Eastern Snake River Plain Subsurface Investigations at the Idaho National Laboratory

Basalt stratigraphy and groundwater flow at the Idaho National Laboratory

USGS INL Project Office Mission

- Maintain a comprehensive groundwater monitoring and hydrogeologic studies program to evaluate the availability and movement of water in the eastern Snake River Plain aquifer.
- Describe processes controlling the fate of contaminants (advective transport, dispersion, adsorption, dilution, diffusion, radioactive decay, and chemical reactions)
- Provide independent reviews of hydrogeological data and reports submitted by DOE and its contractors to the EPA and the State of Idaho

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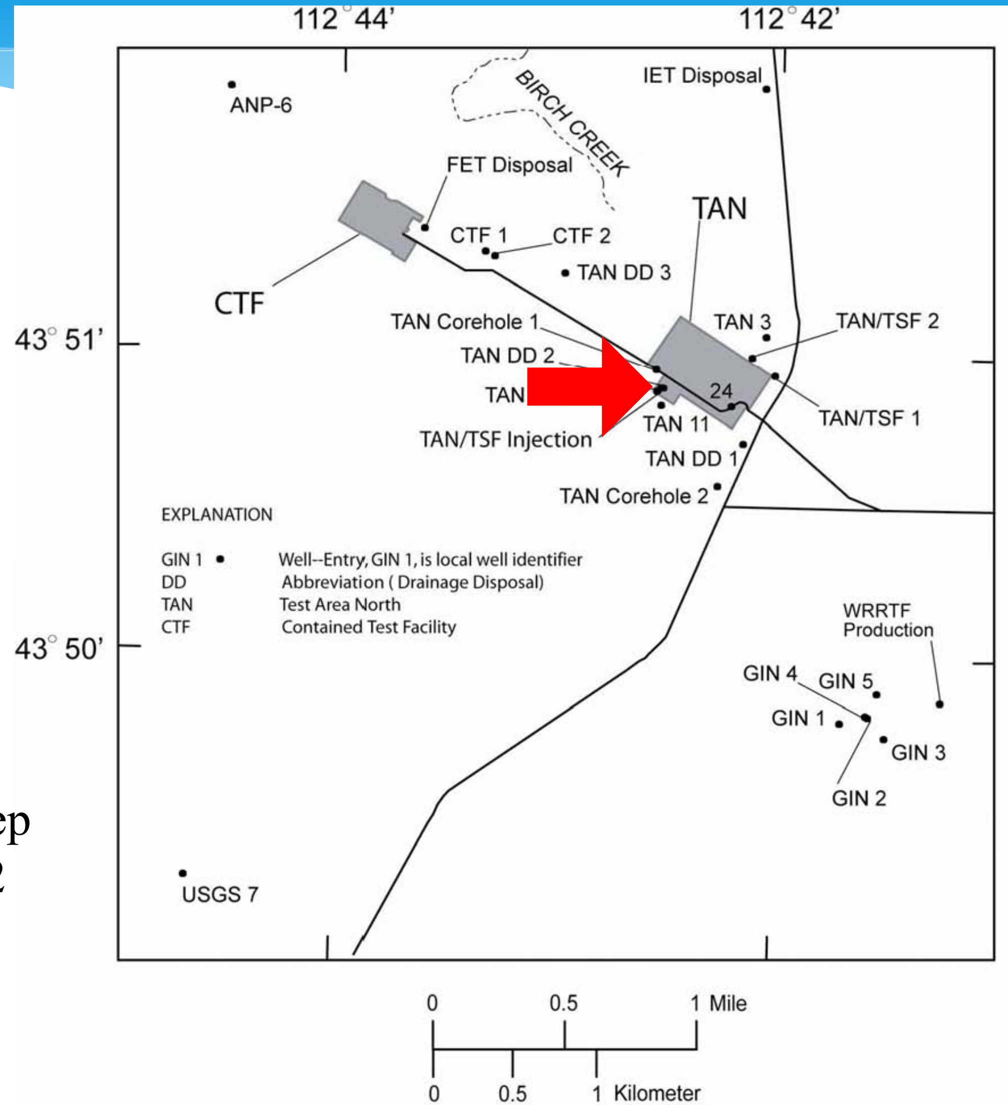
USGS INL Project Office Mission

- OUTLINE
- Brief overview of wastewater disposal history at selected Facilities
- Geologic description of the eastern Snake River Plain and the aquifer system.
- Hydrologic description of the eastern Snake River Plain aquifer



Wastewater discharged to 310 ft deep TAN injection well from 1953-1972

Radioactive chemicals, organic waste, and chloride and sodium primary constituents discharged

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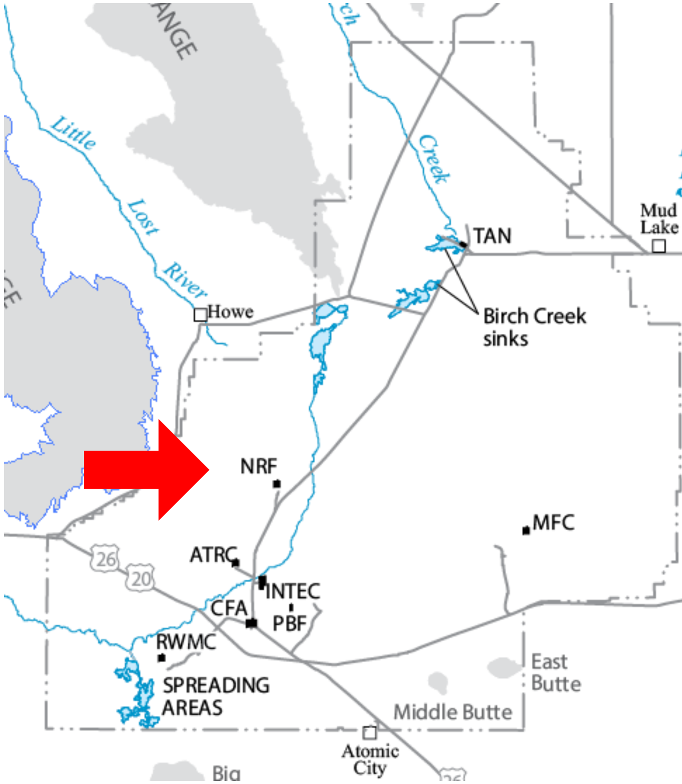
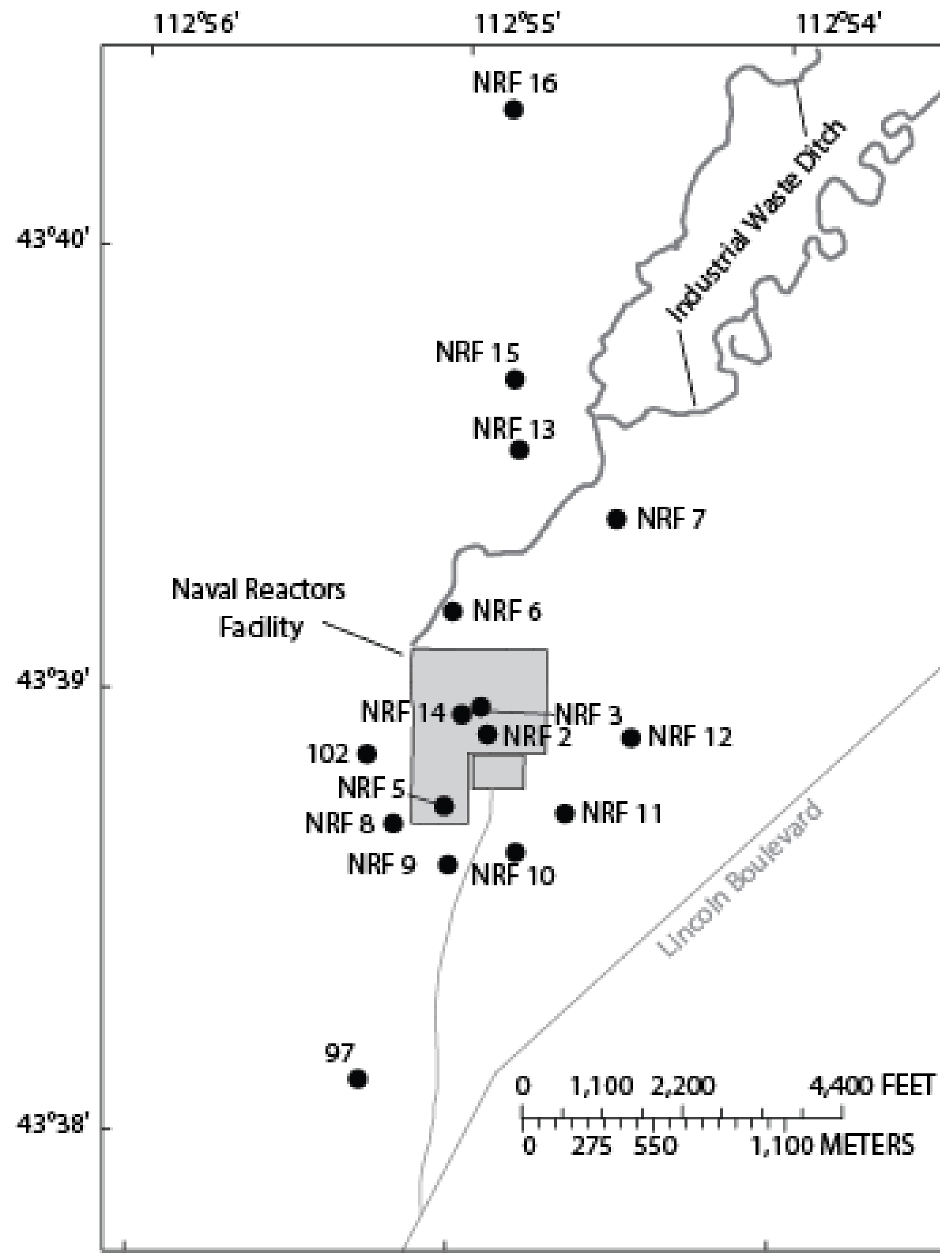
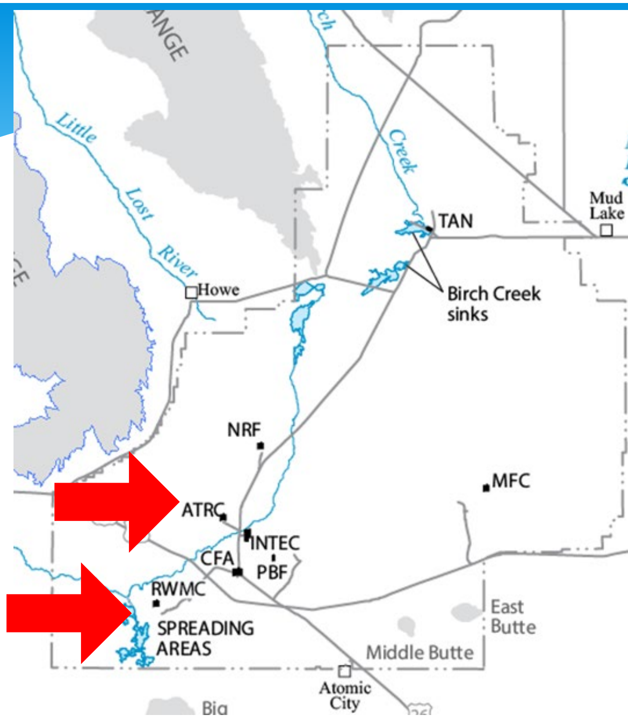


