Potential contributions of “Staring Images” to geodynamics research

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what is geodynamics?

broad definition:

long-term dynamics of Earth deformation

narrow definition:

viscosity structure of Earth's interior

basic problem

- on time-scales shorter than a day
  - Earth behaves like an elastic solid
  - from the surface to the core-mantle boundary
- on plate tectonic time-scales (millions of years)
  - Earth behaves like a viscous fluid
  - from the lithosphere on down
- how does that transition occur?

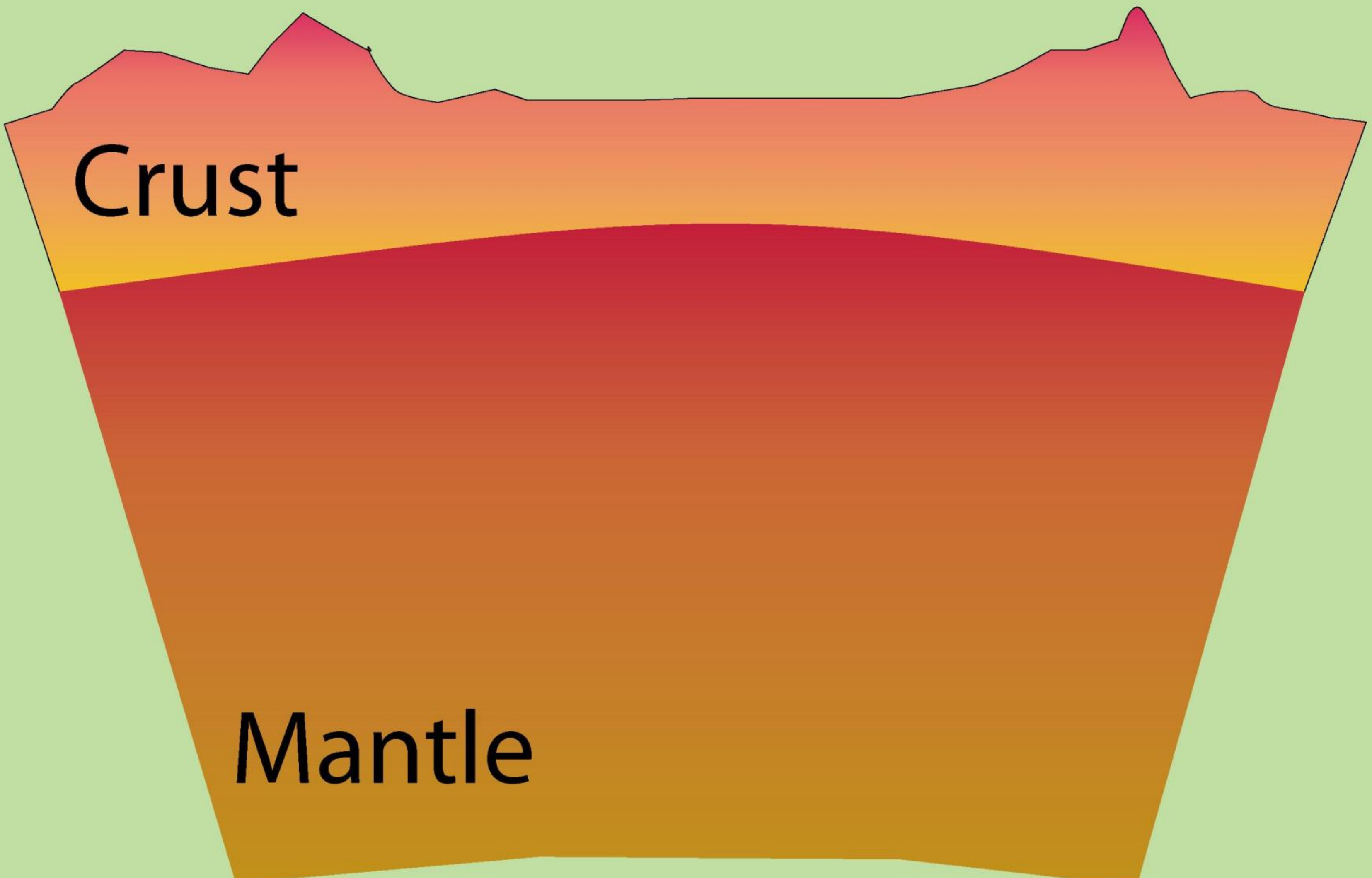
methods of probing Earth structure

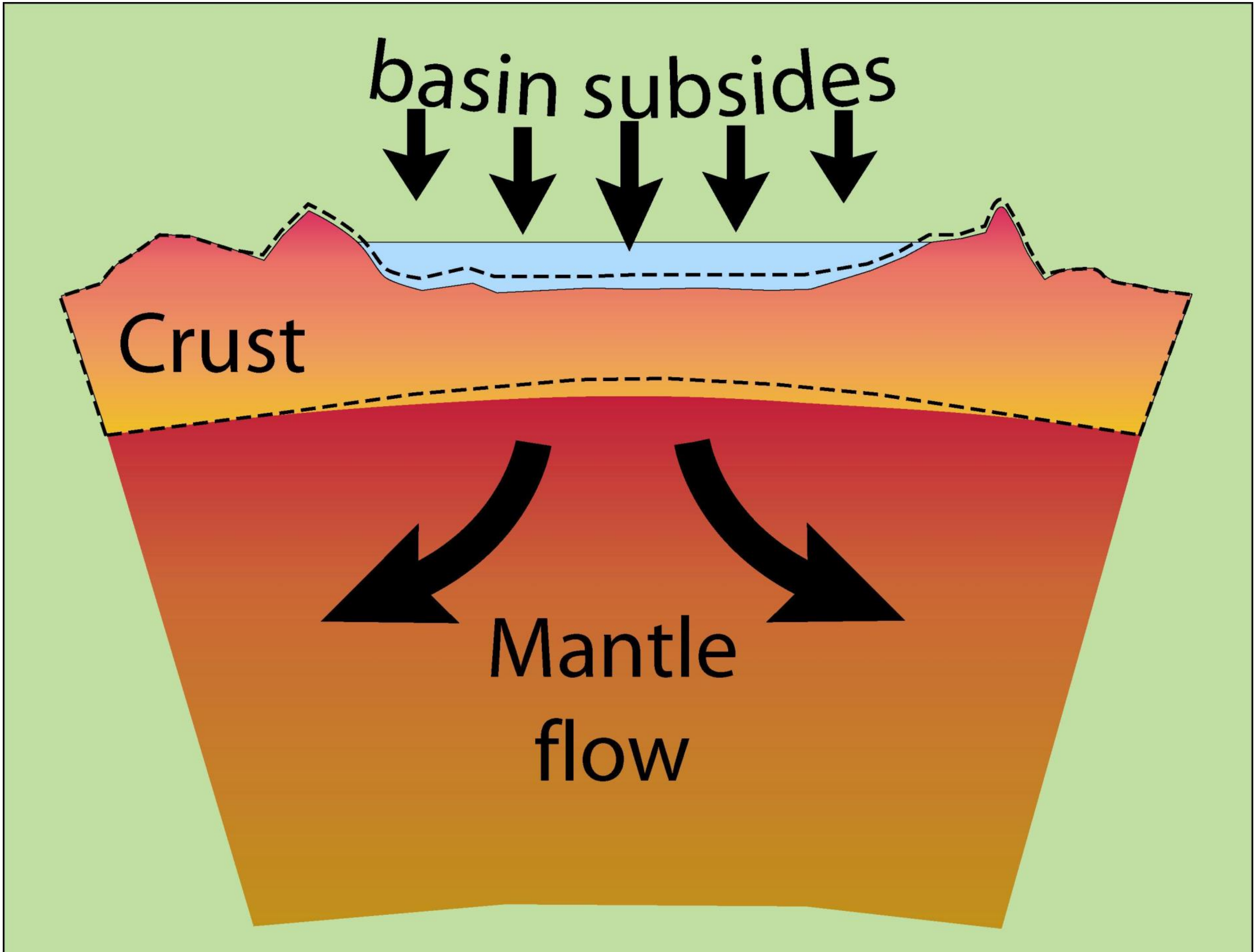
type	input	output	time scale
earthquakes	impulsive displacement	displacement	seconds-days
tides	periodic gravitational potential	displacement, gravity anomaly	hours-weeks
ice sheets	complex vertical load	displacement	10^2-10^4 years
large lakes	complex vertical load	displacement	10^2-10^4 years

