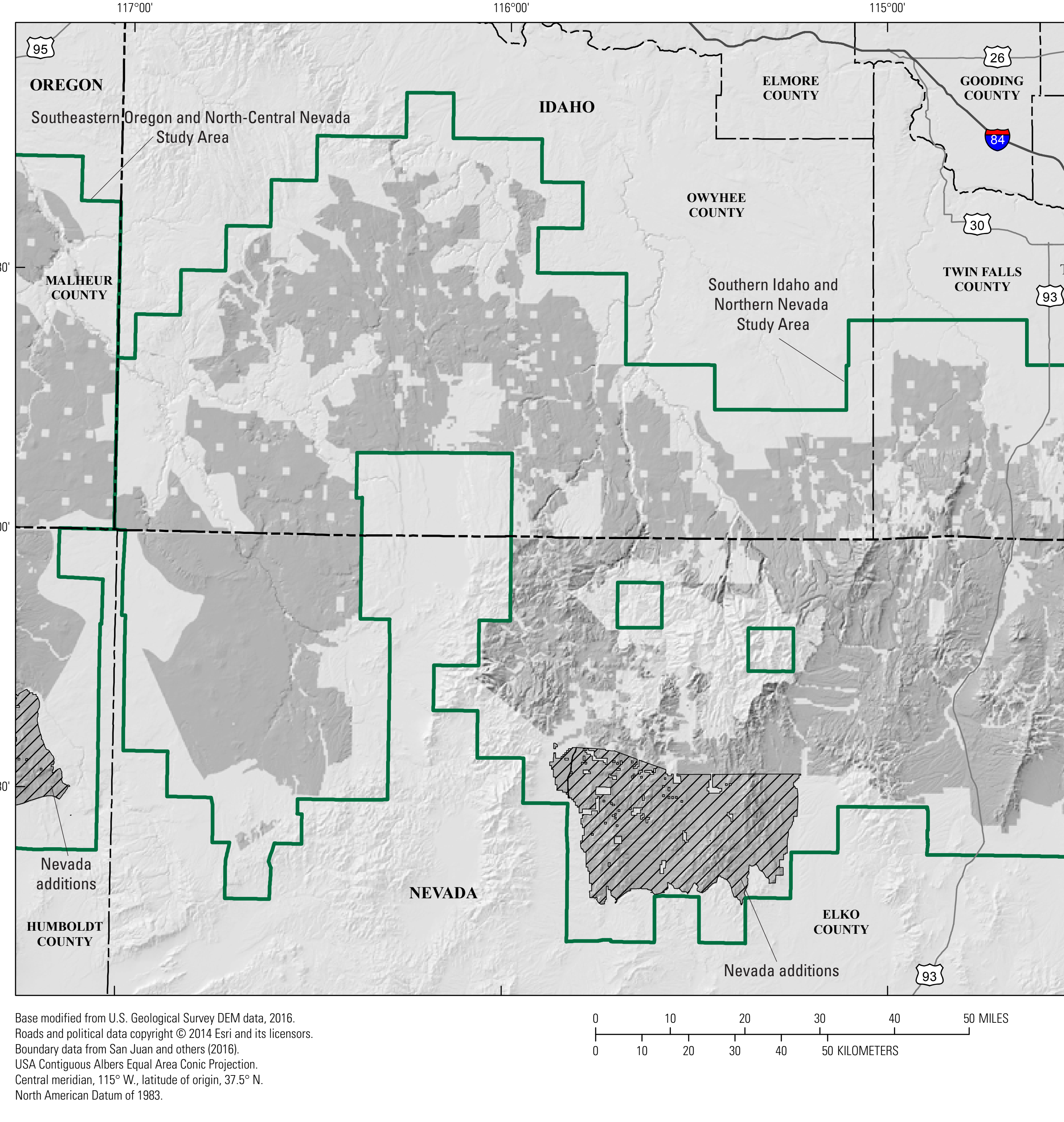
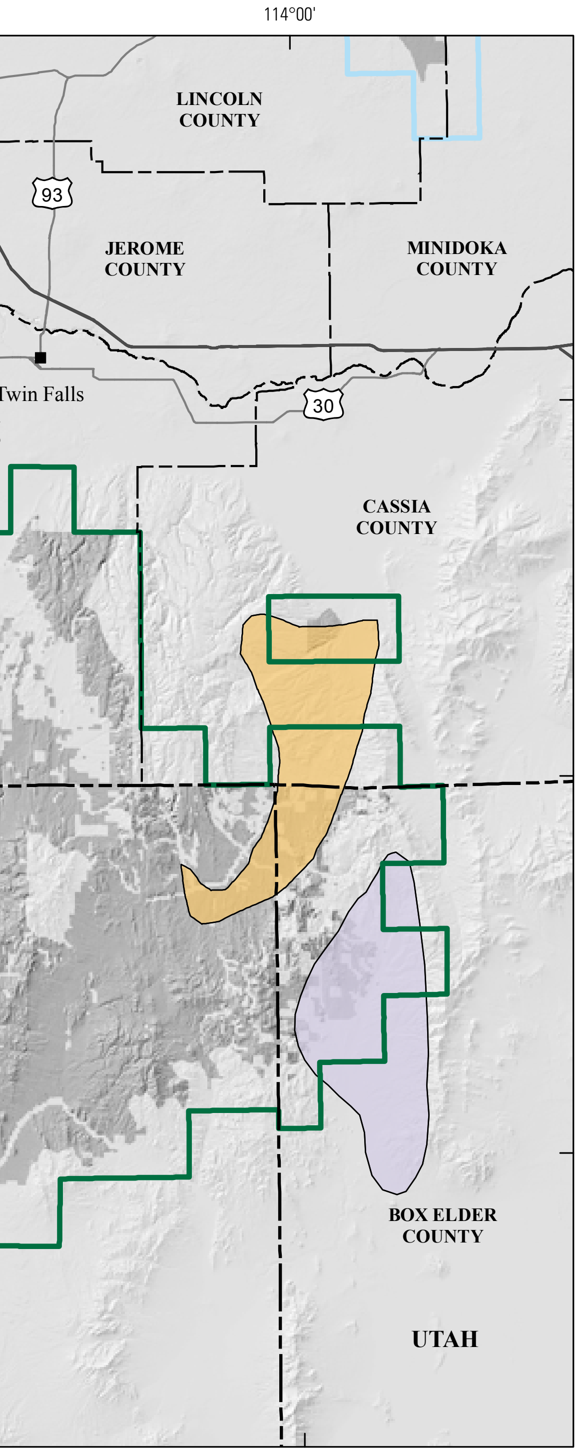
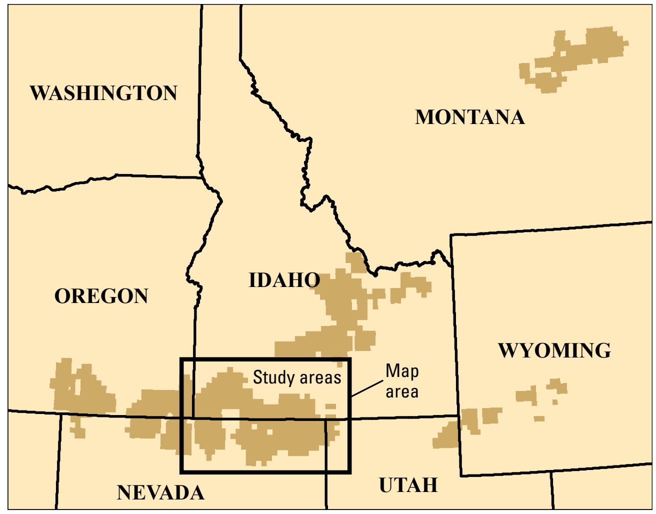


Figure 34. Map showing coal fields in the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, Idaho, Nevada, and Utah (East, 2013). USGS, U.S. Geological Survey.





EXPLANATION

Coal fields

Goose Creek

Grouse Creek

Base data

USGS study area boundary

USGS study area boundary (North-Central Idaho Study Area)

Proposed withdrawal areas

Proposed withdrawal additions

State boundaries

County boundaries

Figure 34.—Continued

is 34.5 percent moisture, 18.0 percent ash, 0.63 percent total sulfur, 5,810 British thermal units per pound (BTU/lb), and 26.4 percent volatile matter (Bowen, 913).

Another carbonaceous zone, the Grant zone, is noted about 125 ft below the top of the Payette Formation (?) and contains as many as six laterally discontinuous beds of carbonaceous shale and lignite (Mapel and Hail, 1959).

The USGS drilled six reconnaissance holes in the Goose Creek coal field in Cassia County, Idaho (Hildebrand, 1983). Core samples were only obtained from three holes, due to the lignite-bearing strata being poorly consolidated and difficult to sample, as well as groundwater inflows into the drill holes. Lignite was observed sandwiched between Miocene volcanic ash and tuffs. The lignites were reported to have highly variable thickness and ash content.

Because of the thinness, lack of lateral continuity, poor quality, and regional faulting, lignite beds in the Salt Lake Formation and Payette Formation (?) within the proposed withdrawal lands area are not likely to generate economic interest in the future.

Phosphate

Sedimentary phosphate deposits (phosphorites) occur in strata of the Permian Phosphoria Formation and Mississippian Deseret Limestone, Woodman Formation, and Chainman Shale in the study area (Ketner, 1982; Jewell and others, 2000; Ketner, 2009) (fig. 35). Phosphate in the Phosphoria Formation is mined east of the focal area in southeastern Idaho and northeastern Utah, but there has been no production of phosphate and there are no active or closed phosphate leasing in the study area (table 16). Large phosphate resources in Idaho and elsewhere, and consideration of the phosphate market, preclude leasing and production of phosphate in the study area in coming decades. However, vanadium, uranium, and rare earth elements (REE) in trace amounts within phosphate rock are recoverable as byproducts during phosphate processing and may be targeted for extraction under appropriate market conditions. Therefore, a brief description of the Western Phosphate Field, phosphate in the study area, and byproduct vanadium, uranium, are provided.

The Permian Phosphoria basin, a large, epicontinental, marine depositional basin centered in southeastern Idaho, formed subsequent to the ancestral Rocky Mountain orogeny of Pennsylvanian and early Permian time (Maughan, 1994). Phosphatic sedimentary strata of the Phosphoria Formation accumulated in the basin. Most western U.S. phosphate production is from the Phosphoria Formation in an extensive area of phosphate mining referred to as the Western Phosphate Field, centered in southeastern Idaho (Lee, 2000). Phosphate in the Phosphoria Formation occurs as pelletal phosphorite that is interbedded with organic-matter-enriched mudstone and siltstone, limestone, dolomite, and chert (Piper and Link, 2002). Surface- and underground-minable resources in the Western Phosphate Field in Idaho include 7.6 billion metric tons at 24 percent phosphorus pentoxide (P_2O_5) and 17 billion metric tons at 28 percent phosphorus pentoxide (P_2O_5), respectively. A resource of 507 billion metric tons of lower grade phosphatic rocks underlies the field at depths of more than 305 m (Moyle and Piper, 2004).