Wastewater discharged to 3 mile long industrial waste ditch

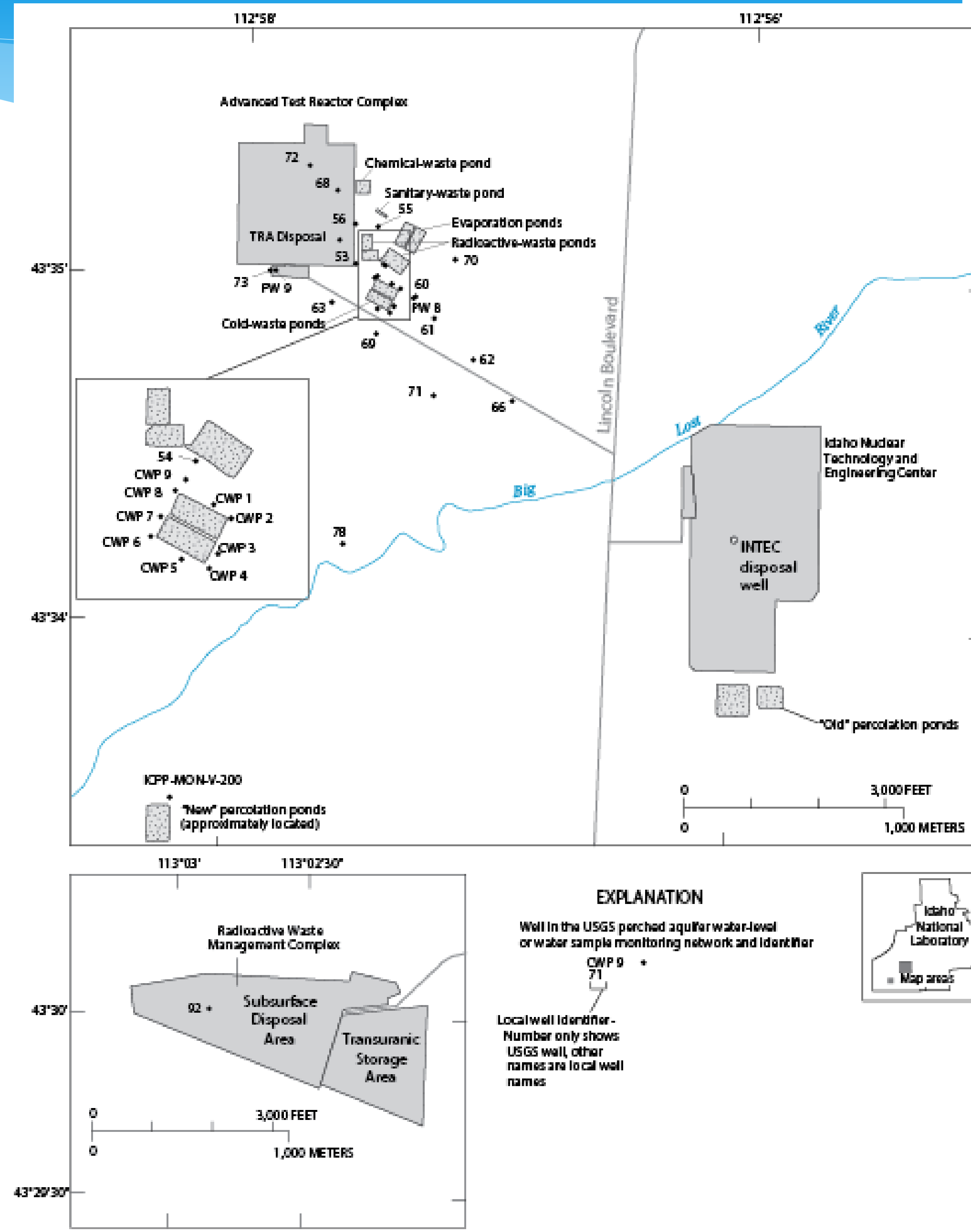
Chloride, sulfate, and sodium primary constituents discharged along with some chromium.





Wastewater discharged to mostly infiltration ponds at ATRC; Disposal well and infiltration ponds at INTEC; buried solid and liquid waste at RWMC

Primary constituents include tritium, strontium-90, sodium, chloride, sulfate, chromium, nitrate, and organic compounds



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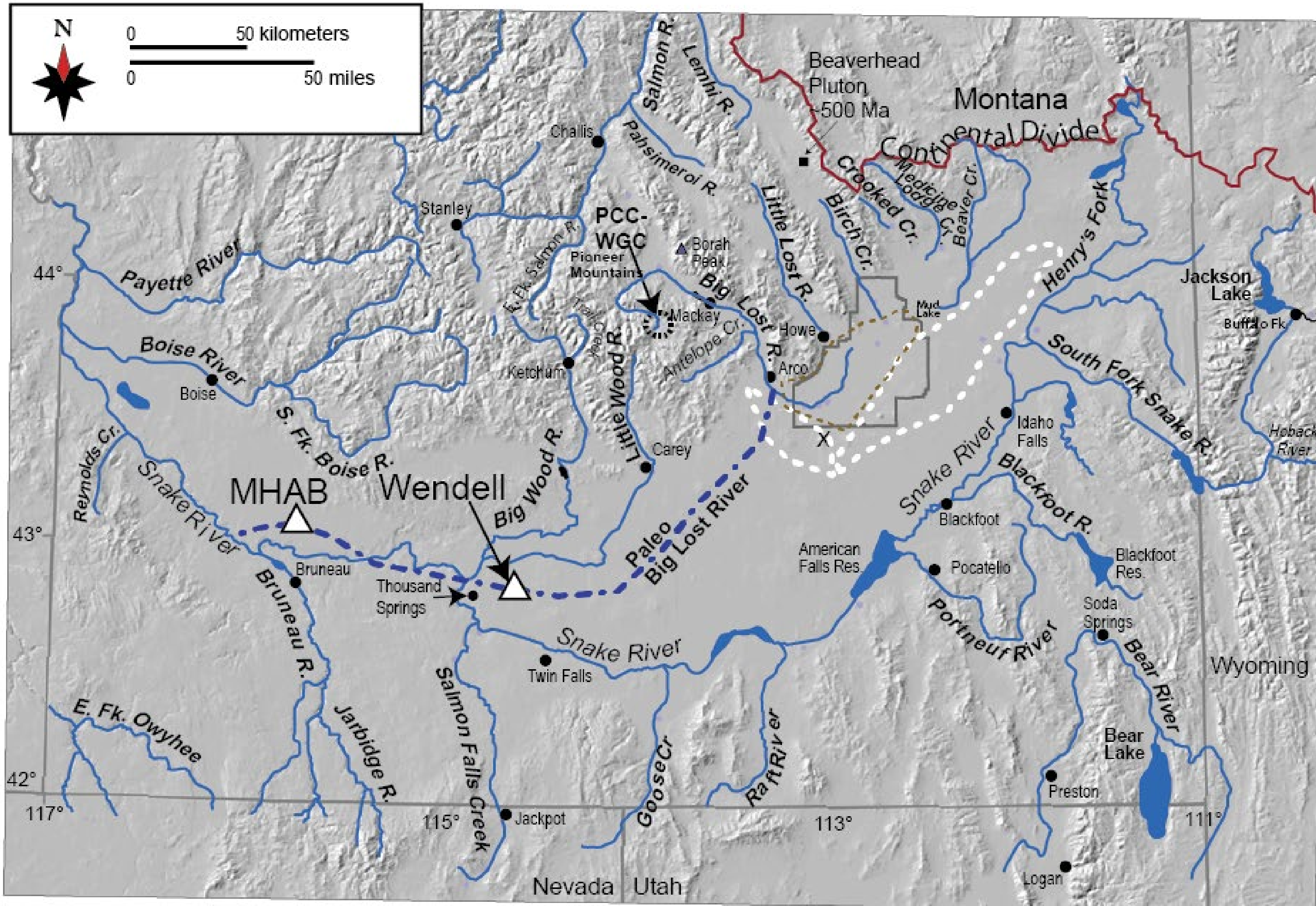