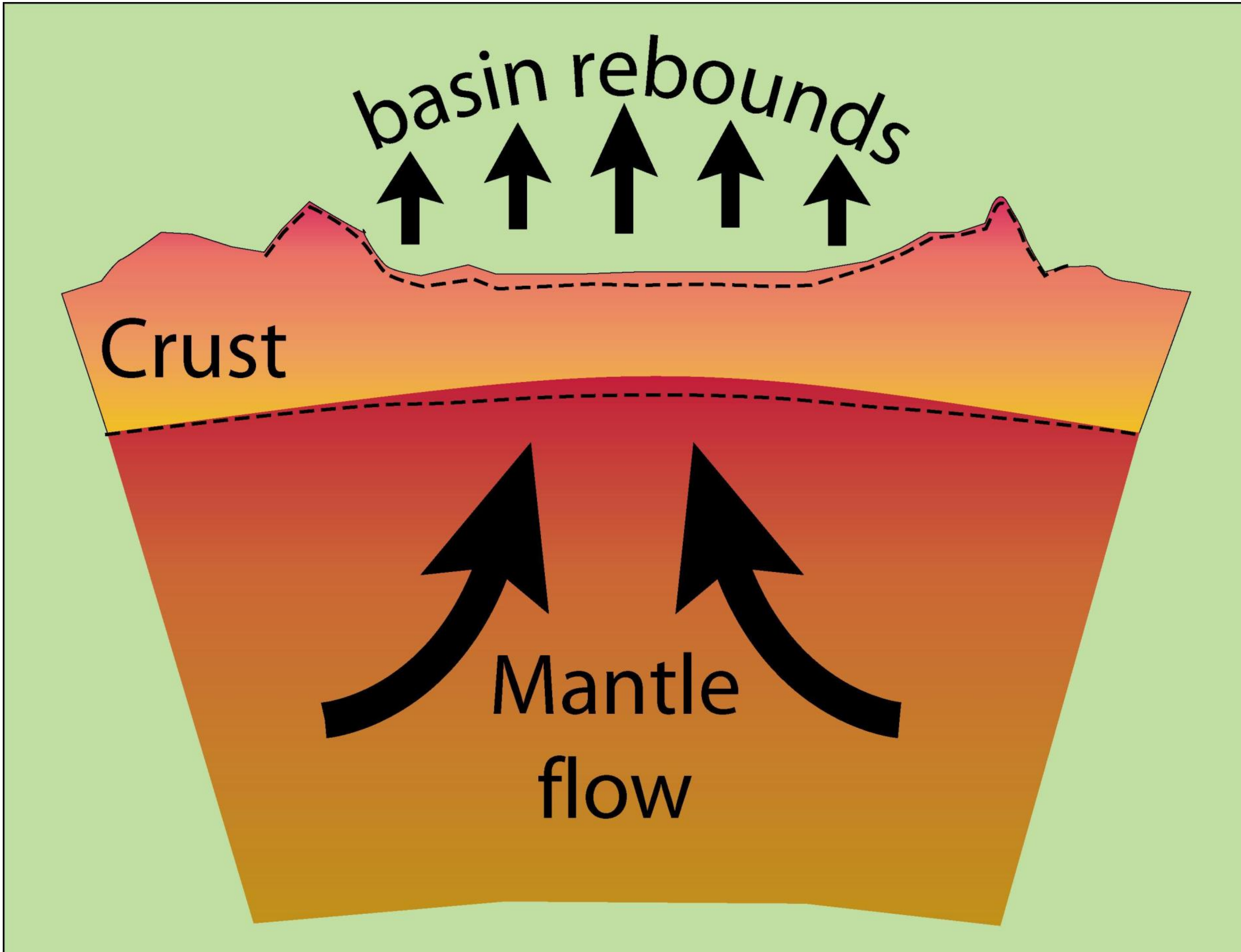
advantages of large lakes

- significant vertical deflection
  - produced via loading
  - recorded in shoreline elevations
- complex load
  - spatial complexity
  - temporal complexity
- temporal record
  - sedimentary layers
  - less destructive than glaciers