The Phosphoria basin extended at least 500 km westward and 700 km southwestward into Nevada, and phosphate is documented in sedimentary strata of the Phosphoria Formation and correlative units that are widely distributed in northern Elko and northern Humboldt Counties, Nevada (Ketner, 2009). Phosphorus concentrations in northern Nevada exposures vary mostly from 1 to 10 percent phosphorus pentoxide (P_2O_5) and to a maximum of 30 percent phosphorus pentoxide (P_2O_5) locally (Ketner, 2009).

Phosphorites of the Mississippian Deseret Limestone and Woodman Formation formed in the Antler foreland basin that is situated in Utah and extends into the eastern half of Nevada (Jewell and others, 2000). The Chainman Shale of Utah and Nevada also contains phosphatic beds (Ketner, 1982). These deposits, referred to as the Delle-event phosphorites, consist of pelletal phosphatic crusts, pisolitic phosphates, and detrital aggregates of ooidal and other types of phosphate grains (Nichols and Silberling 1991a,b). Concentrations of phosphorus pentoxide (P_2O_5) in the Deseret Limestone range from 23 to 36 percent, and in the Woodman Formation, from 25 to 30 percent (Jewell and others, 2000).

Elevated concentrations of vanadium, uranium, and lanthanum occur in carbonaceous shales and phosphorite beds of the Phosphoria Formation. Vanadium concentrations average about 0.05 percent vanadium pentoxide (V_2O_5) (Cathcart and Gulbrandsen, 1973), which exceeds average vanadium pentoxide (V_2O_5) in marine shales (Fischer, 1962; Maughan, 1994). Vanadium, uranium, and lanthanum occur in francolite, a carbonate-rich fluorapatite (Cathcart, 1991; Kolodny and Luz, 1992; Jarvis and others, 1994). Vanadium is recovered during processing of phosphate for production of elemental phosphorus and phosphoric acid (Coleman and Clevenger, 1967); and by the mid-1980s, byproduct vanadium constituted the largest domestic source (Kuck, 1985); yet, by 2003, domestic vanadium was solely recovered from various industrial waste materials such as fly ash, petroleum residues, spent catalysts, and vanadium-bearing iron slag (Magyar, 2003). Uranium also has been recovered during phosphate processing (Kouloheris, 1979; Ulrich and others, 2014).

Trace concentrations of lanthanum in the Meade Peak Member of the Phosphoria Formation in southeastern Idaho are 50–300 ppm, and in the Retort Tongue of the Phosphoria Formation are 50–350 ppm, with highest concentrations in southwestern Montana (Maughan, 1994). Although REEs have not been recovered from sedimentary phosphate deposits (Long and others, 2010), processing of phosphorite for phosphoric acid production is a potential source of byproduct REE (Altschuler and others, 1967; Emsbo and others, 2015).

Occurrence of Salable Minerals

Salable commodities, mainly sand and gravel, and aggregate, have been produced at numerous sites in the study area for the Southern Idaho and Northern Nevada study area. There are 131 salable commodity sites (mineral materials sales sites) in the study area, 18 of which are authorized (approved) and pending, and 113 of which are closed or expired (fig. 36; table 16). Seven approved (authorized) and pending sites are sand and gravel, three are crushed stone, and seven are specialty stone (table 21).

Table 21. Active mineral material sales sites in the proposed withdrawal area within the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, Idaho, Nevada, and Utah.

[Source: Dicken and San Juan, 2016. The number of cases is for the complete Public Land Survey System (PLSS) section that includes a proposed withdrawal area]

Commodity	Number of approved sites	Number of pending sites
Pumice, volcanic cinder	1	0
Sand and gravel	5	1
Sand and gravel, sand	1	0
Stone, crushed and broken	3	0
Stone, specialty	7	0

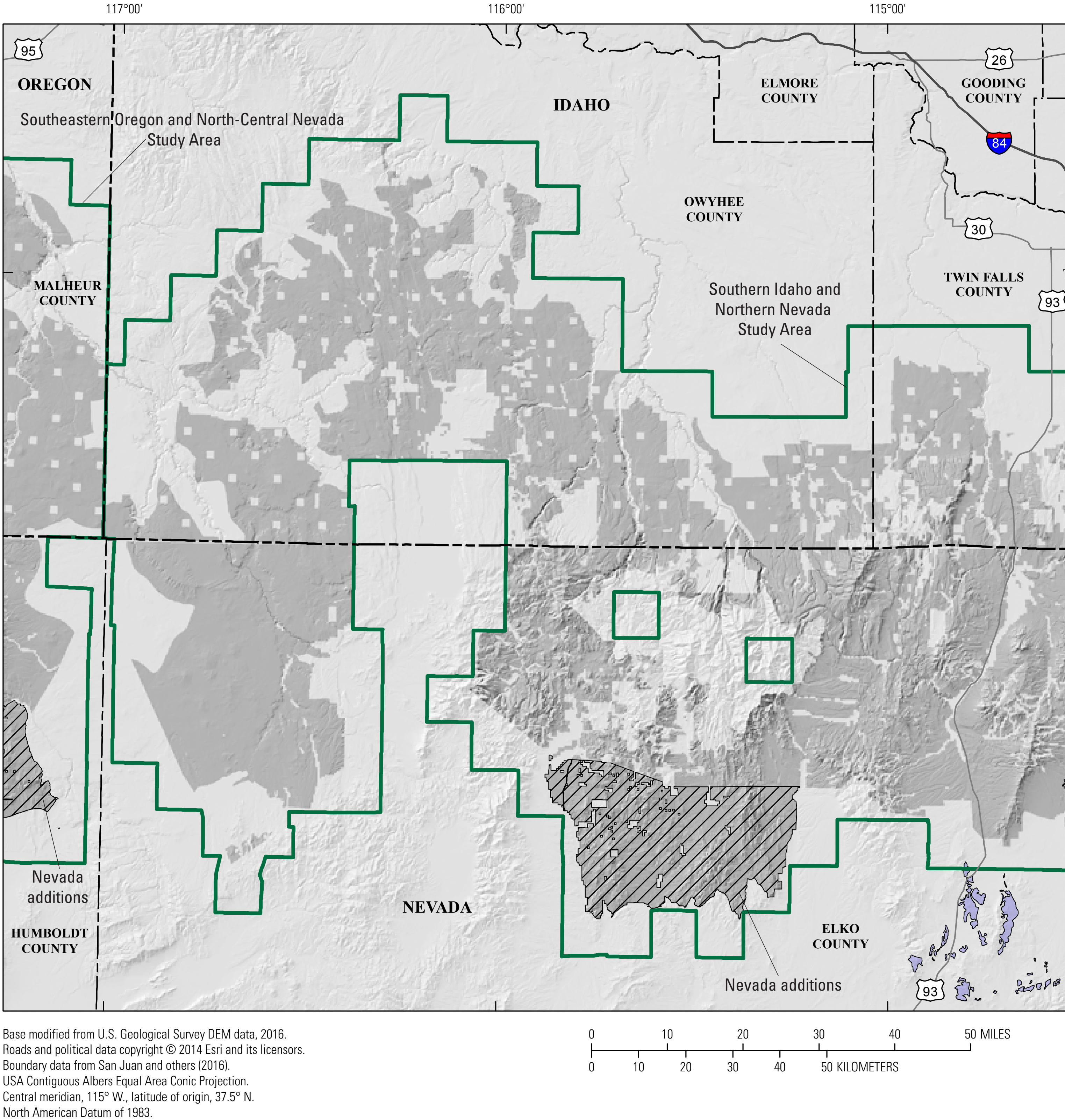


Figure 35. Map showing rocks containing phosphate in the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, Nevada, Idaho, and Utah. Based on stratigraphy from Hintze and others (2000), Crafford (2007), and Lewis and others (2012).