Southern Idaho physiographic and location map

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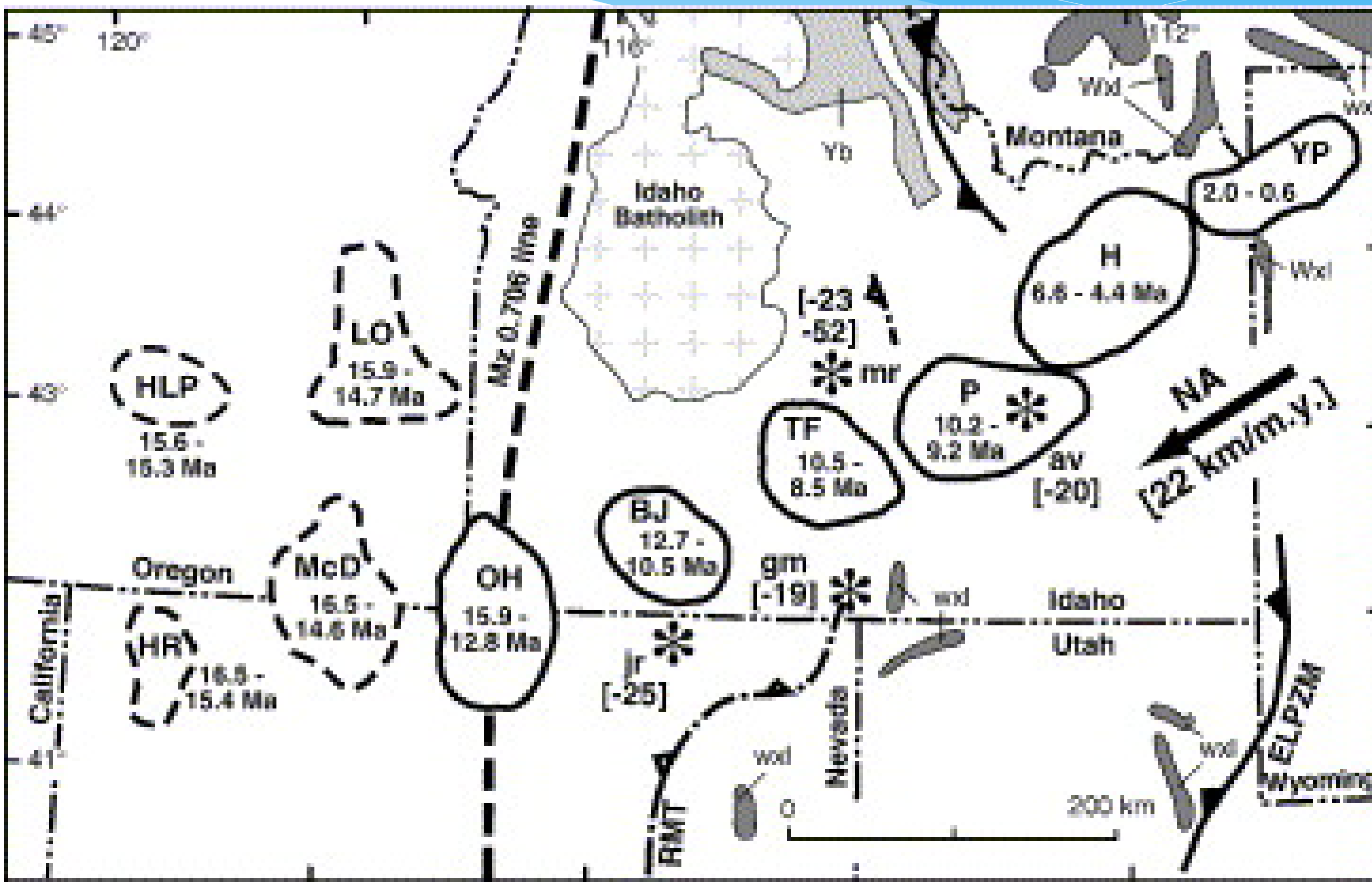
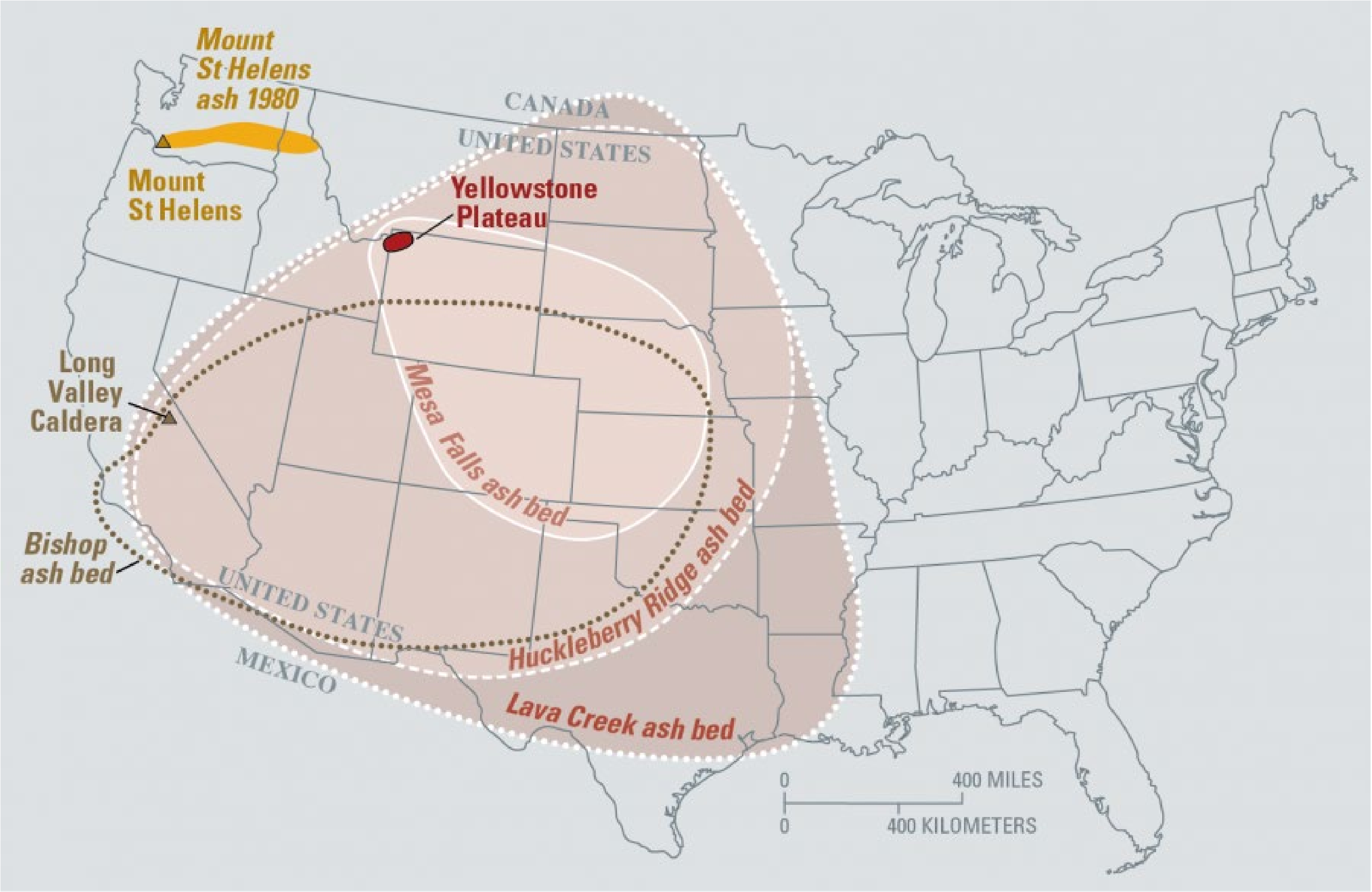
Map of caldera complexes, from Nash and others, 2006



Volcanic fields include High Rock (HR), High Lava Plains (HLP), McDermitt (McD), Lake Owyhee (LO), Owyhee–Humboldt (OH), Bruneau–Jarbidge (BJ), Twin Falls (TF), Picabo (P), Heise (H), and Yellowstone Plateau (YP). Crustal/tectonic boundaries include the Mesozoic (MZ) 0.706 line at the western edge of the North America craton (Nash et al., 2006)

Examples of ash fall extent



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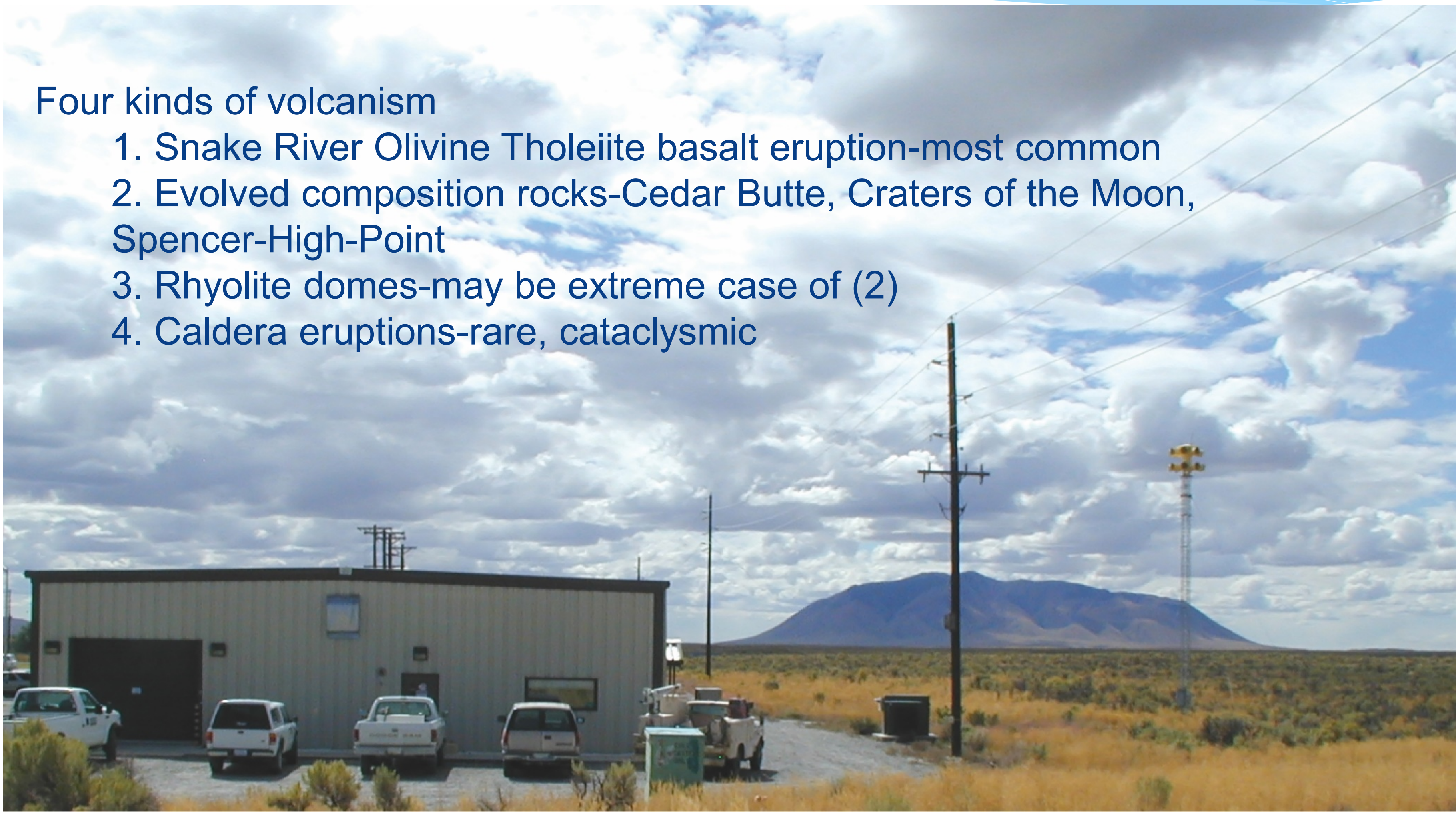
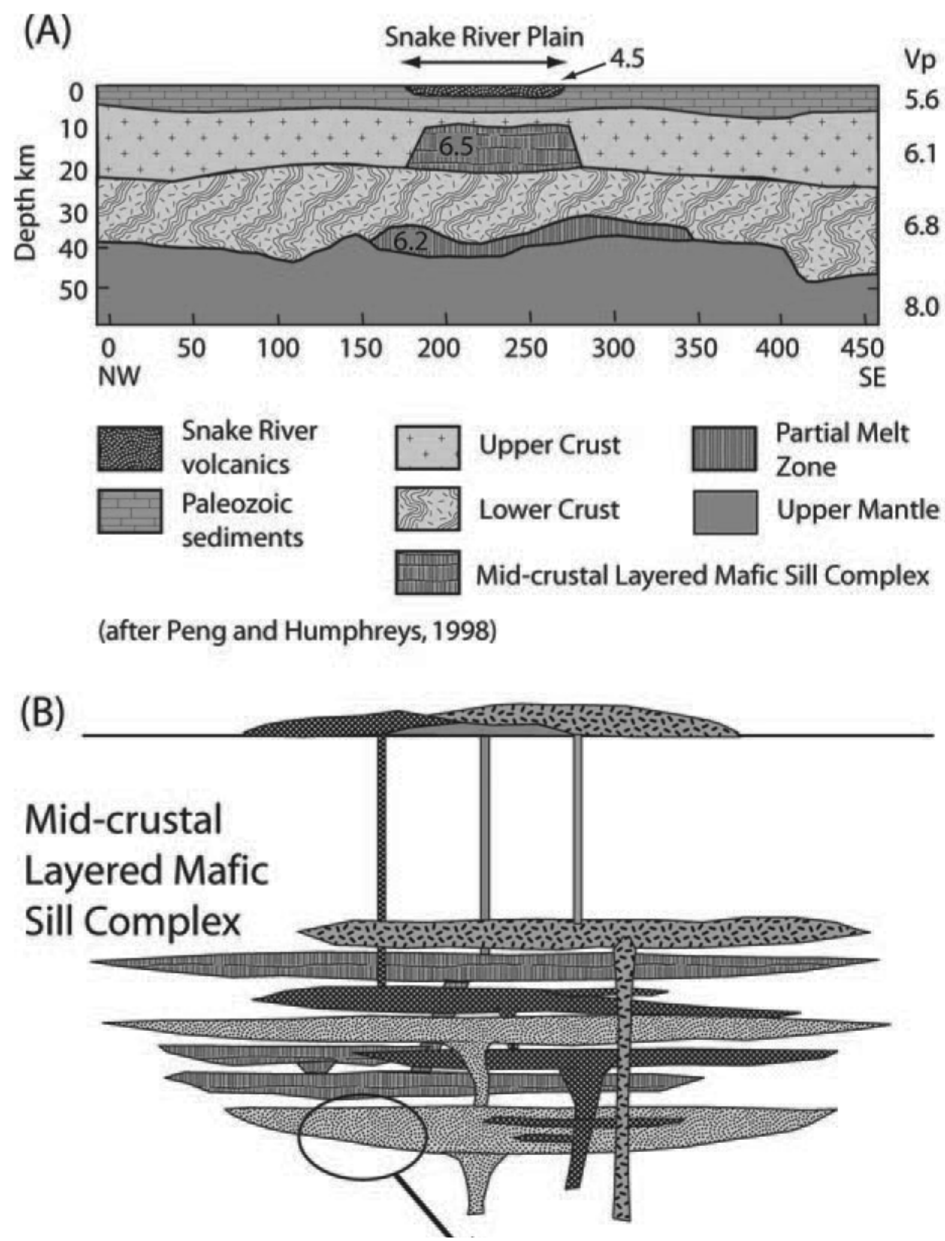
Eastern Snake River Plain geology
Post Hot Spot volcanism