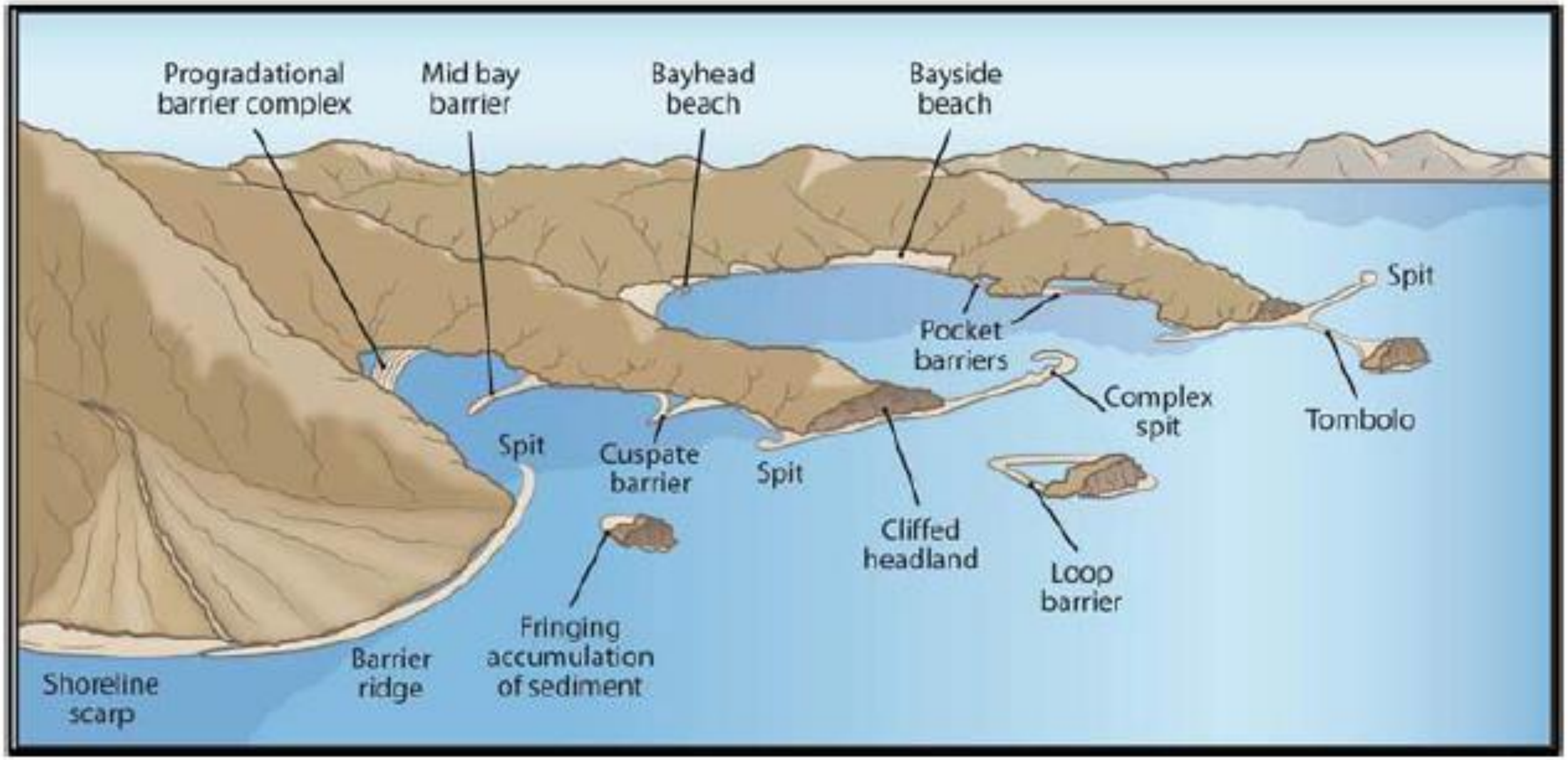
A simple model of the Earth....




basin subsides
Crust
Mantle
flow


basin rebounds
Crust
Mantle
flow

coastal geomorphic systems in a pluvial lake basin



loop barrier in Pyramid Lake, western Nevada

formed within 6 months, when lake level rose 2.8 m in 1997

case study: Lake Bonneville

large lake

300 km E-W extent
600 km N-S extend
300 m maximum depth
~10,000 km^3 maximum volume