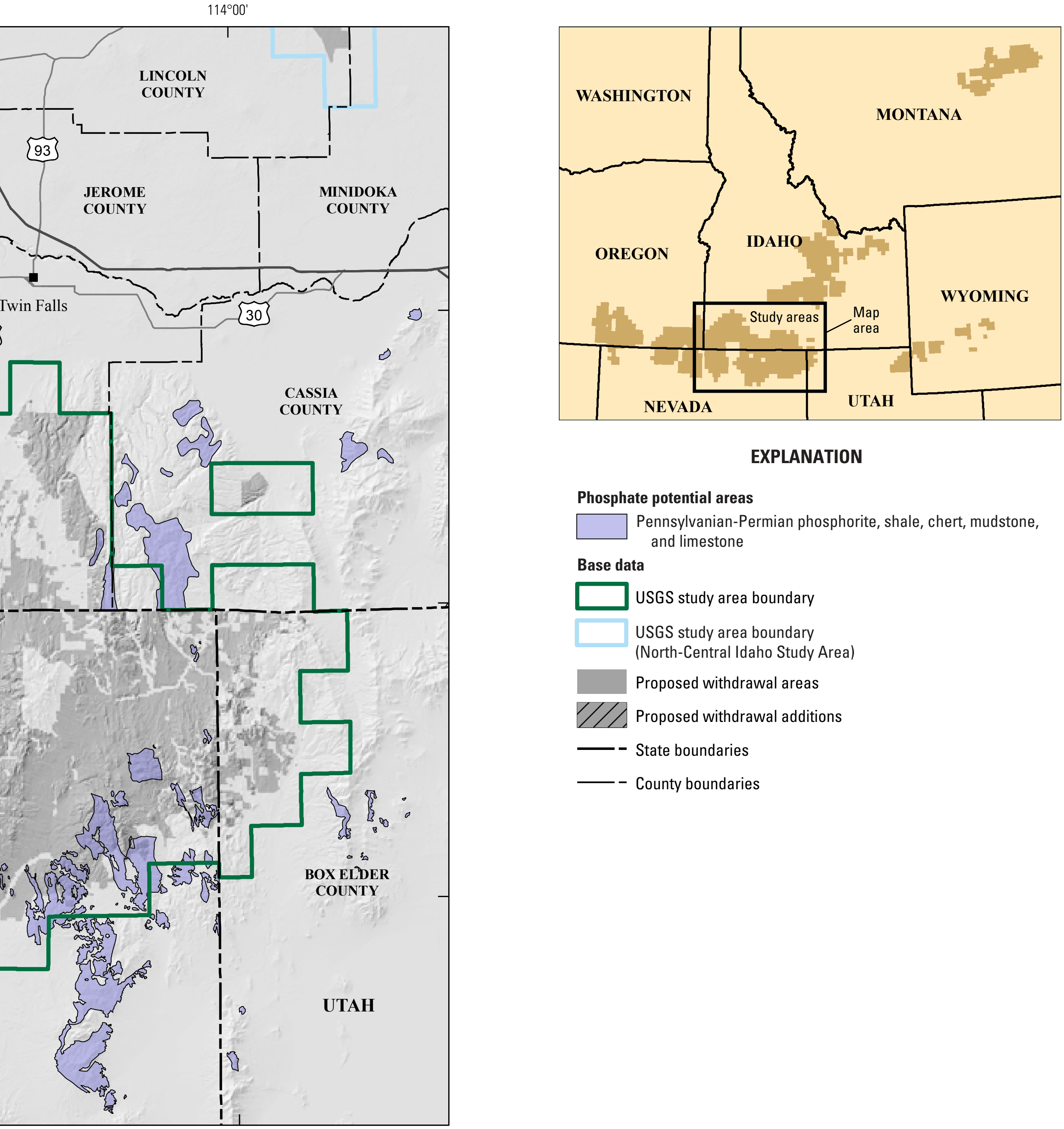


Figure 35.—Continued

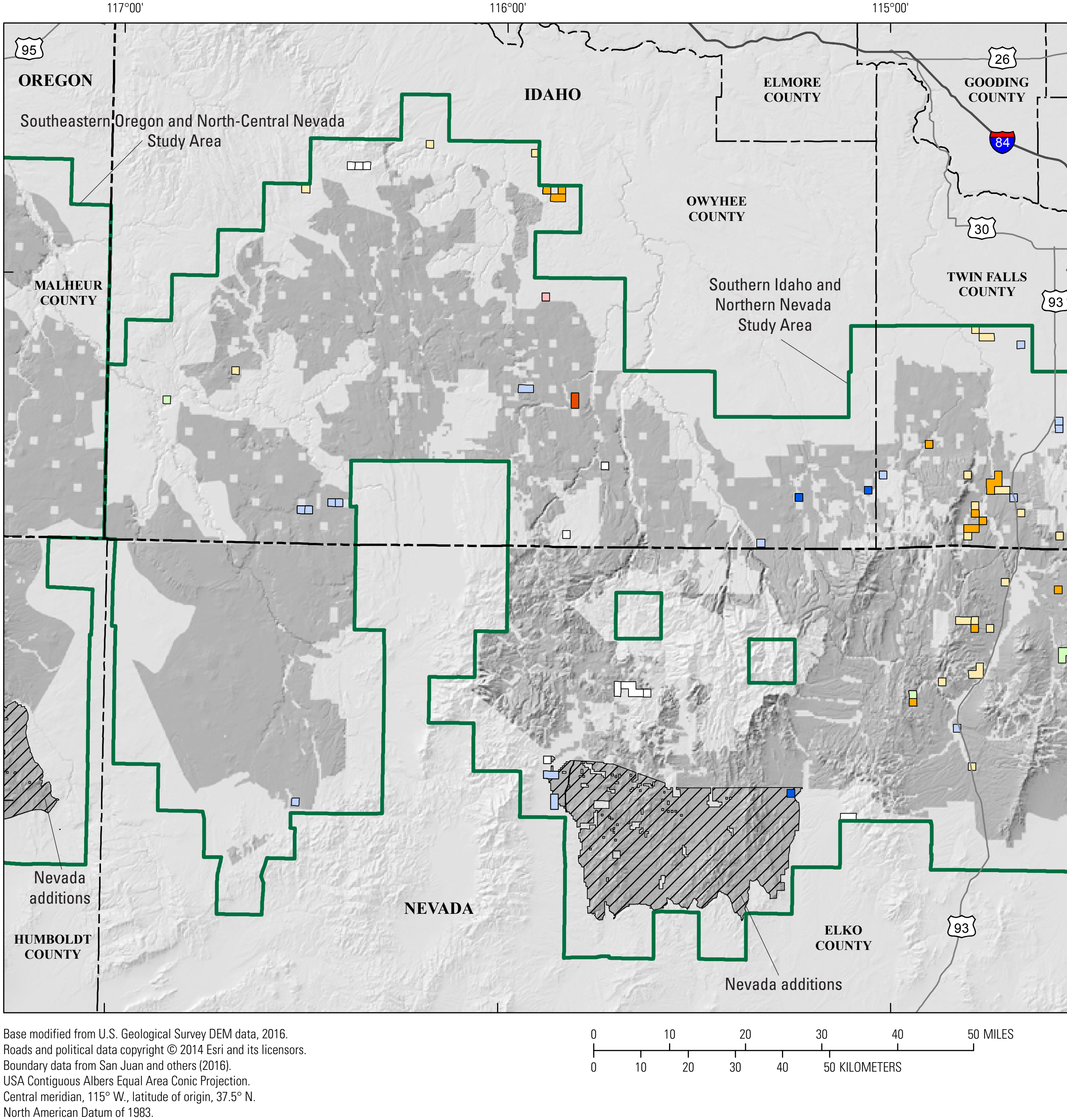


Figure 36. Map showing Bureau of Land Management (BLM) salable mineral commodity sites in the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, Nevada, Idaho, and Utah (Dicken and San Juan, 2016). USGS, U.S. Geological Survey.

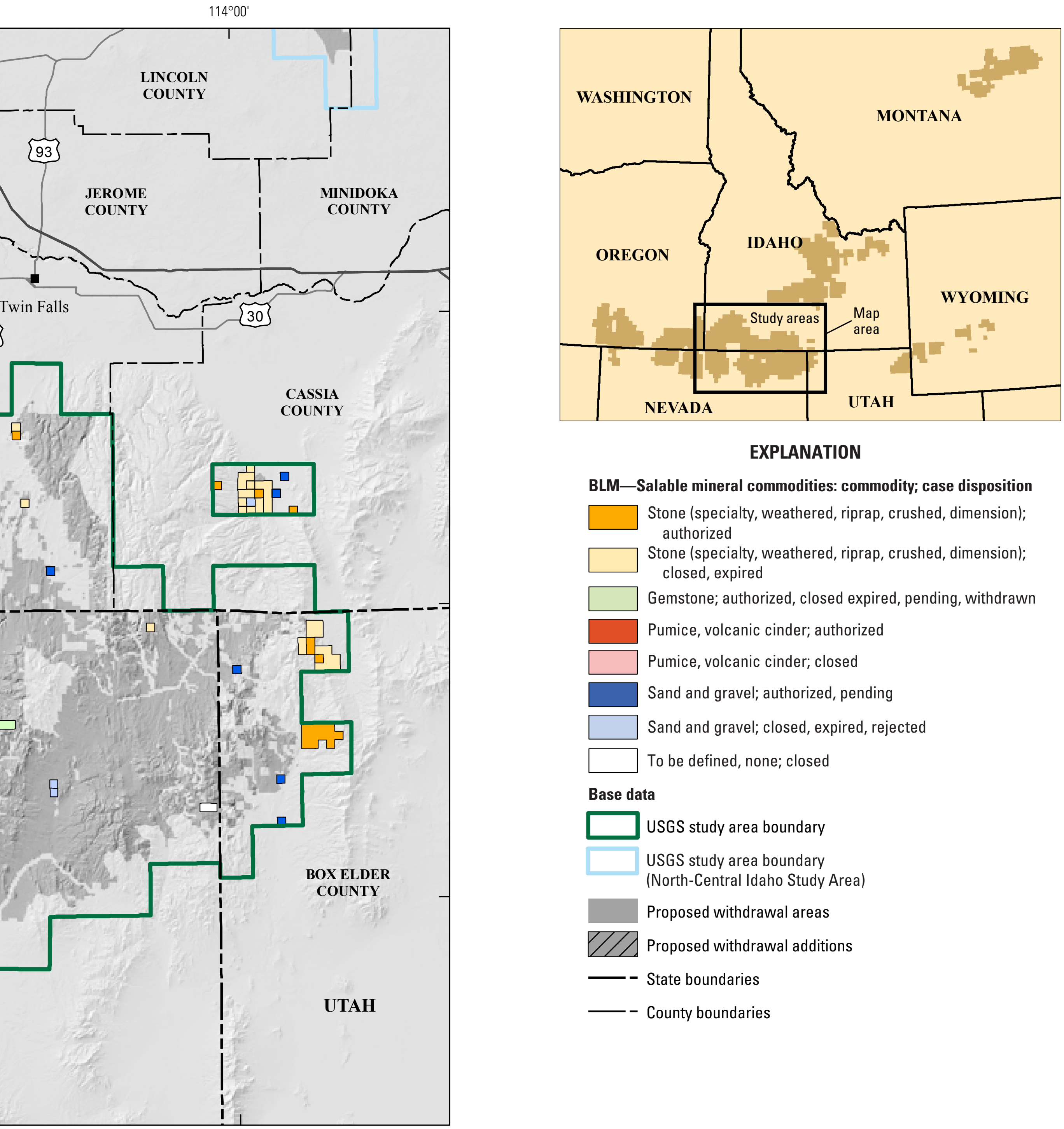


Figure 36.—Continued

Mineral-Resource Potential of the Nevada Additions Study Area

Introduction

The Nevada additions study area consists of two separate groups of townships with separate U.S. Geological Survey (USGS) study area boundaries in Humboldt and Elko Counties, Nevada (figs. 18, 26). This report section addresses mineral potential within the USGS study area boundaries of the proposed withdrawal area within the Nevada additions study area, which is described in report section “Introduction.” Numerous assessment tracts cover parts of the Nevada additions study area but are largely within the study areas for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area and the Southern Idaho and Northern Sagebrush Focal Area. Those tracts are described in report sections “Mineral-Resource Potential of the Study Area for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area, Nevada and Oregon,” and “Mineral-Resource Potential of the Study Area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, Nevada, Idaho, and Utah.” The proposed withdrawal area within the Nevada additions study area encompasses 394,289 acres (~1,596 km^2; ~616 mi^2) managed nearly entirely by the Bureau of Land Management (BLM).

Description of Geology

Paleozoic, Mesozoic, Tertiary, and Quaternary rocks are exposed within the proposed withdrawal area within the Nevada additions and USGS study area boundary. These rocks and related structures are shown on the geologic maps of the study areas for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area and the Southern Idaho and Northern Sagebrush Focal Area (figs. 19, 27), and are described in the report sections on those study areas. The tectonic evolution of the Nevada additions study area is described in report section “Introduction; Description of Geology.”

Mineral-Resource Potential

Mineral Potential of Locatable Minerals

Potential for undiscovered deposits of locatable mineral commodities (metallic locatable minerals and nonmetallic locatable minerals) within the Nevada additions study area was evaluated for the same mineral commodities as the study areas (gold, silver, mercury, gallium, uranium, gemstones, lithium, specialty clays, zeolites, diatomite, barite, copper, molybdenum, lead, and zinc; table 1). These commodities were selected for evaluation on the basis of deposits in the Nevada additions study area, the study area for the Southern Oregon and North-Central Nevada Sagebrush Focal Area, and the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area.

No assessment tracts centered within the Nevada additions study area were delineated and rated because of insufficient evidence of mineral potential in much of the area. However, numerous assessment tracts cover parts of the Nevada additions study area. Two assessment tracts with moderate potential which cover parts of the Nevada additions study area, Paradise Valley (tract ONEP04; fig. 23*A*) and Orovada (tract ONOG01; fig. 23*C*), are largely within the study area for the Southeast Oregon and North-Central Nevada Sagebrush Focal Area, and those tracts are described in report section “Mineral-Resource Potential of the Study Area for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area, Nevada and Oregon.” Assessment tracts with low potential for certain deposit types (that is, favorable or permissive stratigraphy for certain deposit types) that cover parts of the Nevada additions study area include bedded barite (fig. 31*U*), Carlin-type gold (fig. 31*S*), lacustrine diatomite (fig. 31*T*), volcanogenic massive sulfide (fig. 31*R*), and intrusion-related deposits (fig. 31*Q*). Those tracts are described in report section “Mineral-Resource Potential of the Study Area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, Nevada, Idaho, and Utah.” Mineral deposit types, and geology and occurrence of mineral deposit types for tracts which partly cover Public Land Survey System (PLSS) townships of the Nevada additions study area, are also described in report sections “Mineral-Resource Potential of the Study Area for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area, Nevada and Oregon,” and “Mineral-Resource Potential of the Study Area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, Nevada, Idaho, and Utah.”