Four kinds of volcanism

1. Snake River Olivine Tholeiite basalt eruption-most common
2. Evolved composition rocks-Cedar Butte, Craters of the Moon, Spencer-High-Point
3. Rhyolite domes-may be extreme case of (2)
4. Caldera eruptions-rare, cataclysmic



Cartoon of midcrustal sill and associated features, from Shervais and others, 2006



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Snake River Olivine Tholeiites

Photo from Hawaii Volcano Observatory website

- Low SiO2, high in mafic minerals
- Chemically nearly identical
- Rise fairly quickly-little fractionation or crustal assimilation
- Effusive eruptions, very much like Hawai'ian eruptions-no explosions, for the most part
- Bulk of emplacement is by tube-fed pahoehoe
- Monogenetic shield volcanoes-each new volcano has its own plumbing system, erupts from days to decades, then freezes shut

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Snake River olivine tholeiite basalts erupt from shield volcanoes

USGS photo by I. C. Russell, 1901, near Arco, ID, USGS Bulletin 199, Plate 18

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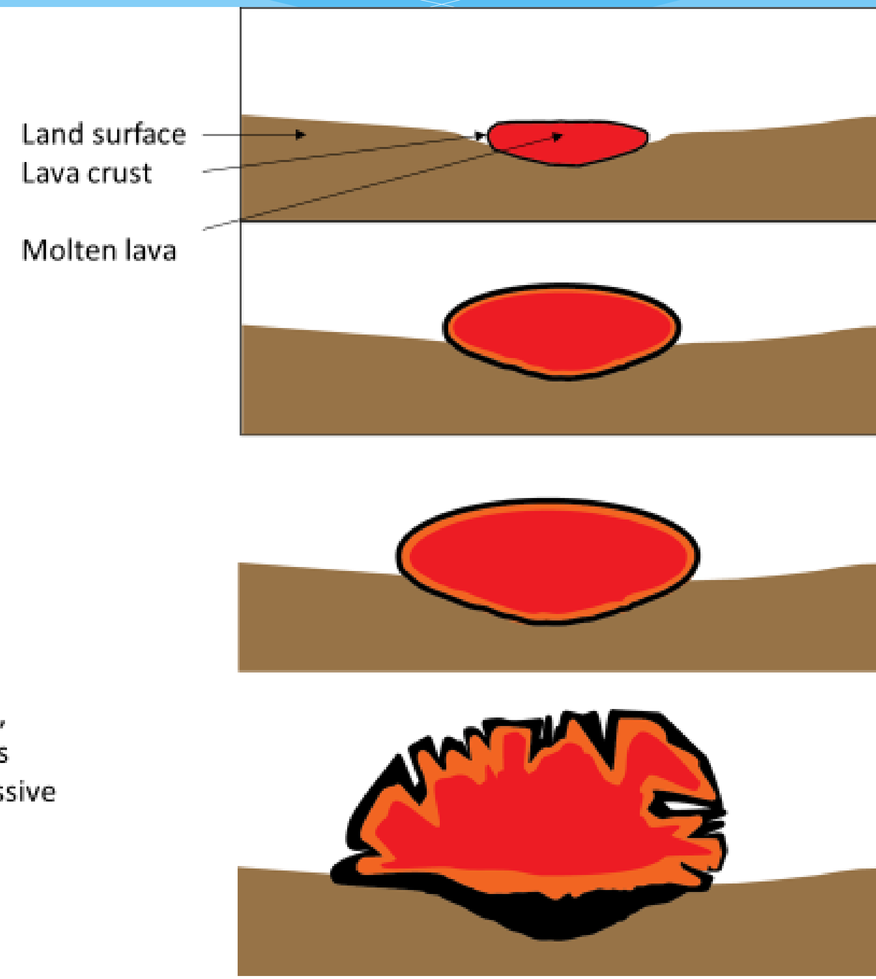
CROSS-SECTION CARTOON OF A BASALT TUBE



Pahoehoe flows follow the low areas in the landscape.
The flow lobe inflates.
As the lobe cools, the exterior surfaces fracture.

Fractures may disrupt magnetic inclination measurements by causing pieces of solidified basalt to rotate.

Nearly all basalt flows are much longer than they are wide, and fracture networks are directional. Groundwater moves rapidly through the fractures, and very slowly through massive basalt interiors and through fine-grained sediment.

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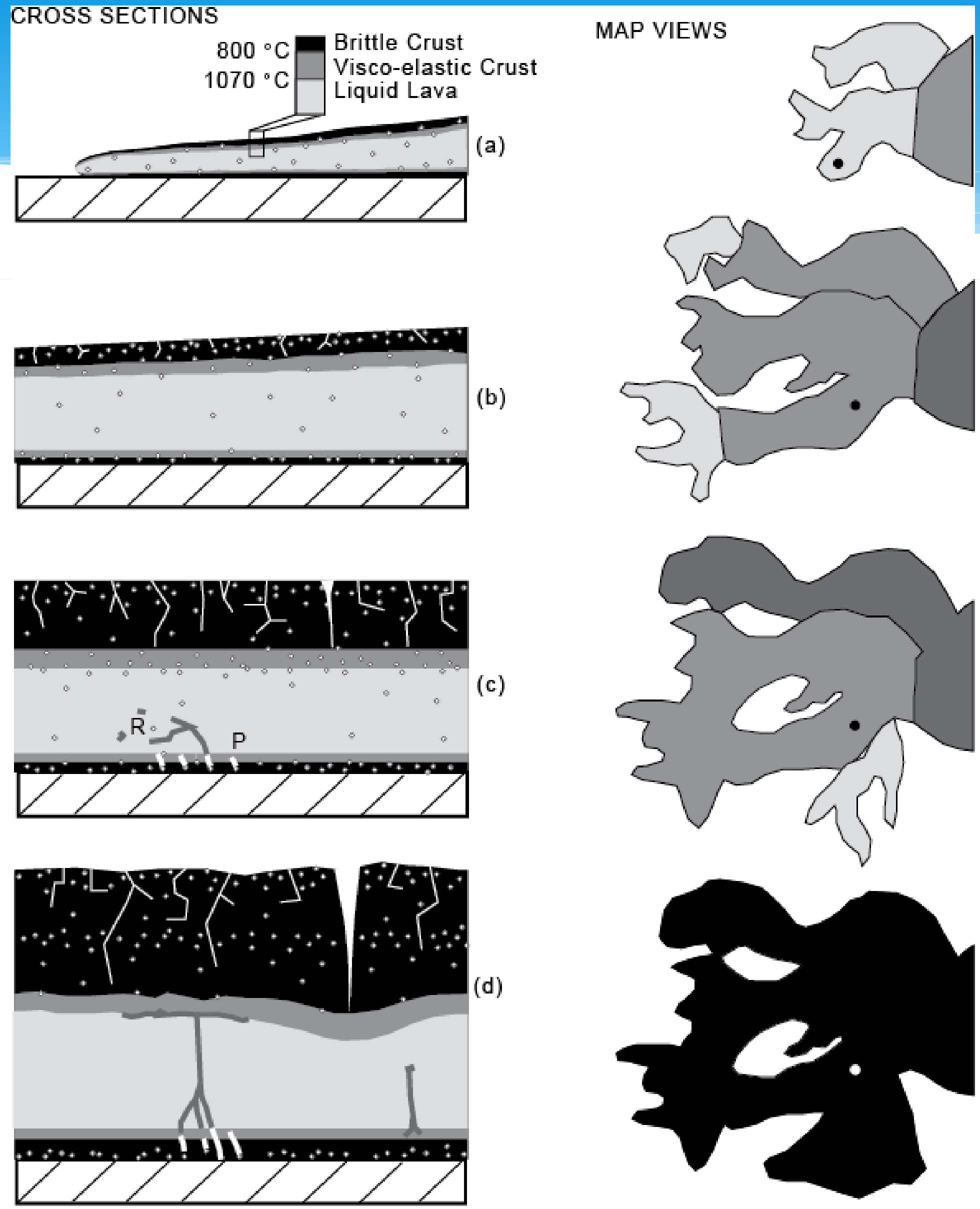
How to tell SROTs apart?