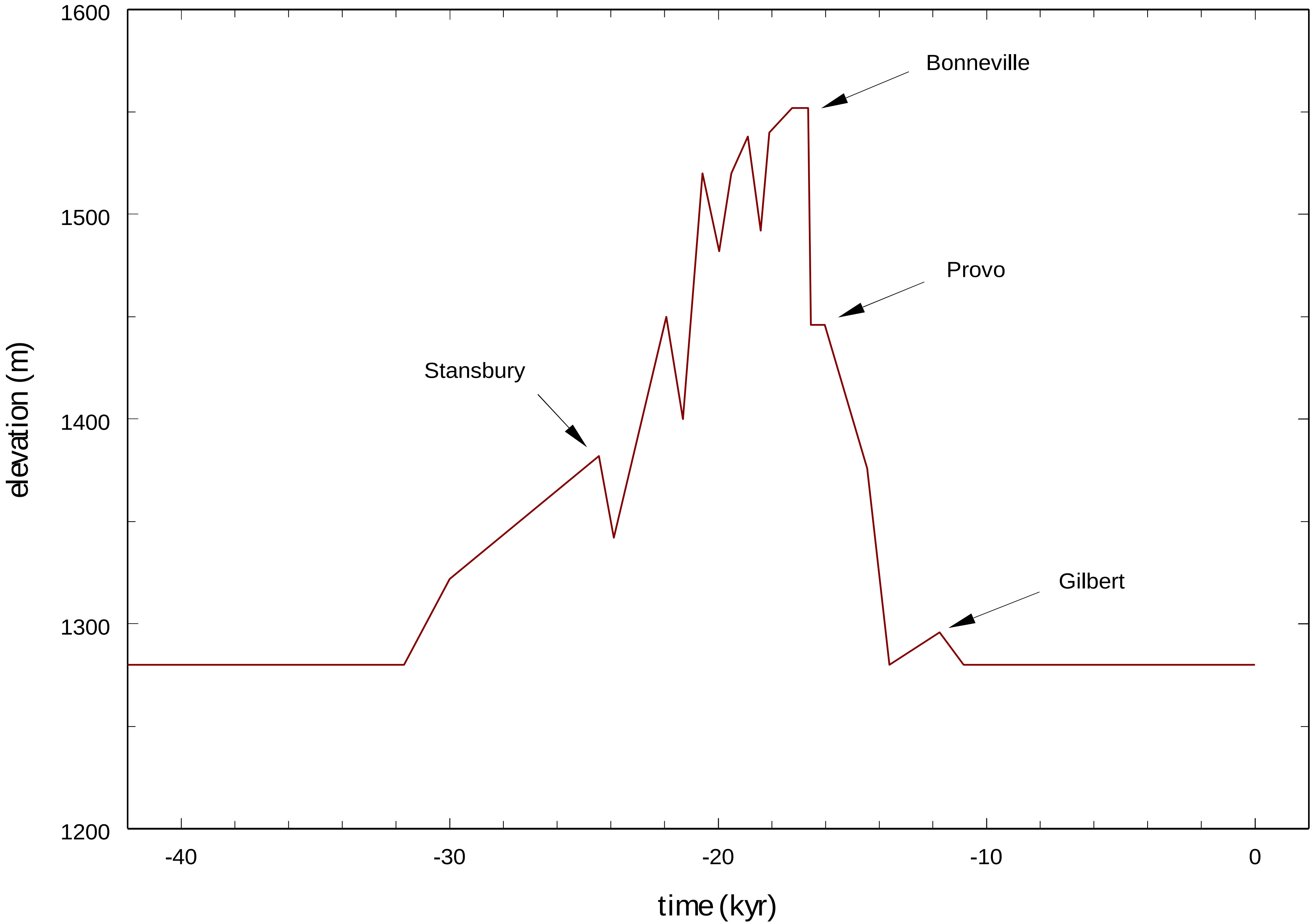
well studied

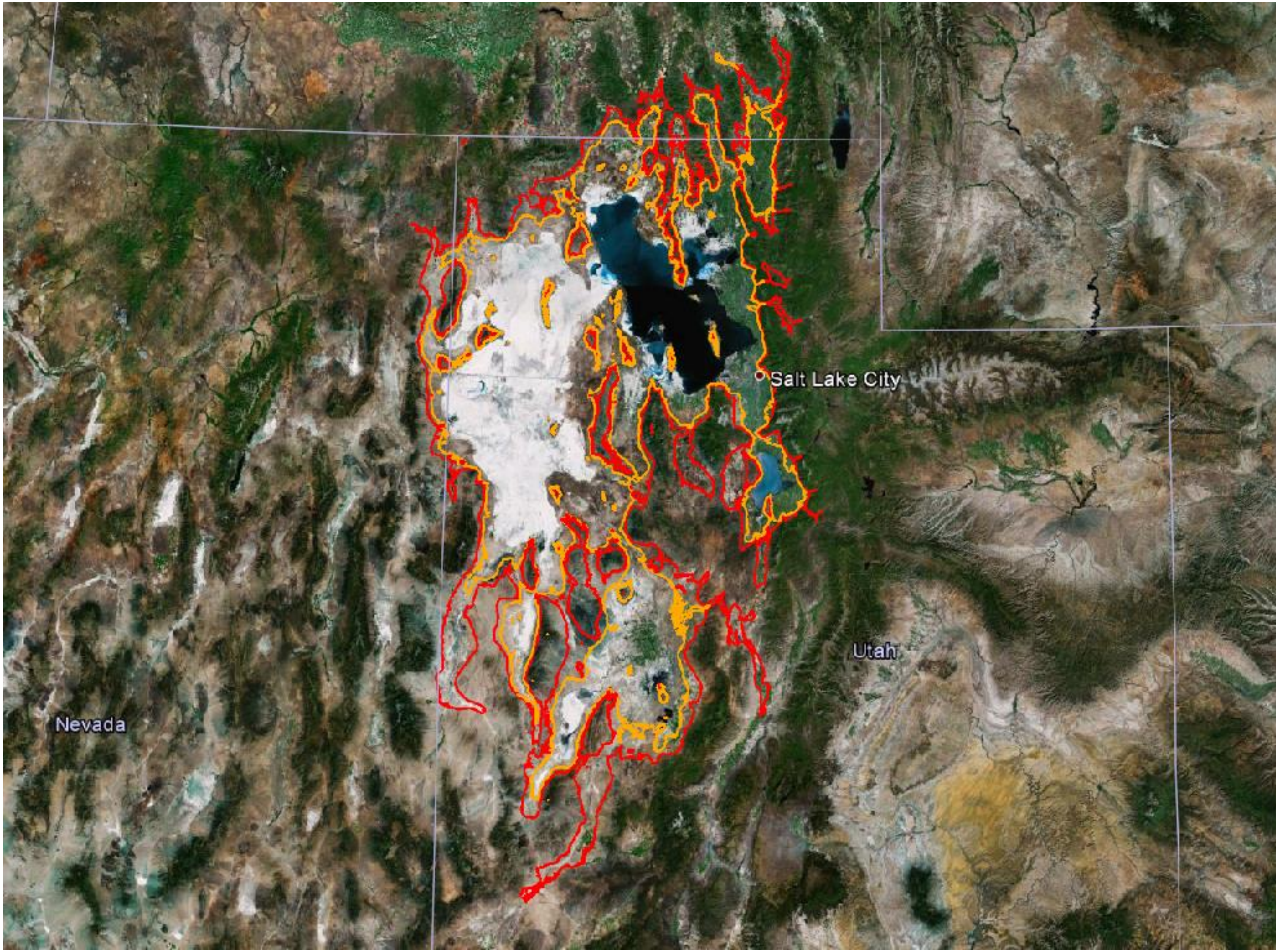
100's of radio-carbon dates
100's of surveyed shoreline elevations