Exploration and Mining Activity for Locatable Minerals

Metallic locatable mineral commodities that have been mined and explored for in and marginal to the Nevada additions study area include silver and gold. The western part of this study area is partly within the Paradise Valley Mining District (Humboldt County, Nevada; Tingley, 1992) from which minor amounts of silver and gold were produced from epithermal silver and gold, and other deposit types (tract ONEP04, Paradise Valley; fig. 23*C*; Vanderburg, 1938; Willden, 1964; Bonham and others, 1985). Although no production was recorded from this district, ten active and thousands of closed and historic lode mining claims have been staked in the western part (figs. 21, 22; tables 22, 23; Causey, 2007, 2011).

No mining and exploration for nonmetallic locatable mineral commodities was recorded in the Nevada additions study area. However, some lode mining claims could have been staked for nonmetallic locatable mineral commodities (figs. 21, 22; tables 22, 23; Causey, 2007, 2011).

Recent, closed, and historic (pre-2011) mining claims, and active exploration sites for locatable mineral commodities cover parts of, and are marginal to, the Nevada additions study area (figs. 21, 22, 29, 30; tables 22, 23). There are 1,332 closed mining claims, 10 active mining claims, 140 closed oil and gas leases, 6 authorized and 3 pending oil and gas leases, 1 closed and 1 authorized mineral materials sales sites, and 6 closed surface-management plans. The closed surface-management plans include 5 notices and 1 plan of operations. No active notices or plans of operations are in this area (tables 24, 25).

Occurrence of Leasable Minerals

Leasable mineral commodities (leasable solid and fluid minerals) were not evaluated for assessment, but were qualitatively appraised for exploration and mining activity and lease status. No production of leasable solid minerals (coal, phosphate, and potash) or production of leasable fluid minerals (oil and gas, and geothermal) was recorded. There is no record of leases for coal, phosphate, potash, and geothermal, and apparently no favorable stratigraphy for coal, phosphate, and potash; however, oil and gas leases cover parts of this study area (figs. 24, 32; table 22). However, based on comparison to deposits of these commodities

Table 22. Type, number, and status of mining claims, leases (coal, geothermal, non-energy solid mineral, oil and gas leases), mineral material sales sites, and 43 Code of Federal Regulations (CFR) 3809 plans in the proposed withdrawal area within the Nevada additions study area.

[Source: Dicken and San Juan, 2016. The number of cases is for the complete Public Land Survey System (PLSS) section that includes a proposed withdrawal area]

Type	Mineral type	Number of unique cases	Active	Authorized	Pending	Closed	Cancelled	Expired	Rejected	Withdrawn
Mining claims	Locatable	1,332	10	—	—	1,322	—	—	—	—
Coal leases	Leasable	—	—	—	—	—	—	—	—	—
Geothermal leases	Leasable	—	—	—	—	—	—	—	—	—
Non-energy solid mineral leases	Leasable	—	—	—	—	—	—	—	—	—
Oil and gas leases	Leasable	149	—	6	3	140	—	—	—	—
Mineral materials sales sites	Salable	2	—	1	—	1	—	—	—	—
Surface-management plans	—	6	—	—	—	6	—	—	—	—

elsewhere in the western United States with past or present production (including oil and gas fields, and geothermal fields), and current market conditions, neither concealed nor exposed deposits of these commodities are likely to be explored for or produced in coming decades. Oil and gas exploration, leases, and dry wells, are described for all four study areas in report section "Introduction; Leasable Minerals; Oil and Gas."

Occurrence of Salable Minerals

Salable mineral commodities apparently have been produced at very few sites in the Nevada additions study area. One approved salable mineral commodity site (mineral materials sales site) for sand and gravel is in the western part of the Nevada additions study area (fig. 25; table 25).

Table 23. Summary of active and closed mining claims for locatable minerals in Public Land Survey System (PLSS) sections that include the proposed withdrawal area within the Nevada additions study area.

[Source: Dicken and San Juan, 2016. The number of cases is for the complete section that includes a proposed withdrawal area]

Area	Active lode claims	Closed lode claims	Active placer claims	Closed placer claims	Active millsites	Closed millsites
Cases containing proposed withdrawal area	10	1,112	—	—	—	210

Table 24. Status and number of 43 Code of Federal Regulations (CFR) 3809 plans of operations and notices for locatable minerals in the proposed withdrawal area within the Nevada additions study area.

[Source: Dicken and San Juan, 2016. The number of cases is for the complete Public Land Survey System (PLSS) section that includes a proposed withdrawal area]

Authorization type	Number of unique cases	Active	Authorized	Pending	Closed	Cancelled	Expired	Rejected	Withdrawn
Plans of operations	1	—	—	—	1	—	—	—	—
Notice	5	—	—	—	5	—	—	—	—

Table 25. Active mineral material sales sites in the proposed withdrawal area within the Nevada additions study area.

[Source: Dicken and San Juan, 2016. The number of cases is for the complete Public Land Survey System (PLSS) section that includes a proposed withdrawal area]

Commodity	Number of approved sites	Number of pending sites
Sand and gravel	1	—

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Appendixes 1–5

Appendix 1. Mineral Potential Classification System

The approach to classification of the qualitative mineral-resource potential for locatable minerals followed that prescribed in Bureau of Land Management (BLM) Manual Sections 3031 and 3060 defined originally by Goudarzi (1984) (fig. 1-1).

Level of Potential

N. The geologic environment, the inferred geologic processes, and the lack of mineral occurrences do not indicate potential for accumulation of mineral resources.

L. The geologic environment and the inferred geologic processes indicate low potential for accumulation of mineral resources.

M. The geologic environment, the inferred geologic processes, and the reported mineral occurrences or valid geochemical/geophysical anomaly indicate moderate potential for accumulation of mineral resources.

H. The geologic environment, the inferred geologic processes, the reported mineral occurrences and (or) valid geochemical/geophysical anomaly, and the known mines or deposits indicate high potential for accumulation of mineral resources. The "known mines and deposits" do not have to be within the area that is being classified, but have to be within the same type of geologic environment.

ND. Minerals potential not determined due to lack of useful data. This does not require a level of certainty qualifier.

Level of Certainty

A. The available data are insufficient and (or) cannot be considered as direct or indirect evidence to support or refute the possible existence of mineral resources within the respective area.

B. The available data provide indirect evidence to support or refute the possible existence of mineral resources.

C. The available data provide direct but quantitatively minimal evidence to support or refute the possible existence of mineral resources.

D. The available data provide abundant direct and indirect evidence to support or refute the possible existence of mineral resources.

For the determination of "no potential" use N/D. This class shall be seldom used, and when used it should be for a specific commodity only. For example, if the available data show that the surface and subsurface types of rock in the respective area are batholithic (igneous intrusive), one can conclude, with reasonable certainty, that the area does not have potential for coal.

As used in this classification, potential refers to potential for the presence (occurrence) of a concentration of one or more energy and (or) mineral resources. It does not refer to or imply potential for development and (or) extraction of the mineral resource(s). It does not imply that the potential concentration is or may be economic, that is, could be extracted profitably.

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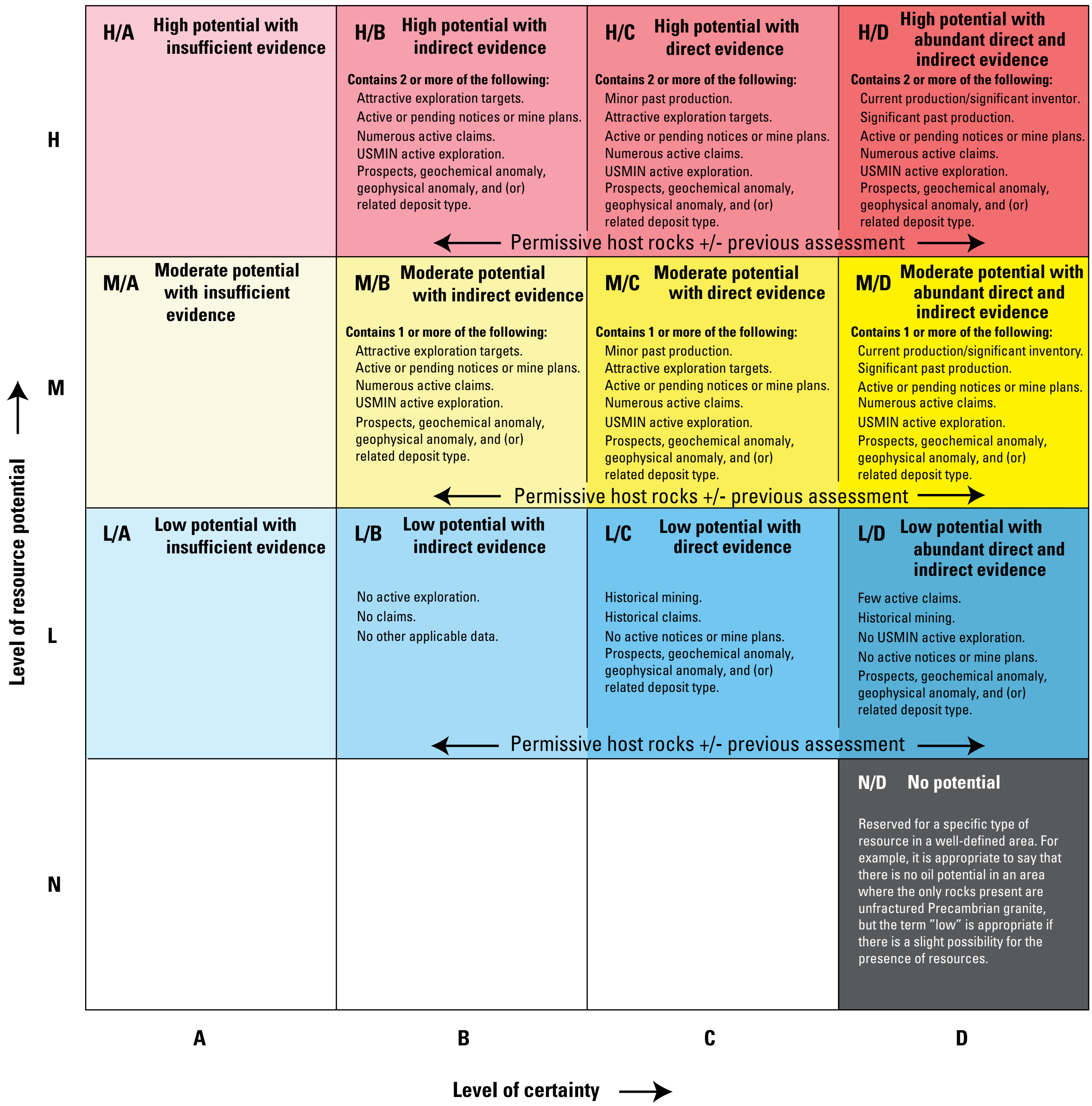

Figure 1-1. Matrix showing the classification system used for qualitative mineral-resource potential for locatable minerals in the Sagebrush Mineral-Resource Assessment (Goudarzi, 1984) (see text for abbreviations). USMIN, U.S. Geological Survey Mineral Deposit Database.