* Stratigraphy
* Rock Geochemistry
* Age
* Paleomagnetism!

Lava tubes Tube fed pahoehoe flows



From Self and others, fig. 2, 1998

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Snake River Aquifer at the Idaho National Laboratory

* Solid part of aquifer is mostly SROT basalt, (averages 85% over whole INL site) and eolian sediment, minor amounts of fluvial sediment
* Sediment amount varies depending on location, volcanic highlands have very little sediment, Big Lost Trough may be up to 30%
* Despite low volume, sediment is a major control on groundwater movement and contaminant transport

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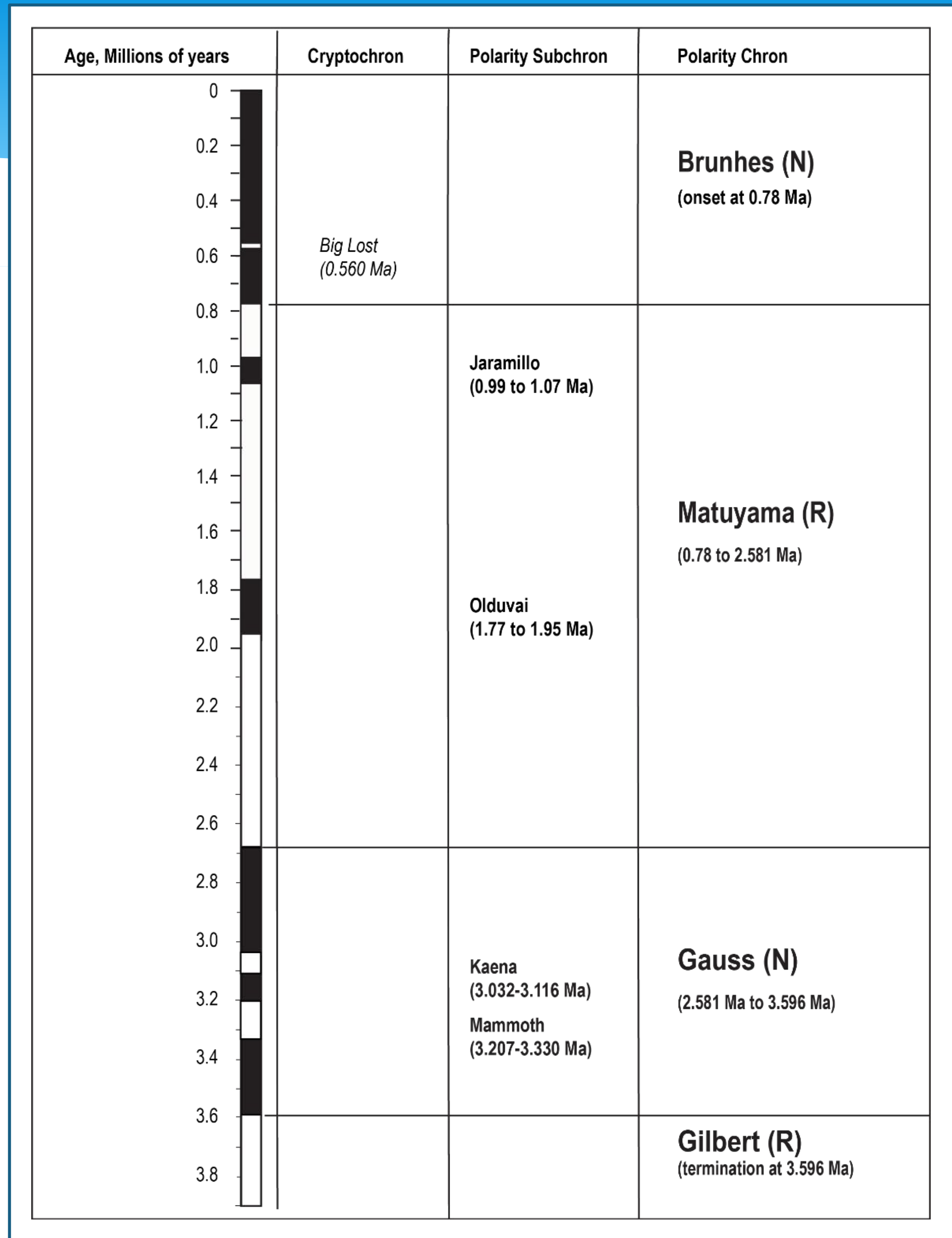
Image from USDA FSA National Agriculture Imagery Program (NAIP)
The USDA-FSA Aerial Photography Field office

Paleomagnetic chrons, subchrons, and cryptochrons for the last 4 million years, modified from Gradstein and others, 2004



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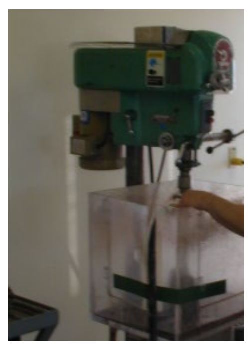
Core drilling and paleomag sampling



Paleomag sampling on core yields only inclination data

Paleomag surface sampling

Duane and Sam with drill and pump

Duane Champion and Sam Helmuth discussing outcrop, Duane with sun compass

Surface paleomag yields both inclination and declination

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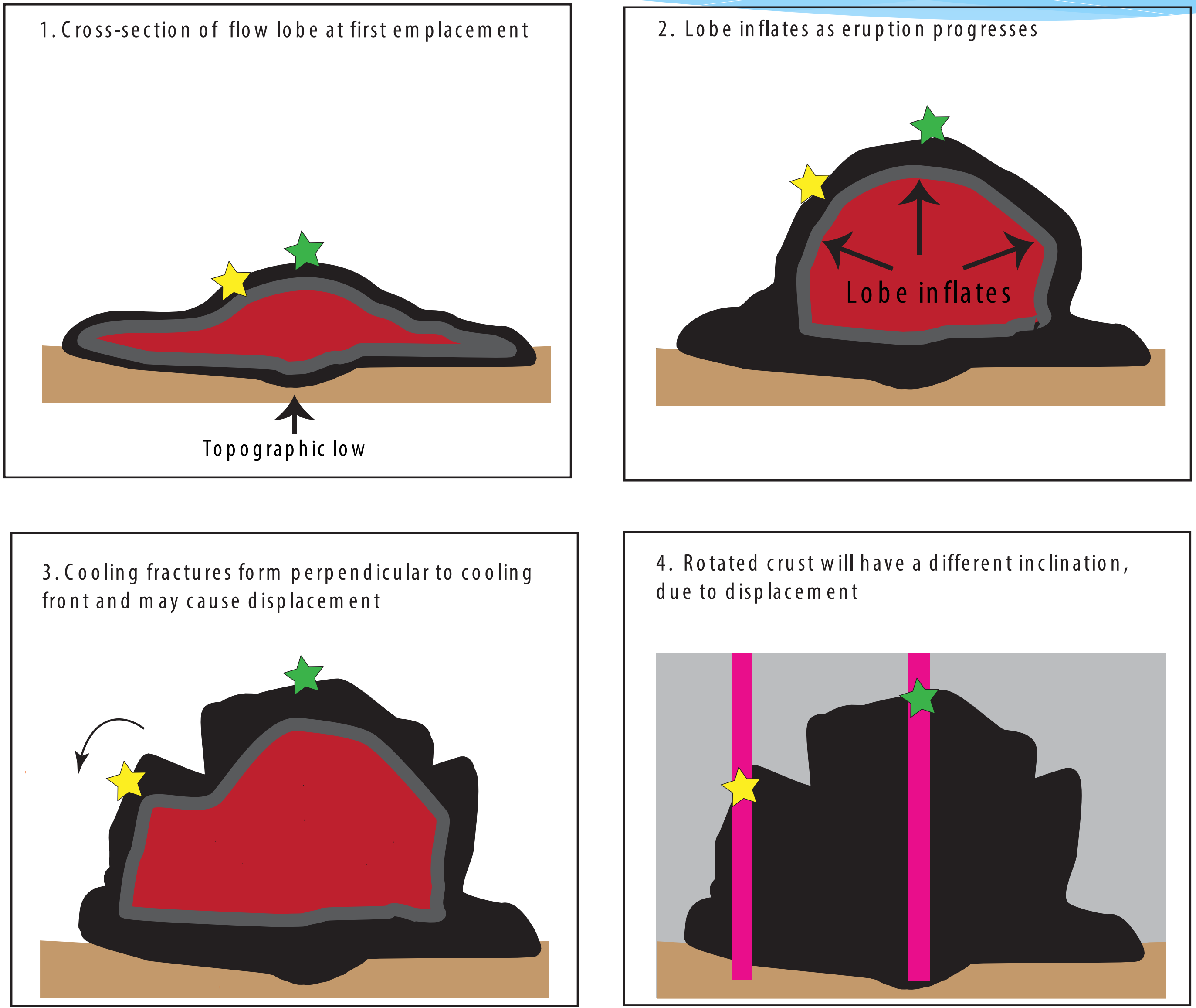
Possible sources of error