Appendix 2. Mineral-Potential Assessment Tracts for Locatable Minerals in the Sheldon-Hart Mountain National Wildlife Refuge Complex, the Southeastern Oregon and North-Central Nevada, the Southern Idaho and Northern Nevada, Sagebrush Focal Areas, Nevada, Oregon, Idaho, and Utah

This appendix is available online only as an Excel (.xlsx) table at http://dx.doi.org/10.3133/sir20165089B. The table lists mineral-potential assessment tracts for locatable minerals in the Sheldon-Hart Mountain National Wildlife Refuge Complex, the Southeastern Oregon and North-Central Nevada, the Southern Idaho and Northern Nevada, Sagebrush Focal Areas, Nevada, Oregon, Idaho, and Utah.

Appendix 3. Locatable Mineral Commodities Not Assessed

Introduction

Information concerning the geologic occurrence and principal sources of locatable mineral commodities is derived principally from the Mineral Commodities Summary (U.S. Geological Survey, 2016). Additional information was gleaned from several U.S. Geological Survey datasets, including (1) the National Minerals Information Center commodities Web site (http://minerals.usgs.gov/minerals/index.html), (2) The National Geochemical database (http://mrdata.usgs.gov/ngdb), (3) the Mineral Resources Data System (MRDS; http://mrdata.usgs.gov/mrds), and (4) Fernette and others, (2016a). In the following commodity descriptions, stream sediment, and soil and rock samples with moderately and strongly anomalous abundances have elemental concentrations 8 to 15, and more than 16 times background values, respectively.

The distribution of geochemical anomalies and commodity occurrences within the four study areas are described for locatable metallic and nonmetallic commodities that were not assessed. For metallic locatable mineral commodities, available data, especially the apparent lack of geologic environments appropriate for the occurrence of significant deposits, indicates negligible resource potential for aluminum, beryllium, bismuth, chromium, cobalt, iron, germanium, manganese, nickel, niobium, tantalum, platinum group elements, tellurium, tin, titanium, vanadium, and zirconium in the four study areas; consequently, no assessment of these commodities, and the deposit types in which they occur, is warranted (table 3-1).

Most geochemical anomalies associated with metallic locatable mineral commodities are geographically diffuse and reflect only weak to moderate enrichments. Many of these anomalies likely reflect mineralogically and geochemically distinct geologic units and are therefore manifestations of slightly unusual rock types, not mineralization. Widely dispersed sediment samples with anomalous abundances of chromium, cobalt, or titanium may reflect incidental concentration of detrital, chromium-cobalt-titanium-rich opaque oxide minerals derived from mafic eruptive rocks, including the Columbia River and Steens Basalts, and basalts of the Snake River Plain, especially in and around the study area for the Sheldon-Hart Mountain National Wildlife Refuge Complex Sagebrush Focal Area. Similarly, sediment samples with moderately high iron contents may reflect local concentration of magnetite in fluvial sediments and (or) enhanced contributions of magnetite from weathered, iron-enriched skarn. Sediment samples with anomalous nickel abundances probably reflect fluvial concentration of nickel-rich olivine derived from nearby mafic volcanic rocks. Many samples with anomalous geochemistry are from sample sites outside the USGS study area boundaries of the four study areas. Accordingly, they represent geochemical processes that may also have been operative in the four study areas, but they do not directly identify the presence of mineralized rocks in a particular study area. Another subset of geochemically anomalous samples is geospatially coincident with demonstrably mineralized or hydrothermally altered rock. However, many of these anomalies represent geochemical dispersion haloes rather than mineralized rock that corresponds directly to mineralization consistent with deposits of commodities of interest. Mineral occurrence data indicate that significant deposits of these commodities are not present within the four study areas; accordingly, the potential for significant undiscovered deposits is correspondingly limited.

For locatable nonmetallic mineral commodities, the absence of geologic environments appropriate to the occurrence of significant deposits of some commodities, including fluorspar, garnet, calcium borates, uncommon decorative stone, mica, sulfur, and travertine, warrant exclusion from assessment of deposit types that contain those commodities. Other nonmetallic mineral commodities with historically low unit value, including bentonite, gypsum, perlite, pozzolan, and vermiculite, either do not occur in deposits in the four study areas, or the quantity, quality, depth of cover, and distance from markets of occurrences of these commodities, preclude their production in coming decades (table 3-1).

Locatable Metallic Mineral Commodities Not Assessed

Aluminum—Bauxite is the principal source of aluminum, and domestic resources comprise only a small fraction of the international supply. Neither bauxite nor geologic terranes favorable for its occurrence are known in the four study areas, therefore, the potential for aluminum deposits is correspondingly negligible. Aluminum is reported as the principle commodity at a minor mineral occurrence just north of Scraper Springs near the southern tip of the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area (U.S. Geological Survey, 2005).

Table 3-1. Locatable metallic (metals, metalliferous minerals) and nonmetallic (industrial) minerals, locatable or salable nonmetallic minerals, leasable minerals, salable minerals, and deposit types for locatable mineral commodities in the four USGS study areas. Locatable mineral commodities that were assessed are bold font.

Locatable metals/ metalliferous minerals		Locatable nonmetallic (industrial) minerals	Leasable minerals	Salable minerals
Aluminum	**Molybdenum**	**Barite**	Borates, sodium	Clay (common)
Antimony	Nickel	**Bentonite**	Coal	Sand and gravel
Beryllium	Niobium (Columbium)	Borates, calcium	Geothermal	Stone, building
Bismuth	Platinum group metals	Carbon	Oil and gas	Stone, crushed (aggregate)
Carbon	Rare earth elements	Diamond	Phosphate	Stone, dimension
Chromium	Silicon	**Diatomite**	Potash	—
Cobalt	**Silver**	Fluorspar (fluorite)	Sodium	—
Copper	Tantalum	Travertine	—	—
Gallium	Tellurium	Vermiculite	—	—
Germanium	Thorium	**Zeolite**	—	—
Gold	Tin	—	—	—
Iron	Titanium	—	—	—
Lead	**Tungsten**	—	—	—
Lithium	**Uranium**	—	—	—
Magnesium	Vanadium	—	—	—
Manganese	**Zinc**	—	—	—
Mercury	Zirconium	—	—	—

Deposit types for locatable commodities

Epithermal gold-silver (mercury)	Lead-zinc skarn	Volcanogenic massive sulfide
Basalt-hosted sunstone	Polymetallic replacement	Sedimentary-exhalative lead-zinc-silver (SEDEX)
Porphyry copper	Polymetallic veins	Bedded barite
Arc-related porphyry molybdenum (low-fluorine)	Distal disseminated silver-gold (antimony)	Mississippi Valley-type lead and zinc
Climax-type porphyry molybdenum	Carlin-type gold (silver, mercury, antimony)	Orogenic low-sulfide gold-quartz vein
Molybdenum-tungsten greisen	Black shale vanadium	Hectorite (lithium clay)
Copper skarn	Hydroallogenic uranium	Specialty clay
Tungsten skarn	Volcanogenic uranium	Zeolites

Classification based on quality

Locatable or salable nonmetallic (industrial) minerals, depending on quality	Quality criteria for locatable or salable determination
Building stone	Salable; locatable if uncommon
Clay, specialty	Locatable (for example, ceramic grade); otherwise salable
Garnet	Locatable if high quality (for example, abrasive)
Gemstone	Salable; locatable if uncommon (semi- and nonprecious)
Geodes	Salable; locatable if uncommon
Gypsum	Locatable if high quality (for example, optical grade)
Limestone	Salable; locatable if high quality (for example, chemical, cement grade)
Mica	Locatable if high quality (for example, large sheets, books)
Mineral specimens	Locatable if uncommon
Perlite	Locatable if high quality (for example, industrial or construction grade)
Pozzolan	Salable; locatable if uncommon (for example, concrete additive specifications)
Pumice	Salable; locatable if one dimension $\geq$2 inches
Silica and silica sand	Salable; locatable if uncommon or high purity (for example, fracking proppant)
Stone, decorative	Locatable; otherwise salable

Antimony—Antimony is derived principally from sedimentary and hydrothermal vein deposits, including epithermal and Carlin-type gold deposits; stibnite is the predominant antimony ore mineral. No primary antimony ore has been mined in the United States during the past 5 years. Domestic reserves are inconsequential in a global perspective and the majority of the antimony used domestically comes from China and Russia. Some epithermal and Carlin-type gold deposits in and near the four study areas have anomalously high antimony values and may be potential sources of antimony. Rock samples with moderately to highly anomalous antimony contents include (1) a group in and near the Lone Pine district in the study area for the Sheldon-Hart Mountain National Wildlife Refuge Complex Sagebrush Focal Area; (2) individual samples in the Trident Peak, Disaster, Opalite, and Poverty Peak districts in the study area for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area; and (3) individual samples in or near the Edgemont, Elk Mountain, and Contact districts in the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area. Sediment samples with strongly anomalous antimony abundances include one in the Lone Pine district and groups of samples (1) north and east of the Star Lake deposit; and (2) extending northeast in and adjacent to the Independence Mountains, Edgemont, Aura, Mountain City, Island Mountain, Gold Basin, Jarbidge, and Contact districts in the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area. Mineralized occurrences that include antimony as a commodity are in the Opalite, National, Paradise Valley, Burner, Aura, Mountain City, Hicks, Alder, Charleston, Elk Mountain, Delano, and Ashbrook districts across northern Nevada, in the study areas for the Southeastern Oregon and North-Central Nevada and Southern Idaho and Northern Nevada Sagebrush Focal Areas (U.S. Geological Survey, 2005; Fernette and others, 2016a).

Beryllium—The principal domestic source of beryllium is the epithermal Spor Mountain deposit in Utah where the ore mineral betrandite is associated with highly evolved topaz rhyolite. Christiansen and others (1986) describe topaz rhyolites in the western United States, including one in the geographically widespread Jarbidge Rhyolite, which crops out in the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area; however, neither betrandite nor beryl were identified in the rhyolite. Beryllium, in beryl, is also contained in some pegmatite dikes, but few of these occurrences, which require ore to be hand-sorted, constitute economically viable resources. Small quantities of beryl were recovered from pegmatites in the Almo area (U.S. Geological Survey, 2005) immediately east of the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area; however, beryl-bearing pegmatite dikes have not been documented elsewhere in the four study areas. In the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, a single stream-sediment sample from Salmon Creek, northeast of the Hicks district, has a moderately anomalous beryllium abundance, whereas a rock sample from the Delano district has a strongly anomalous beryllium abundance.