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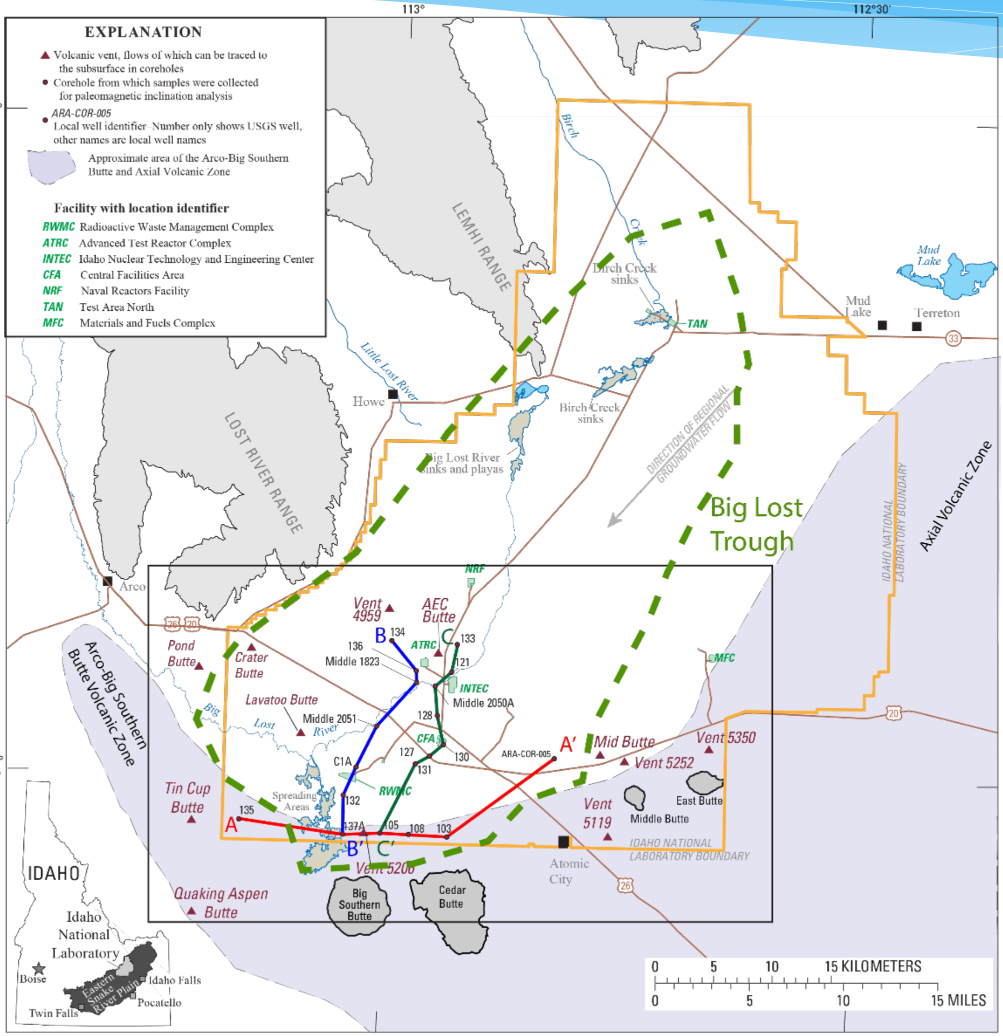
More sources of error

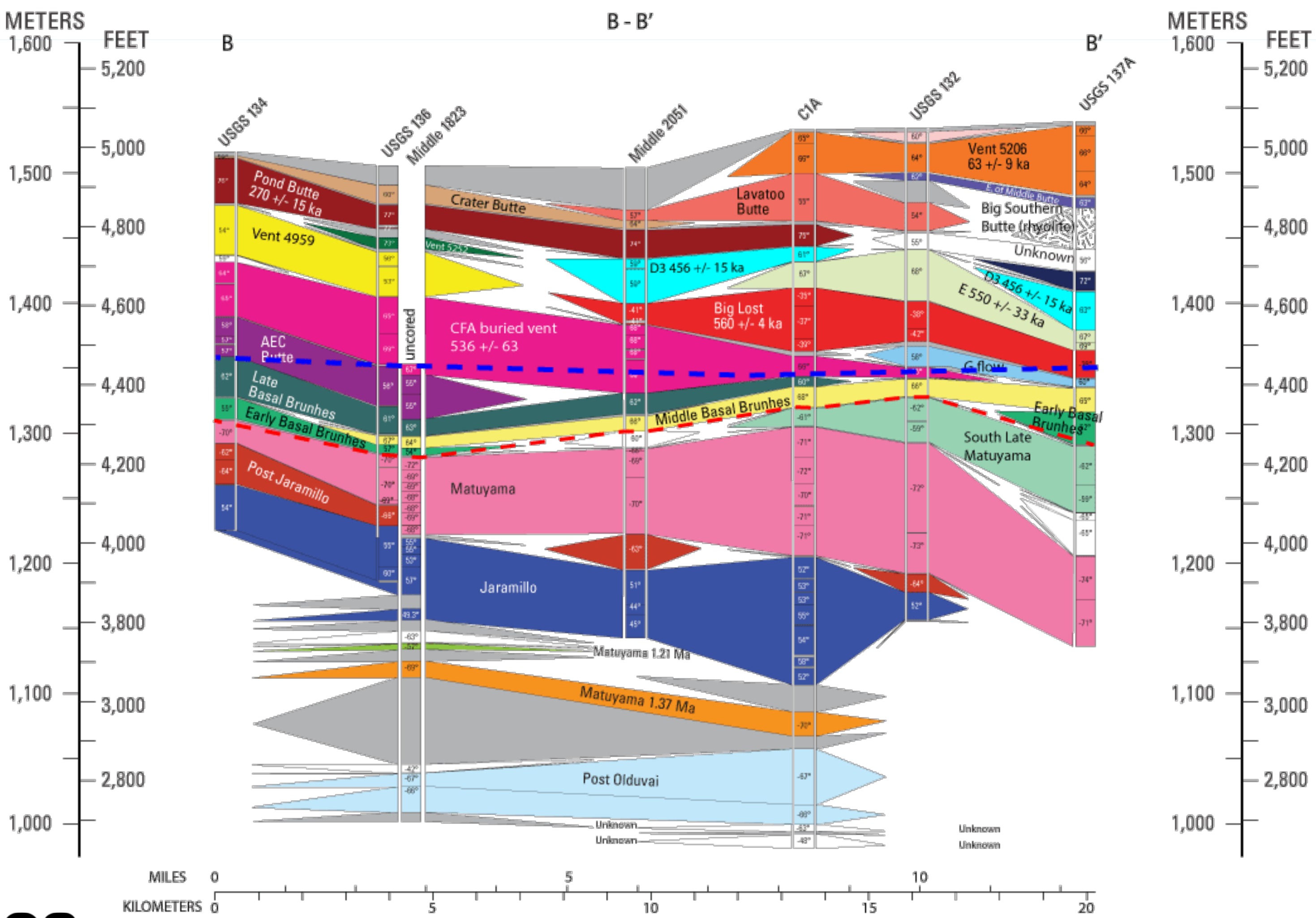
* Corehole deviates from vertical-gyroscopic deviation log allows mathematical correction
* Lightning strike when lava flow was at surface resets paleomag
* Subsequent overlying lava flow raises older flow above blocking temperature and reset paleomag- can be corrected for to some extent
* Paleomagnetic data is non-unique, two lava flows of very different age may have the same directions

Create cross-sections using paleomagnetic data



Base from U.S. Geological Survey digital data, 1:24,000 and 1:100,000
Universal Transverse Mercator projection, Zone 12
Datum is North American Datum of 1927

Cross-section based on subsurface paleomagnetic inclination from core, from Hodges and others, 2016



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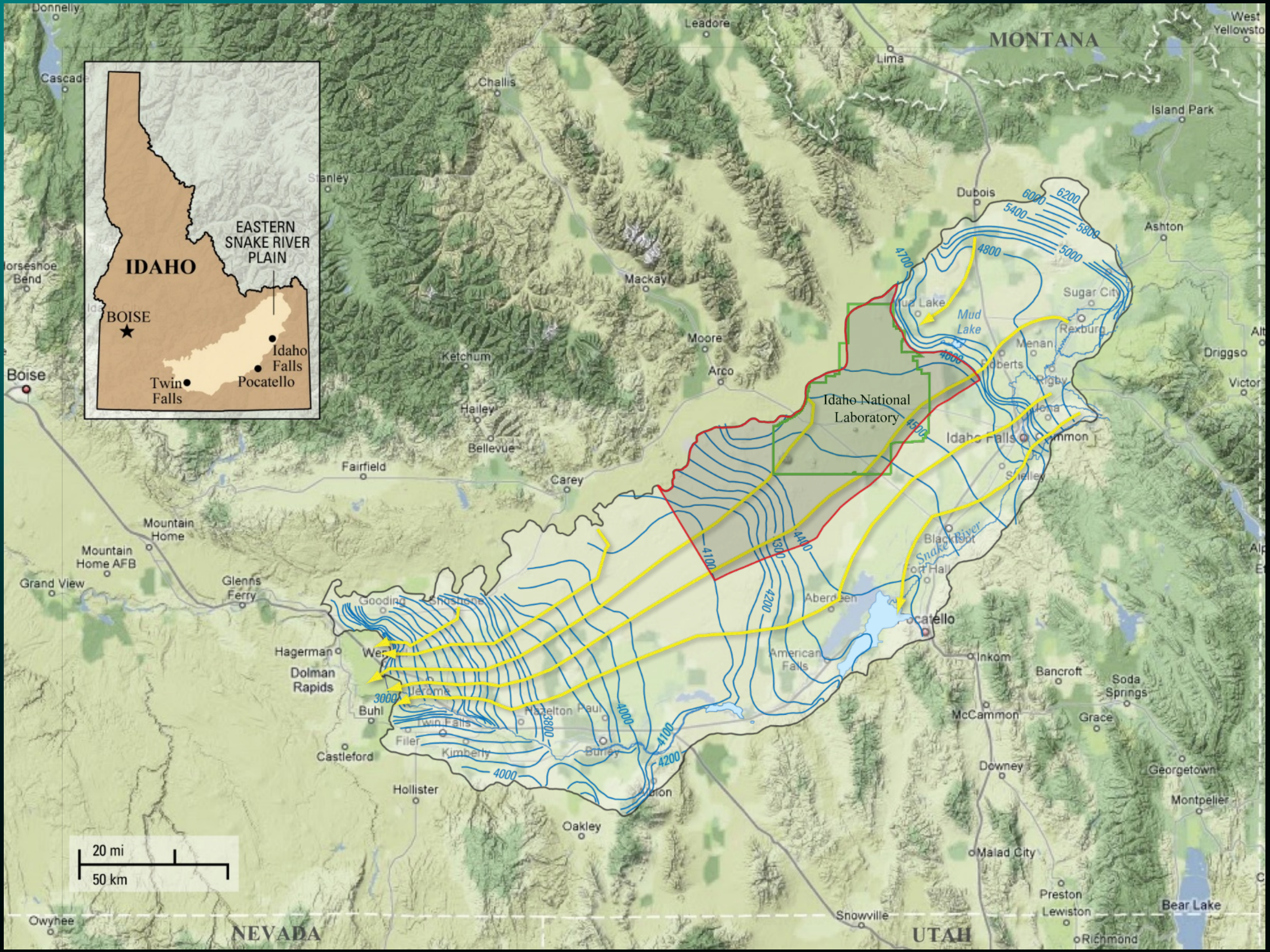
Hydrology of the Eastern Snake River Plain Aquifer



Modified from Lindholm (1996)

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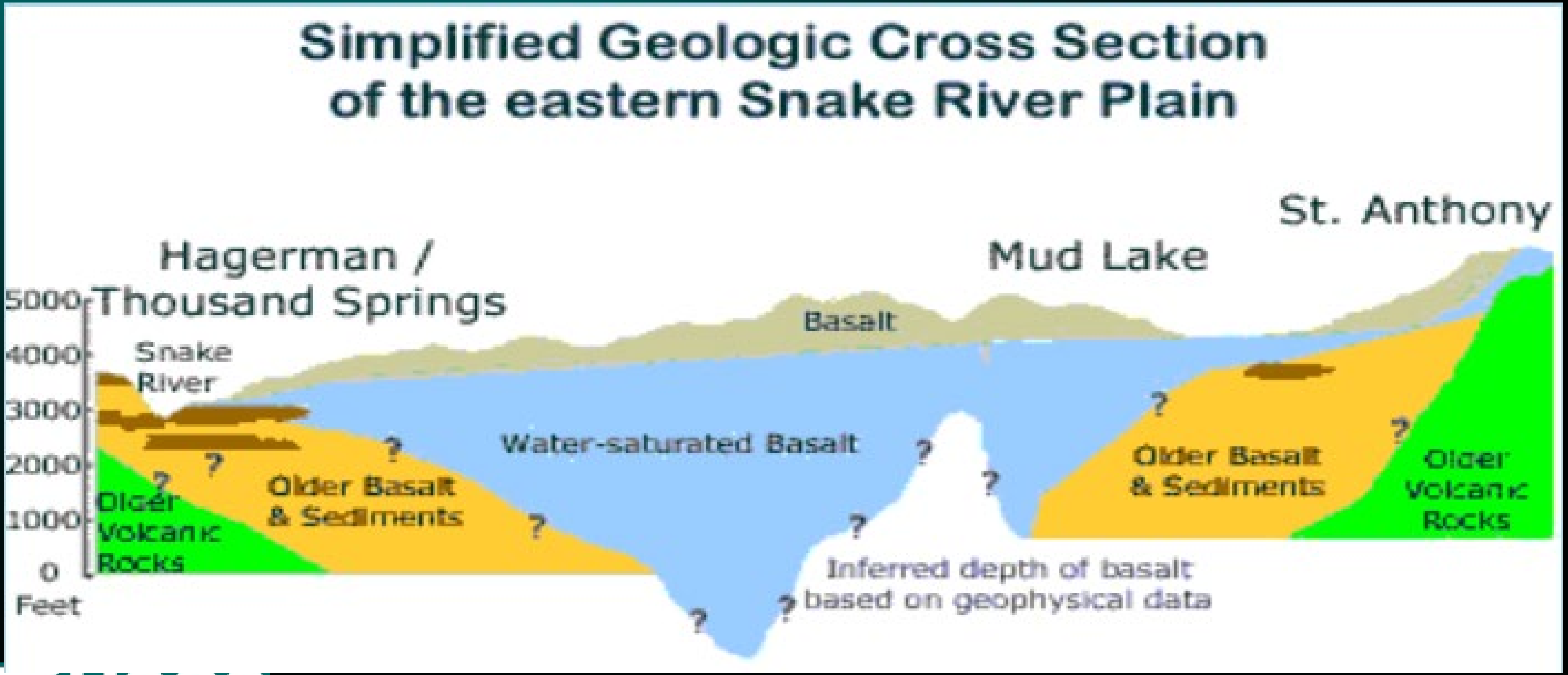


From Geller 2006

Basaltic characteristics for water movement

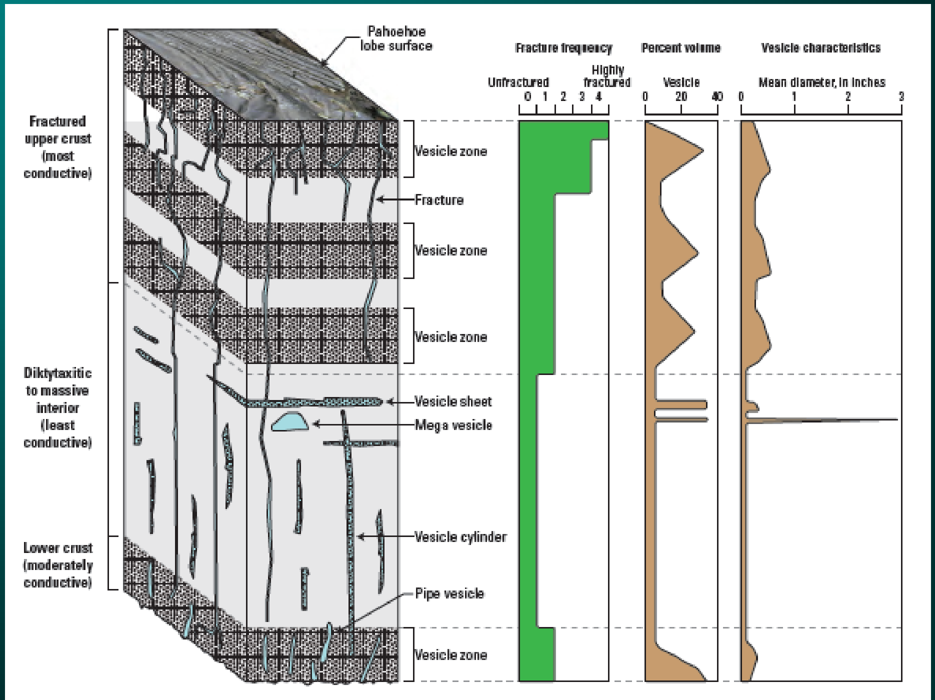
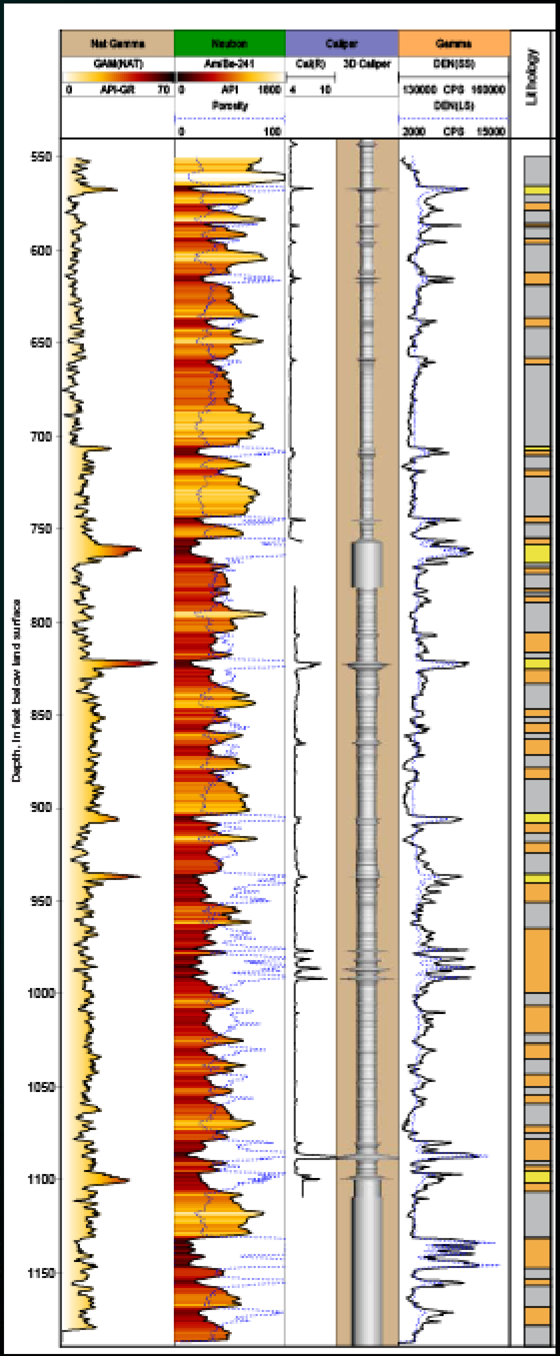


Figure 3. Idealized typical olivine tholeiite pahoehoe basalt flow (modified from Self and others, 1998, fig. 3, p. 90). The basalt flow is divided into three sections on the basis of vesicle characteristics and fracture frequency. Hydraulic conductivity is highest for the fractured upper crust, moderate for the lower crust, and lowest for the diktytaxitic to massive interior. The photograph of the pahoehoe lobe surface is courtesy of Scott Hughes, Emeritus Professor, Idaho State University, Pocatello, Idaho.



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Age and velocity of groundwater

- Two studies were done in the Mid-1990's on aging the young fraction of water at the Idaho National Laboratory (INL) and from south-central Idaho.
- Studies were done using stable isotopes, chlorofluorocarbons, dissolved gases, and tritium/helium.
- Several wells at the INL and from wells in rangeland southwest of the INL only contained small fractions of young water.
- Flow velocities calculated at the INL ranged from about 0.5 to 4.3 m/day (about 2-14 ft/day)
- Flow velocities for wells in south-central Idaho (where the gradient is steeper) ranged from 5 to 8 m/day (16 -26 ft/day)

DOE/ID-22177

ESTIMATED AGE AND SOURCE OF THE YOUNG FRACTION OF GROUND WATER AT THE IDAHO NATIONAL ENGINEERING AND ENVIRONMENTAL LABORATORY

U.S. GEOLOGICAL SURVEY
Water-resources Investigations Report 01-4265

Prepared in cooperation with the U.S. DEPARTMENT OF ENERGY

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Groundwater
Volume 38, Issue 2, Article first published online: 4 AUG 2005
Abstract | References | Cited By

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Age of Irrigation Water in Ground Water from the Eastern Snake River Plain Aquifer, South-Central Idaho

by L.N. Plummer[a], M.G. Rupert[b], E. Busenberg[a], and P. Schlosser[c]