Bismuth—Bismuth is principally produced as a byproduct of lead ore processing, but bismuth is not presently recovered from the residues of domestic lead ore processing. Globally, only two mines, one in Bolivia and the other in China, produce bismuth from bismuth ore (U.S. Geological Survey, 2016); consequently, the potential for economically significant bismuth resources within the four study areas is limited. Five widely distributed sediment samples from the areas in and near the Jarbidge, Elk Mountain, Snake Mountains and Contact districts, and east of the Independence Mountains districts have highly anomalous bismuth abundances, whereas rock samples with anomalous bismuth abundances are limited to single samples in the Trident Peak, Contact, and Delano districts, all in the study areas for the Southeastern Oregon and North-Central Nevada and Southern Idaho and Northern Nevada Sagebrush Focal Areas. Bismuth is reported as an incidental component of occurrences in the National district, Southeastern Oregon and North-Central Nevada Sagebrush Focal Area, and in the Lime Mountain and Alder districts, in the Southern Idaho and Northern Nevada Sagebrush Focal Area (U.S. Geological Survey, 2005). An additional occurrence of bismuth is found in the Charleston district, Southern Idaho and Northern Nevada Sagebrush Focal Area (Fernette and others, 2016b).

Carbon/Diamond—Diamonds are a dense, crystalline phase of carbon, and form in the lithospheric mantle at depths of about 140–190 km (Erlich and Hausel, 2002). They are transported upward into cratonal crust as xenoliths (foreign inclusions) by ultramafic magmas that often erupt to form “pipes,” which are somewhat similar to a volcanic neck. Geologic names for these crystallized intrusions are kimberlites and lamproites. Few of these intrusions contain diamond xenoliths, and only a small percentage of diamond-bearing kimberlites, usually those containing a high percentage of gem quality diamonds, are minable. Diamonds are also recovered from alluvium derived from erosion of kimberlite intrusions. No kimberlites are exposed in the four study areas, and no alluvial diamonds have been found in or near the study areas. The nearest diamonds are in colluvium that fills Tertiary stream channels on the western slope of the Sierra Nevada Mountains, California, where they were recovered with gold in placer mines.

Chromium—Globally, chromium is dominantly produced from layered mafic-ultramafic intrusions and from podiform deposits associated with ophiolitic rocks. Domestic chromium resources are generally limited to the Stillwater layered mafic-ultramafic complex in Montana. The four study areas lack similar geologic terranes, which suggests that chromium deposits are unlikely therein. There are 4 sediment samples in the western part of the study area for the Sheldon-Hart Mountain National Wildlife Refuge Complex Sagebrush Focal Area that have moderately anomalous chromium abundances. Among sediment samples from the study area for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area, 6 samples from in and near the Trident Peak and Disaster districts and 1 sample from the Santa Rosa Range have moderately anomalous chromium abundances, whereas a group of 4 samples from north of Louse Canyon have strongly anomalous chromium abundances. Similarly, about 10 samples from southwestern Idaho and one sample from Bruneau Canyon, in the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, have moderately anomalous chromium abundances. Chromium abundances for samples from northeast Nevada are analytically incompatible with other data and were not evaluated. The four study areas include only one rock sample, from south of the Delano district in the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, with moderately anomalous chromium content. An insignificant prospect in the study area for the Sheldon-Hart Mountain National Wildlife Refuge Complex Sagebrush Focal Area has chromium, cobalt, nickel, and platinum as minor constituents (U.S. Geological Survey, 2005; Fernette and others, 2016a).

Cobalt—Cobalt is mostly derived as a byproduct from sediment-hosted stratiform copper, laterite, sedimentary exhalative (SEDEX), or layered mafic-ultramafic complex deposits. Only the sedimentary exhalative environment is present, although sparingly, within the four study areas, and therefore, potential for associated cobalt deposits is limited. There are 2 sediment samples with moderately anomalous cobalt abundances that are from near the center of the study area for the Sheldon-Hart Mountain National Wildlife Refuge Complex Sagebrush Focal Area, 1 sample is from north of the Disaster district in the study area for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area, and 2 samples are from the western part of the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, which also includes 1 sample with a strongly anomalous cobalt abundance. None of the analyzed rock samples contains moderately or strongly anomalous cobalt abundances. In addition to its occurrence in the minor prospect described above, cobalt is a minor constituent of mineralized rock identified at a small prospect in the southwest part of the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area (U.S. Geological Survey, 2005).

Germanium—Germanium is principally derived as a byproduct of zinc ore processing. Zinc ore and sphalerite from the sedimentary exhalative deposit at Red Dog, Alaska, and from select Mississippi Valley-type deposits in Tennessee, are presently the sole domestic sources of germanium; these sources constitute a very small fraction of global germanium production. Historically, zinc production from the four study areas, largely limited to northern Nevada, is relatively minor and is restricted to skarn and polymetallic vein and replacement deposits. Given the relatively small size of these deposits, their relatively insignificant sphalerite content, large quantities of germanium-bearing sphalerite in deposits located in Alaska and Tennessee, and dominance of the global germanium markets by international suppliers, small skarn and polymetallic deposits in the four study areas probably do not contain economically significant germanium deposits. Stream-sediment data do not include high germanium abundances, no rock samples contain high germanium abundances, nor is germanium described as a constituent of mineralized occurrences within any of the four study areas (U.S. Geological Survey, 2005).

Iron—Domestic iron ore production constitutes about 2 percent of worldwide production and is relatively inconsequential in a global context. Banded iron formation mines in Michigan and Minnesota dominate domestic production. The study areas lack banded iron formations, but small bodies of magnetite-rich skarn are present. However, these skarn deposits, including those associated with the granodiorite of the Contact Mining District (U.S. Geological Survey, 2005), are inconsequential relative to deposits in Michigan and Minnesota and do not constitute a significant resource. No analyzed rock or sediment samples contain strongly anomalous iron contents. Isolated iron-enriched mineral occurrences are present at several sites in and adjacent to the four study areas, but iron is not the primary commodity of interest among these occurrences. Scattered occurrences of volumetrically insignificant iron-rich rock have been identified in or near the Lone Pine, Rebel Creek, National, Paradise Valley, Cornucopia, Aura, Independence Mountains, Alder, and Contact districts in association with small placer, epithermal, skarn, and polymetallic vein deposits in which iron-rich gangue minerals may be abundant (U.S. Geological Survey, 2005). Additional, isolated occurrences of minor amounts of iron are scattered in and around the Disaster and Contact districts in the study area for the Southeastern Oregon and North-Central Nevada and Southern Idaho and Northern Nevada Sagebrush Focal Areas, respectively (Fernette and others, 2016a).

Magnesium—Magnesium is produced from seawater and brines, as well as from magnesium minerals such as magnesite, dolomite, brucite, and olivine (Kramer, 1985). Magnesium is produced from magnesite, brucite, and dolomite, in Nevada, but these mines are located south of the four study areas. In Utah, brines from the Great Salt Lake are processed for magnesium, but these deposits and facilities are outside the study area for the Southern Idaho and Northern Nevada Focal Area (Bray 2016a,b).

Manganese—Manganese is primarily derived from a variety of sediment- and volcanic-hosted deposits and from deep-sea nodules. Domestically, no ore principally mined for manganese has been produced in more than 45 years; the majority of domestically consumed manganese is derived from South Africa or Ukraine. No rock samples from in or near the four study areas contain moderately or strongly anomalous manganese abundances. Clusters of sediment samples with moderately to highly anomalous manganese abundances are restricted to an area in the eastern part of the study area for the Sheldon-Hart Mountain National Wildlife Refuge Complex Sagebrush Focal Area and a broad area west of the Bull Run Mountains, in north-central Nevada. Most mineral occurrences that include manganese as a commodity are poorly characterized and restricted to northern Nevada; these include occurrences in and near the Opalite and Poverty Peak districts in the study area for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area and Aura, Independence Mountains, Mountain City, Hicks, Elk Mountain, Contact, and Delano districts in the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Areas (U.S. Geological Survey, 2005). In the Scraper Springs area (tract INOR14, Scraper Springs) and Alder districts, Southern Idaho and Northern Nevada Sagebrush Focal Area, manganese is also reported as a minor commodity (Fernette and others, 2016a).

Nickel—Nickel is principally derived from mafic-ultramafic complex intrusions and laterites. Domestic production is limited to one mine in Michigan and represents an inconsequential contribution to world nickel production. The geologic setting of the three Sagebrush Focal Areas includes neither mafic-ultramafic complex intrusions nor laterites. Sediment samples that have moderately or strongly anomalous nickel contents are scarce. The west part of the study area for the Sheldon-Hart Mountain National Wildlife Refuge Complex Sagebrush Area includes a small group of moderately to strongly nickel-anomalous sediment samples and six moderately anomalous samples are scattered across the study area for the Southeastern Oregon and North-Central Nevada, and Southern Idaho and Northern Nevada Sagebrush Focal Areas. Within the study area for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area, several rock samples from the Poverty Peak district contain moderately to strongly anomalous nickel abundances. In addition to its occurrence in the minor prospect described above, nickel is reported as an accompanying commodity in a small prospect in the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, West of the Bull Run Mountains (U.S. Geological Survey, 2005).

Niobium and tantalum—See “Rare earth elements (REE), niobium, and tantalum.”

Platinum group elements—The platinum group elements (PGE) are mined from deposits in mafic and ultramafic layered intrusions. The Bushveld Complex in South Africa is the world’s major producer of PGE ore; domestic production, very minor by comparison, is from the Stillwater Complex in Montana. The four study areas do not contain mafic-ultramafic intrusive complexes. Incomplete geochemical data indicate that neither sediment nor rock samples from the four study areas include anomalous PGE concentrations. Platinum is described as a secondary commodity of the Stillwater Complex described above (U.S. Geological Survey, 2005).

Rare earth elements (REE), niobium, and tantalum—The rare earth elements (REE) include the 15 lanthanoid elements, plus yttrium and scandium, which are commonly regarded as REE because they have similar chemical and physical properties and affinities with the lanthanoids (Van Gosen and others, 2014). Niobium (columbium) and tantalum are considered together with the REE because they often co-occur in similar host-rock types and minerals (Schulz and Papp, 2014).

Globally, ore-grade concentrations of REE, niobium, and tantalum are most commonly found in carbonatites, alkaline igneous rocks, and pegmatite dikes, including weathering-related deposits associated with each of these rock types (such as placers, laterites, and clay accumulations), as well as sedimentary phosphate deposits, all of which are rare or unknown in the four study areas. Domestically, REE are currently mined from only one deposit at Mountain Pass, California (Gambogi, 2016a,b). Domestic production of niobium or tantalum has not been reported since 1959 (Papp, 2016a). World production of REE has been dominated by ion-absorption clay deposits in southern China since the late 1990s, while niobium production is primarily from carbonatite deposits in Brazil, and tantalum mostly from sources in Congo (Kinshasa) and Rwanda. The global supply of REE will likely be derived from China in the near future. World resources of niobium and tantalum are considered adequate (Gambogi, 2016a,b; Papp, 2016a,b).

REE, niobium, and tantalum have not been identified as economically recoverable commodities in mineral occurrences in the four study areas. Neither notable concentrations nor current exploration activities are related to these commodities. REE was reportedly associated with gallium mineralization at the Cordero gallium deposit, located in the McDermitt Caldera Complex, but no gallium or REE resources or production was recorded (the property is now a silver-gold exploration target; Silver Predator Corp., 2015). Elevated REE, niobium, and tantalum abundances occur in 9 stream-sediment and 2 rock geochemical samples within the four study areas (Smith and others, 2016). There are 9 stream-sediment samples with moderately anomalous REE concentrations that are scattered across the Nevada parts of the four study areas. These samples are isolated, single-point anomalies with low to moderate concentrations of REE, niobium, or tantalum.

Silicon—Silica (SiO_2), in quartz veins, and quartz in quartzite, sandstone, and pegmatites, is used to produce silicon ferroalloys and silicon metal. Manufacture of silica and silicon requires high-purity feedstock and deposits with more than 98 percent SiO_2 are the preferred resources (Murphy and Brown, 1985). None of the principal producers of silicon alloys or silicon metal have operations within the four study areas (Schnebele, 2016). In Oregon, silica resources are in quartz replacement deposits and quartzofeldspathic sands, which are mined for glass manufacture and construction sand from locations outside the study areas (Geitgey, 1989).

Tellurium—Most tellurium is produced as a byproduct of copper ore milling and refining; recovery from copper anode slimes constitutes its dominant source. Tellurium is also moderately to highly enriched in epithermal precious metal deposits but is seldom recovered from the associated ore. Historically, copper production from the four study areas has been moderate; copper resources in the Contact district within the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area constitute additional ore from which byproduct tellurium could be recovered. No rock samples with moderately or strongly anomalous tellurium abundances are present within the study areas. Sediment samples with moderately anomalous tellurium abundances, and one sample with a strongly anomalous abundance, are restricted to the

Montana Mountains and widely spaced sites in and adjacent to the Santa Rosa Mountains, in the southeast part of the study area for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area. Tellurium resource potential in the four study areas is likely restricted to future copper production and the economics of tellurium byproduct recovery. The USMIN database (Fernette and others, 2016) identifies one isolated mineral occurrence, in the Contact district, Southern Idaho and Northern Nevada Sagebrush Focal Area, that includes tellurium as a minor commodity.

Thorium—Thorium is a radioactive element used in limited quantities in a number of industrial applications such as specialized metal, ceramics, and optics manufacturing (Gambogi and Aquino, 2013). The world demand for thorium is so low that thorium is not mined as a primary product. Research into the use of thorium as a fuel in nuclear reactors has been ongoing for at least 50 years. Should commercial thorium-fueled nuclear reactors be developed, world demand would significantly increase. The most likely source of thorium is as a coproduct of REE mining (Van Gosen and Tulsidas, 2016). Within the four study areas, no mineral deposits of the type that would potentially produce coproduct thorium are known.

No thorium production was recorded, and one thorium occurrence is in the study area for the Southeast Oregon and North-Central Nevada Sagebrush Focal Area (U.S. Geological Survey, 2005). Description of the occurrence also includes uranium and beryllium as commodities and appears to be part of a cluster of pegmatite deposits in Oligocene granites (Lewis and others, 2012). This deposit cluster includes the City of Rocks deposit from which a small amount of feldspar, but no thorium or uranium, was mined (Lesure, 1963). Thorium-bearing pegmatites have low mineral-resource potential unless thorium is further concentrated, most notably into heavy mineral sand deposits (Anderson and Savage, 1964: Van Gosen and Tulsidas, 2016).

Tin—Tin ore forms in veins, disseminations, and skarns. Many deposits are associated with highly evolved magmatic systems, although more than half of the world’s tin is produced from placer deposits associated with hard-rock lode deposits. Domestic tin production has never been significant and no tin ore has been mined in the United States since 1993. Two rock samples with moderately anomalous tin abundances are restricted to the National district and a site south of the Elk Mountain district, in the study area for the Southeastern Oregon and North-Central Nevada, and Southern Idaho and Northern Nevada Sagebrush Focal Areas, respectively. Three clusters of sediment samples with moderately or strongly anomalous tin abundances include those in and near Owyhee Canyon in southeast Oregon and southwest Idaho, a set east of the Charleston district, and a group in extreme northwest Utah. Isolated samples with moderately or strongly anomalous tin abundances include single samples southwest of the National district, near the northeast tip of the study area for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area, in the Gold basin district, west of the Elk Mountain district, and in the Burner district. Tin is reported as an incidental constituent of the polymetallic Cleveland deposit in the Delano Mountains, Southern Idaho and Northern Nevada Sagebrush Focal Area (U.S. Geological Survey, 2005).

Titanium—Most titanium is produced from ilmenite or rutile. Principal geologic sources for these two minerals are mafic-ultramafic layered intrusive complexes, anorthosite intrusions, iron-oxide-apatite deposits, and placer deposits. In a global context, domestic production from two operations, in Virginia and Florida, is minor. The four study areas lack the geologic environments conducive to titanium deposits. In the study area for the Sheldon-Hart Mountain National Wildlife Refuge Complex Sagebrush Area, a single sediment sample from the Lone Pine district contains strongly anomalous titanium abundance, and several nearby samples and a group located north and east of the nearby Virgin Valley district contain moderately anomalous titanium abundances. Another small cluster of sediment samples with anomalous titanium abundances is west of the Bilk Creek Mountains in the study area for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area. About a dozen additional sediment samples with moderately anomalous titanium abundances are scattered across the study area for the Southeastern Oregon and North-Central Nevada and Southern Idaho and Northern Nevada Sagebrush Focal Areas. The study areas contain no rock samples with anomalous titanium contents. Titanium, zirconium, and fluorite are reported as incidental constituents of a minor mineral occurrence in the Disaster district, within the study area for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area, and titanium is reported as the primary commodity of a small prospect at Willies Point in the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area (U.S. Geological Survey, 2005).

Vanadium—Vanadium is not recovered as a primary commodity but rather as a byproduct from phosphate rock, some black shale deposits, uranium ore, and as a constituent of titanomagnetite. The United States obtains vanadium from foreign sources and presently has reserves that are minor in a global context. Some shale horizons within the four study areas are prospective sources of vanadium; however, no rock samples from within the study areas have moderate or strongly anomalous vanadium contents. Clustered groups of sediment samples with elevated vanadium abundances are limited to 1 highly anomalous sample and 10 moderately anomalous samples from north and southeast of the Lone Pine district, respectively, in and adjacent to the study area for the Sheldon-Hart Mountain National Wildlife Refuge Complex Sagebrush Focal Area, and a large group of moderately anomalous samples in and adjacent to the west edge of the study area for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area. There are 4 additional sediment samples with moderately anomalous vanadium abundances that are irregularly distributed across the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area. A north-trending array of outcrops in the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area is underlain by the Phosphoria Formation that includes occurrences with vanadium as a principal commodity (Fernette and others, 2016a).

Zirconium—Zirconium, from zircon, is principally derived as a byproduct from heavy mineral sands processed for their titanium or tin mineral content. Lack of data for domestic zirconium production, the small contribution of domestic titanium resources relative to global production, suggests that domestic zirconium production is similarly small; domestic zirconium mining is limited to beach sand operations in Florida, Georgia, and Virginia. No rock samples from the study areas contain anomalous zirconium abundances. A cluster of sediment samples from southwest Idaho in the west part of the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area, and a smaller subset of samples from the east part of the study area for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area, contain moderately to highly anomalous zirconium abundances. These elevated zirconium abundances may reflect mechanical concentration of zircon derived from high-silica rhyolite tuffs that crop out extensively in the southern Snake River Plain area. A single sediment sample from the Charleston district also contains a moderately anomalous zirconium abundance. Zirconium is reported as a minor constituent in the small prospect in the Disaster district (U.S. Geological Survey, 2005).

Locatable Nonmetallic Mineral Commodities Not Assessed

Bentonite—Bentonite is a smectite clay used for drilling mud, pet waste absorbents, foundry sand, and iron ore pelletizing (Flanagan, 2016). The sodium end member is called a "swelling clay" and is mined largely for use in drilling muds; calcium-bentonite is also mined for adsorbents and water treatment and filtering (Ampian, 1985). In Nevada, Kent Exploration and Senator Minerals have a surface bentonite deposit in Elko County, with an estimated 1.9 million short tons of high-quality calcium bentonite (U.S. Geological Survey, 2015a); this deposit is outside the USGS study area boundary. Bentonite deposits in Oregon are outside the study areas (Geitgey, 1989). Some Wilderness Study Areas in both Oregon and Nevada have moderate to low potential for undiscovered bentonite resources, but these areas are outside the study areas (Conrad, 1990; Diggles, 1991).

Calcium Borates—The bulk of calcium borate resources is comprised of the minerals ulexite, a sodium-calcium borate, and colemenite, a calcium borate. Borates are used in ceramics, specialty glasses, fertilizers, and detergents, and ulexite is used in the specialty glass and ceramics industries (Crangle, 2016a). The majority of domestic borate resources are from dry lake beds in the Mojave Desert of California, although there is a low-grade colemenite deposit in Clark County, Nevada (Lyday, 1985). In Oregon, surface efflorescences of borate minerals have been found near Borax Lake in southern Harney County, which is outside the USGS study area boundary (Geitgey, 1989).

Building Stone—The U.S. Geological Survey commodity summaries do not include "building stone," instead they refer to "dimension stone" and "crushed stone." The Maryland Geological Survey provides the following definition: "A building stone is defined as any massive, dense rock suitable for use in construction. Whether igneous, metamorphic or sedimentary, a building stone is chosen for its properties of durability, attractiveness, and economy. A dimension stone is a building stone that is often quarried and prepared in blocks according to specifications. A decorative stone is a stone that can be quarried, cut or carved and is most highly valued for its pleasing appearance. It is more often used in interior construction for decoration and monuments than as standard building stone" (Kruff and Brooks, 1990). The British Geological Survey notes that "Building stone is also commonly referred to as 'Dimension Stone' in many countries" (British Geological Survey, 2005). Hence, "building stone" is defined as "dimension stone" for the purpose of this description.

In 2015, dimension stone was mined from quarries in 34 states. Texas, Indiana, Wisconsin, Massachusetts, and Georgia account for 66 percent of production. Limestone, granite, and sandstone are the primary rock types of this commodity (Dolley, 2015). Split dimension stone is produced in Clark and White Pine Counties, Nevada (U.S. Geological Survey, 2004), for use as flagstone, ashlar, boulders, crushed landscape rock, and other types of uncut building stone. These quarries are outside the four study areas. In Idaho, quarries in Bonneville and Cassia Counties produce travertine, quartzite, and Oakley stone (micaceous quartzite) for use as dimension stone. The quarries in Cassia County are outside the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area (Fernette and others, 2016a). In Utah, the Oakley Mountain Corporation and Sawtooth Stone LLC operate dimension stone quarries in Box Elder County; both quarries are at the edge of the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area. Approximately 18 suppliers and quarries for dimension stone are in Oregon, but all are on the western side of the state near centers of large population.

Decorative Stone, Uncommon—See "Limestone" and "Travertine."

Fluorspar—Fluorspar is produced principally from Mississippi Valley-type deposits, limestone quarries, and highly evolved granitoid rocks; domestic production is minimal at present. Fluorspar is the principal commodity at the small Pavlak Mine in the Jarbidge district, Southern Idaho and Northern Nevada Sagebrush Focal Area. It is also reported in the minor prospect in the Disaster district and as an incidental component of mineralized rock in the Scraper Springs district and in the Delano district, Southern Idaho and Northern Nevada Sagebrush Focal Area (U.S. Geological Survey, 2005). As part of a fluorspar inventory of Nevada, Papke (1979) delineated a terrane, which extends south from Winnemucca, Nevada, into the southern part of the state that contains several dozen deposits. None of the deposits identified by Papke (1979) is within the four study areas.