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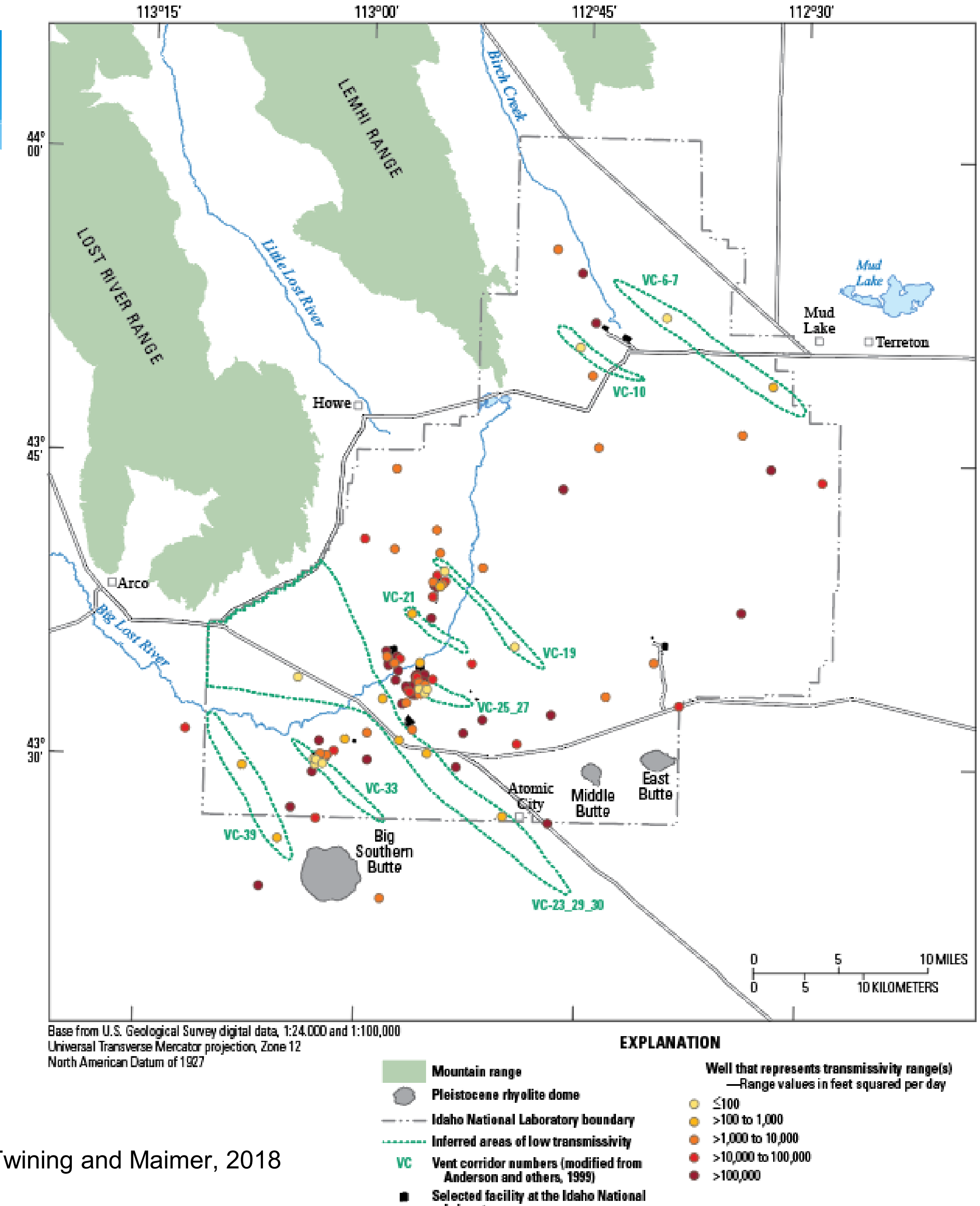
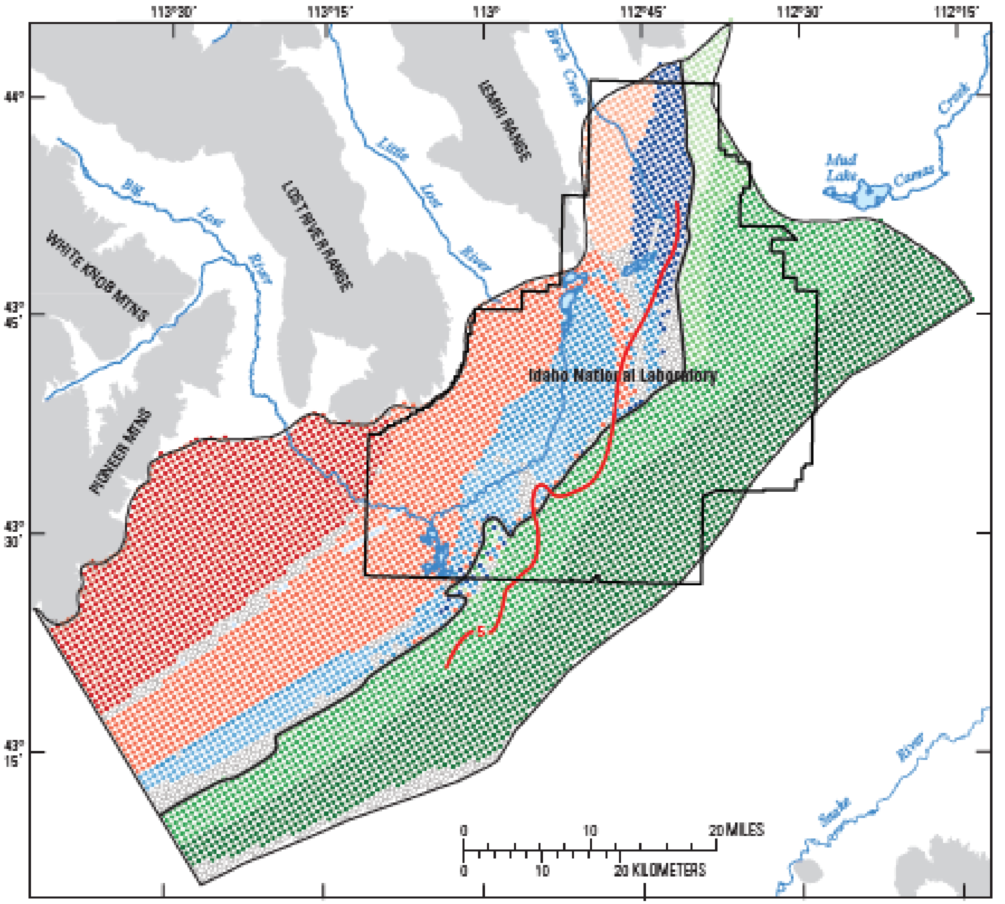
USGS has tested the aquifer to learn about water movement in different areas. Green circled areas on this figure are areas where water will move very slowly.



From Twining and Maimer, 2018

Particle tracking from our Groundwater flow model provided us with the initial assessment of how particles will move through the aquifer.



Base from U.S. Geological Survey digital data, 1:24,000 and 1:100,000
Albers Equal-Area Conic projection, standard parallels 42°50'N, 44°10'N;
central meridian 113°00'W; North American Datum of 1927.

EXPLANATION

Model area boundary

Major simulated interface between types A and B water

5 — 5-microgram-per-liter lithium concentration isopleth—Applies only to the upper 200 feet of the aquifer

Particles starting location and source area in model layer 1—layer is about 100 feet thick, varying with the water-table altitude. n is the number of particles that terminate in a designated source area.

Northwest mountain-front boundary source areas
- Big Lost River valley (n = 1,199)
- Little Lost River valley (n = 1,410)
- Birch Creek valley (n = 200)

Northeast regional-underflow boundary source areas
- Northeast boundary Reno section (n = 125)
- Northeast boundary Monteview section (n = 189)
- Northeast boundary Mud Lake section (n = 1,370)
- Northeast boundary Terreton section (n = 1,734)

Streamflow infiltration source areas
- Big Lost River stream reaches 600 and 601 (n = 15)
- Big Lost River spreading area, stream reaches 602 and 605 (n = 0)
- Big Lost River stream reaches 606 and 607 (n = 302)
- Big Lost River sinks and playas, stream reaches 609 and 610 (n = 461)
- Little Lost River stream reach 611 (n = 0)
- Birch Creek stream reach 612 (n = 270)

Orphans
- Particles that did not terminate in one of the specified source areas (n = 426)

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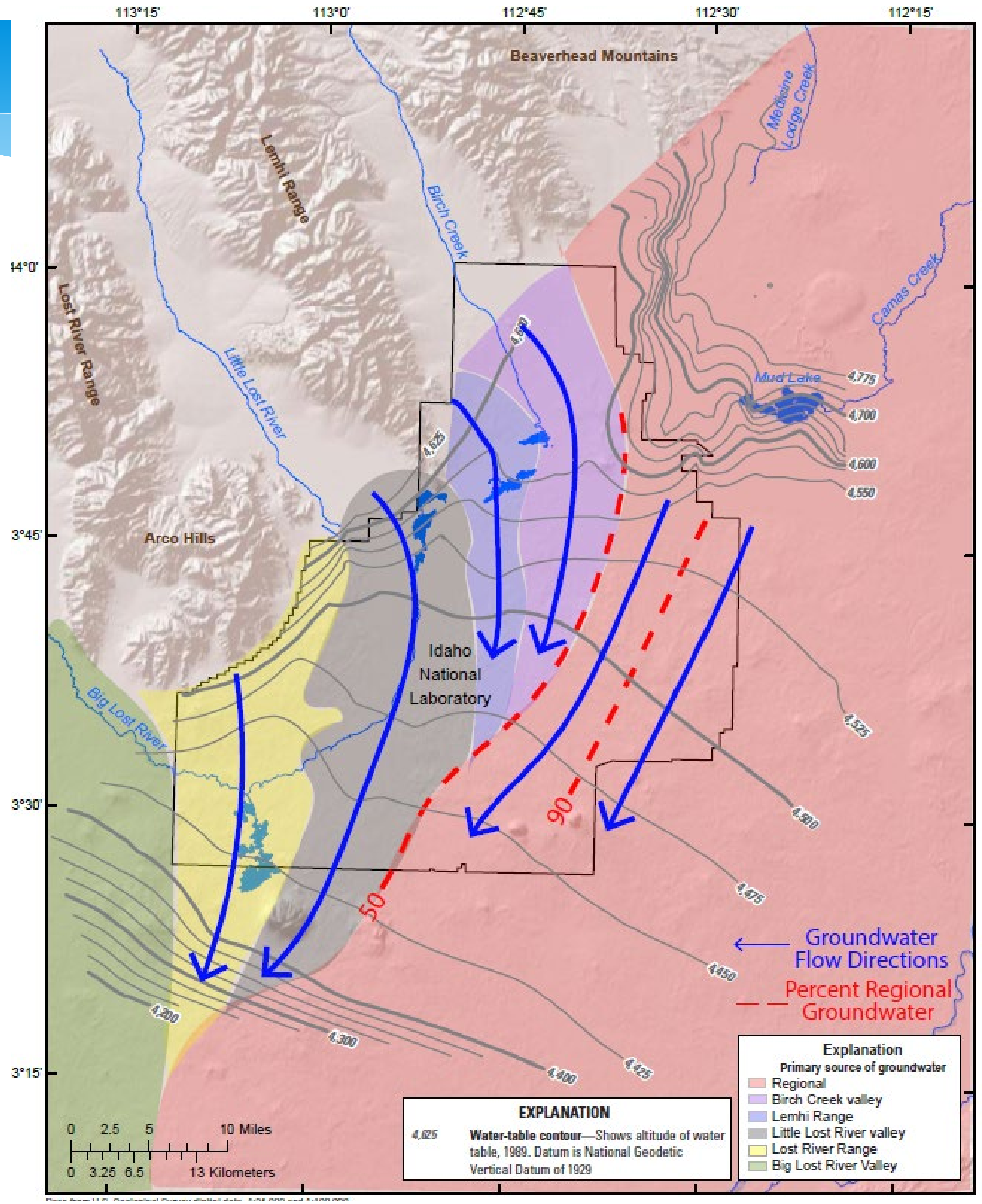
From Fisher and others, 2012

Recent work is researching source water chemistry to better understand water types and flow direction.



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