Garnet—Garnet is produced principally from metamorphic rocks, and skarn and placer deposits. Domestic garnet production, limited to one operation in Idaho, one in

Montana, and two in New York, is minor in a global context. Garnet is reported only as a constituent of minor placer deposits east and north of the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area (U.S. Geological Survey, 2005).

Gypsum—Gypsum ($CaSO_2 \cdot 2H_2O$) commonly occurs in bedded sedimentary deposits. In the United States, gypsum has been mined around the Great Lakes, and in Texas, Oklahoma, and California (Pressler, 1985). In 2015, Oklahoma, Texas, Nevada, Kansas, Iowa, and Arkansas were the leading crude gypsum-producing States (Crangle, 2016b). No gypsum deposits or resource potential have been identified within the study areas.

Limestone—Limestone constituted 70 percent of the domestic market for crushed stone in 2015, and was used primarily for road construction and maintenance (Willet, 2016a). Used as such, it is a salable commodity and is mined by contract. In Nevada, claims for cement-grade limestone were staked near Wells and Wendover, but these are outside the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area. In 2011, there were six quarries for limestone crushed stone in Nevada, but they are outside the study area for the Sagebrush Focal Areas (U.S. Geological Survey, 2015a). In Idaho, there were six quarries for limestone crushed stone in 2011 (U.S. Geological Survey, 2015b), but those within the study area for the Southern Idaho and Northern Nevada Sagebrush Focal Area are classified as salable. In Oregon, limestone has been mined for agricultural lime and for production of cement and calcium carbide. The limestone deposits are located in the north and southwestern portions of the state and outside the study areas (Geitgey, 1989).

Limestone is also used as dimension stone and constituted 42 percent, by tonnage, of the market in 2015. Because dimension stone is selected for its color, grain texture, and pattern, an unusual deposit with prized and distinctive characteristics might be designated a locatable commodity. In 2015, Texas, Indiana, Wisconsin, Massachusetts, and Georgia produced 66 percent of dimension stone used in the United States (Dolley, 2016). No high-quality, locatable, limestone production is recorded in the study areas.

Mica—Natural mica (mostly muscovite and phlogopite) is marketed as scrap, flake, and sheet products. Domestic production is mostly from Georgia, North Carolina, South Dakota, and Virginia, where it is mined from mica schists, sericite schists, and pegmatites. Mica is also produced as a coproduct of feldspar and kaolin mining. Most domestically produced micas are ground to small particle sizes and used in drywall joint compound, oil well drilling additives, paint, roofing, plastics, and rubber products. Sheet mica is used in the manufacture of electrical and electronic equipment (Willett, 2014, 2016b). No mica mines or areas with mica potential have been identified in the four study areas.

Mineral Specimens, Uncommon— Mineral specimens are not described because there are a few deposit type models for them, deposits are mostly small, markets are mostly small and are set by collectors and dealers, and demand is based entirely on appearance.

Perlite—Perlite is rhyolite volcanic glass that has 2–5 percent water (Bolen, 2010). It is mined in the states of Nevada, Oregon, and Idaho, but no significant production is reported in the four study areas. In Oregon, the Eagles Nest deposit at Tucker Hill in southern Lake County has produced perlite for many years but is outside the USGS study area boundary. Other perlite occurrences in Lake County, Oregon (Glass Slipper, No Name, and Lucky Day OO), are also outside the study area for the Sheldon-Hart Mountain National Wildlife Refuge Complex Sagebrush Focal Area (Peterson, 1961; Geitgey, 1989). A perlite occurrence with no resource estimate was identified in the Spaulding Wilderness Area (inside the USGS study area boundary), and a moderate potential for perlite was assigned to the Alvord Peak Wilderness Area (outside the USGS study area boundary; Diggles, 1991).

Pozzolan—Pozzolans are minerals and nonmineral materials that have properties of hydraulic cement when mixed with lime (CaO). Once prepared, hydraulic cement sets, hardens, and remains stable underwater. Pozzolanic minerals and materials are derived from certain volcanic rocks and some industrial byproducts such as slag and fly ash (van Oss, 1997). Pozzolans can partially or completely substitute for Portland cement. Uneconomic occurrences of pozzolan have been identified in tuffaceous rocks in the northwestern corner of the Spaulding Wilderness Study Area, Oregon (inside the USGS study area boundary; Sawlan and others, 1994). Pozzolanic rocks occur throughout the Basin and Range Province in Nevada, Oregon, Idaho, and Utah, and deposits closest to markets are preferentially mined (Sawlan and others, 1994).

Pumice—Pumice is porous, low-density volcanic rock formed by rapid cooling of gas-rich lava. It is an industrial mineral commodity used mostly as aggregate in production of lightweight construction building block and in horticulture. Less common uses include abrasives, concrete aggregate and admixture (ingredients which modify properties of concrete), absorbents, filtration, laundry stone washing (for example, “stone washed” blue jeans; Geitgey, 1989), and road construction (Crangle, 2013, 2016). Most domestic resources of pumice are in the western United States, and, in 2015, the largest producers were in Oregon and Idaho. Mining is by open pit, usually in remote areas with few land-use conflicts. Pumice production is highly influenced by transportation costs, and alternative mineral materials such as crushed aggregate, diatomite, expanded shale and clay, and vermiculite, which may be economically competitive substitutes for pumice (Crangle, 2016).

The main pumice mines in Oregon are in the central part of the state, outside the study area for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area and USGS study area boundaries. Pumice occurs as scattered fragments in volcanic tuff in two Wilderness Study Areas (public lands proposed for Wilderness designation) within the study area for the Southeastern Oregon and North-Central Nevada Sagebrush Focal Area, but these areas have been assigned low mineral-resource potential (Diggles, 1991). No pumice mines or areas with potential for pumice production occur within the study area boundaries in Idaho, Nevada, and Utah (Fernette and others, 2016a).

Sulfur—Sulfur has been mined for thousands of years, but demand for sulfur increased significantly in the 1800s when sulfuric acid became one of the most common acids used by industry. Sulfur is one of the few chemical elements that can occur in its elemental (native) form. It is found in volcanic strata and fumeroles, evaporate deposits, and salt domes. In evaporates and salt domes elemental sulfur is produced by bacterial reduction of anhydrite ($CaSO_4$). Sulfur can also be obtained from sulfide and sulfate deposits, and from sour natural gas (containing H_2S) where it is recovered at the wellhead (Morse, 1985). In recent years, compliance with environmental regulations has led to increased sulfur recovery from fossil fuels, and more than 75 percent of the world's sulfur is produced at petroleum refineries, natural-gas-processing plants, and coking plants, mostly in Louisiana and Texas. Byproduct sulfuric acid represents 6 percent of the sulfur market and is produced at nonferrous metal smelters and roasters (Apodaca, 2013, 2016). Sulfuric acid, a critical component for global fertilizer and manufacturing industries, is the main product derived from sulfur. No sulfur production or sulfur deposits are recorded in the four study areas.

Travertine—Travertine is a form of calcium carbonate ($CaCO_3$) deposited by mineralized waters and hot springs. It is used in the construction industry for tiles, slabs, and pavers, where color, pattern, and texture determine marketability. Consequently, travertine is also considered decorative stone. Most travertine used in the United States is imported from Italy, Iran, Turkey, Mexico, and Peru (Stone Contact, 2016). While travertine deposits are known within the four study areas, none have produced travertine for commercial purposes. These deposits are unlikely to be mined in coming decades because of insufficient quantity, inferior quality, and distance from markets.

Vermiculite—Vermiculite is a hydrous magnesium-aluminum-iron silicate with a platy cleavage similar to that of mica. When it is heated to 900 °C, associated water vaporizes into steam and expands the cleavage planes, creating a lightweight, chemically inert, fire-resistant material used mainly in the agricultural and construction industries (Tanner, 2016). Major deposits in the United States are in Montana, Virginia, and South Carolina, but the United States reserve base includes deposits in Wyoming, Nevada, and Colorado (Meisinger, 1985). No vermiculite deposits or potential for vermiculite production has been identified in the four study areas.

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Appendix 4. Oil and Gas Plays and Assessment Units in the Sheldon-Hart Mountain National Wildlife Refuge Complex, the Southeastern Oregon and North-Central Nevada, the Southern Idaho and Northern Nevada Sagebrush Focal Areas, Nevada, Oregon, Idaho, and Utah, and the Nevada Additions

This appendix is available online only as an Excel (.xlsx) table at http://dx.doi.org/10.3133/sir20165089B. The table relates Public Land Survey System (PLSS) townships to U.S. Geological Survey (USGS) reports on oil and gas resource assessments for assessment units or plays in the Sheldon-Hart Mountain National Wildlife Refuge Complex, the Southeastern Oregon and North-Central Nevada, the Southern Idaho and Northern Nevada Sagebrush Focal Areas and the Nevada additions, Nevada, Oregon, Idaho, and Utah. If an assessment was conducted in 1995 then the terminology used was “play.” After 1995, the terminology became “assessment unit” (AU). In many cases, more than one play or AU may be present within a given PLSS township. The table lists each PLSS township and the associated play or AU, the name of the play or AU, the related USGS publication title, and a link to the published USGS geologic assessment report. The USGS reports include many additional details regarding the source rocks, reservoir rocks, type of trap, reservoir properties, and resource potential.

Appendix 5. Dimensions of Epithermal Quartz-Adularia Gold-Silver Deposits in Northern Nevada

Deposit/District	Approximate area (maximum dimensions, in kilometers)	Notes	References
Buckhorn	0.5 × 1.5	Area containing main open pits	Monroe and others (1988), Google Earth (2016)
Buckhorn	3 × 4	Area containing all open pits including large areas of post-alteration cover rocks	Monroe and others (1988), Jennings (1991), Google Earth (2016)
Buckskin Mountain	2 × 3	Surface alteration and underlying veins	Vikre (1987), Weiss and others (2015)
Fire Creek	1 × 2.2	Exploration area	Odell and others (2015)
Goldbanks	1–3 × 7	Alteration including areas of post-alteration cover rocks	Ellis and Stroup (2015)
Hycroft	3 × 6	Surface and subsurface extent of alteration	Wilson (2010)
High Grade (CA)	1 × 5	Mapped alteration	Feinstein (2011)
Ivanhoe	1 × 2	Area encompassing surface projection of veins, Hollister pit, and mercury-bearing sinters	Smith (2014)
Jarbidge	5 × 7	Area containing major veins	Schrader (1923), Atna Resources Ltd. (2016)
Midas	2 × 5	Surface projection of veins	Marma and Vance (2011)
Mule Canyon	2 × 6	Area containing 6 open pits and 2 prospects	John and others (2003)
National	2 × 3	Area containing mines and prospects	Vikre (1985b)
Seven Troughs	2 × 8	Mapped alteration	Hudson and others (2006)
Sleeper	0.6 × 1.2	Ultimate pit outline	Nash and others (1995)
Tuscarora	1.5 × 1.5	Area containing major veins	Castor and others (2003)

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