Drainage area
Pleistocene lakes
Present day lakes
Interbasin divides
Drainage
Harney Lake
Malheur Lake
OREGON
Summer Lake
Albert Lake
Alvord Lake
Goose Lake
IDAHO
Lake Bonneville
Bear Lake
WASATCH RANGE
Lake Lahontan
Great Salt Lake
Honey Lake
NEVADA
Pyramid Lake
Utah Lake
Lake Tahoe
Carson Lake
Walker Lake
UTAH
SIERRA NEVADA
Mono Lake
Lake Russell
Lake Manly
CALIFORNIA
ARIZONA
Lake Searles
Lake Mojave
Lake Manix
0
100 MILES
0
100 KILOMETERS
42°
40°
38°
36°
120°
118°
116°
114°
112°

Bonneville Elevation History

Oviatt, Geology, 25, 155-158, 1997.




Salt Lake City
Utah
Nevada

Lake Bonneville shorelines on Antelope Island

Lake Bonneville shorelines: Stansbury island

data and models for Bonneville and Provo shorelines

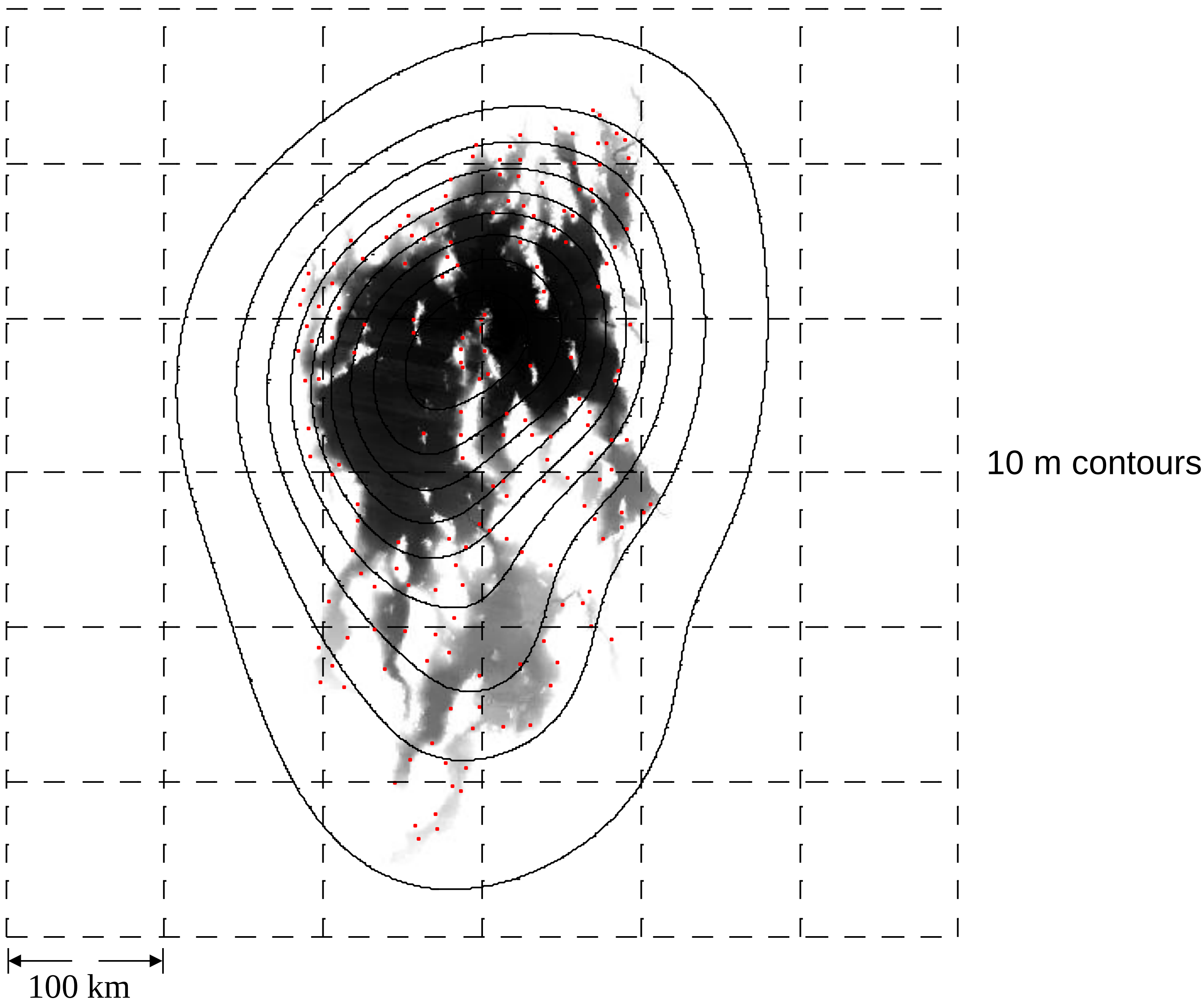
data:

Currey, D.R. (1982),
Lake Bonneville: Selected features of relevance
to neotectonic analysis,
U.S. Geol. Surv. Open File Rep., 82-1070, 31 pp.

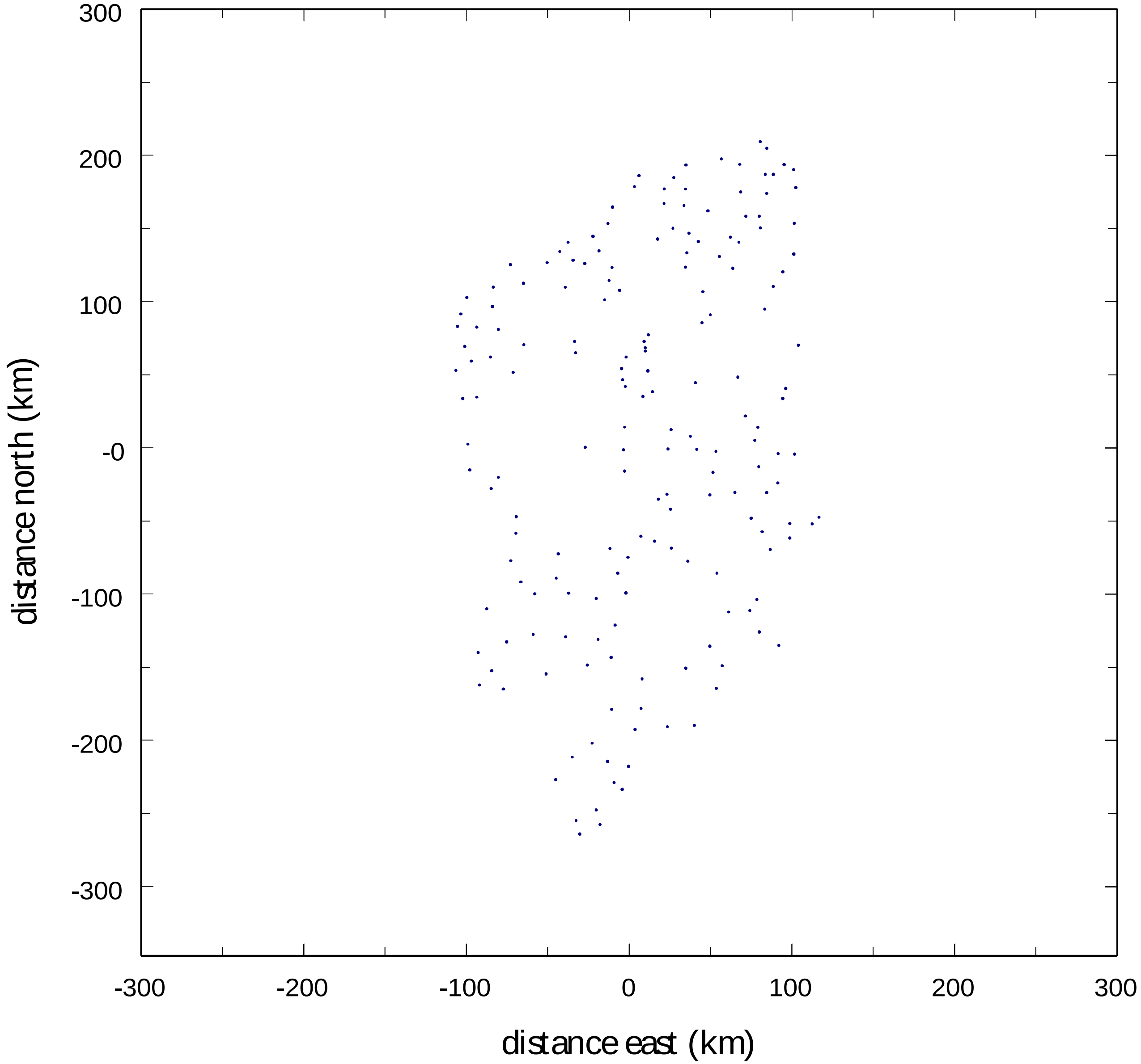
models:

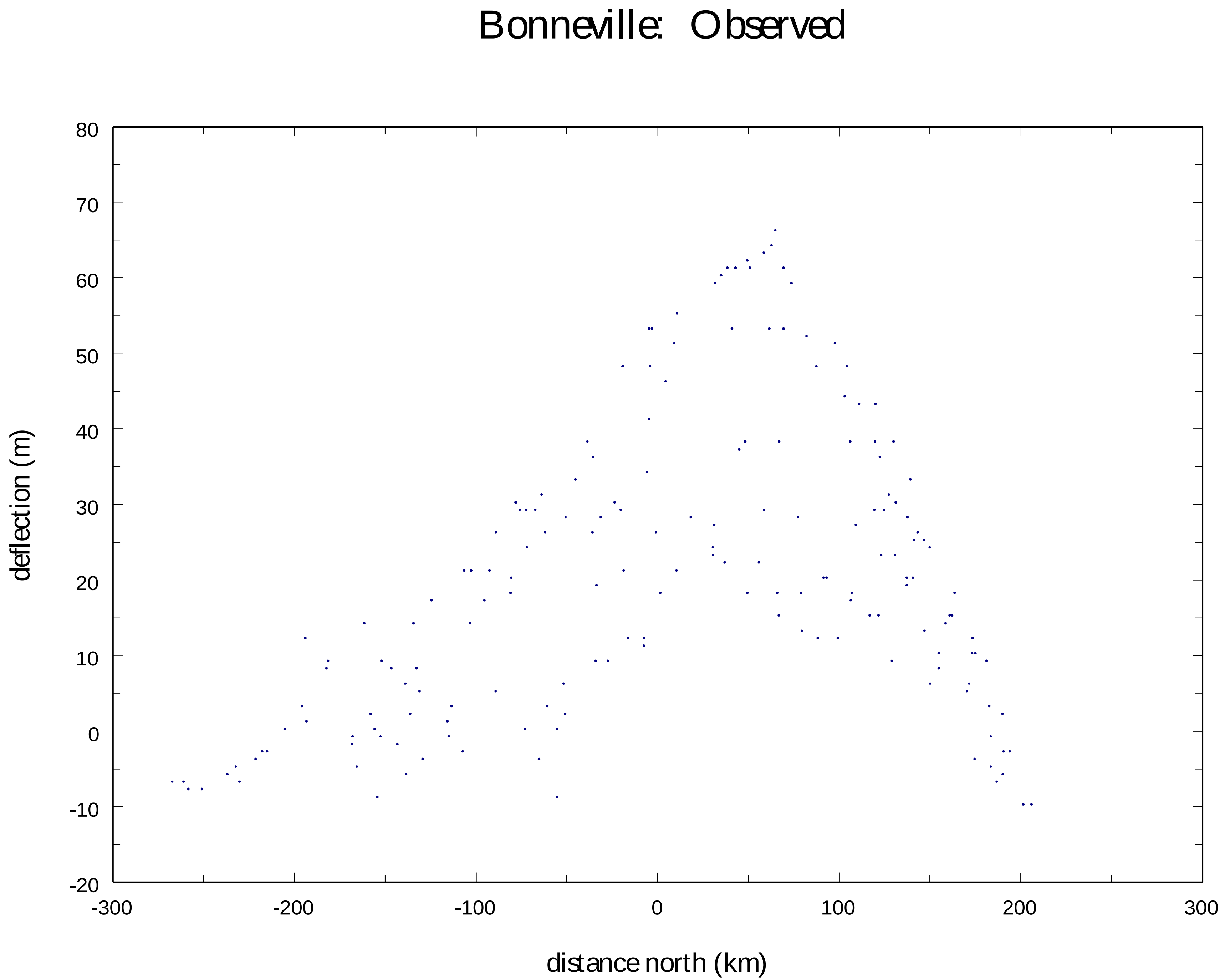
Bills, B.G., D.R. Currey, & G.A. Marshall (1994),
Viscosity estimates for the crust and upper mantle
from patterns of lacustrine shoreline deformation,
J. Geophys. Res., 99, 22,059-22,086.

lake Bonneville load and rebound pattern

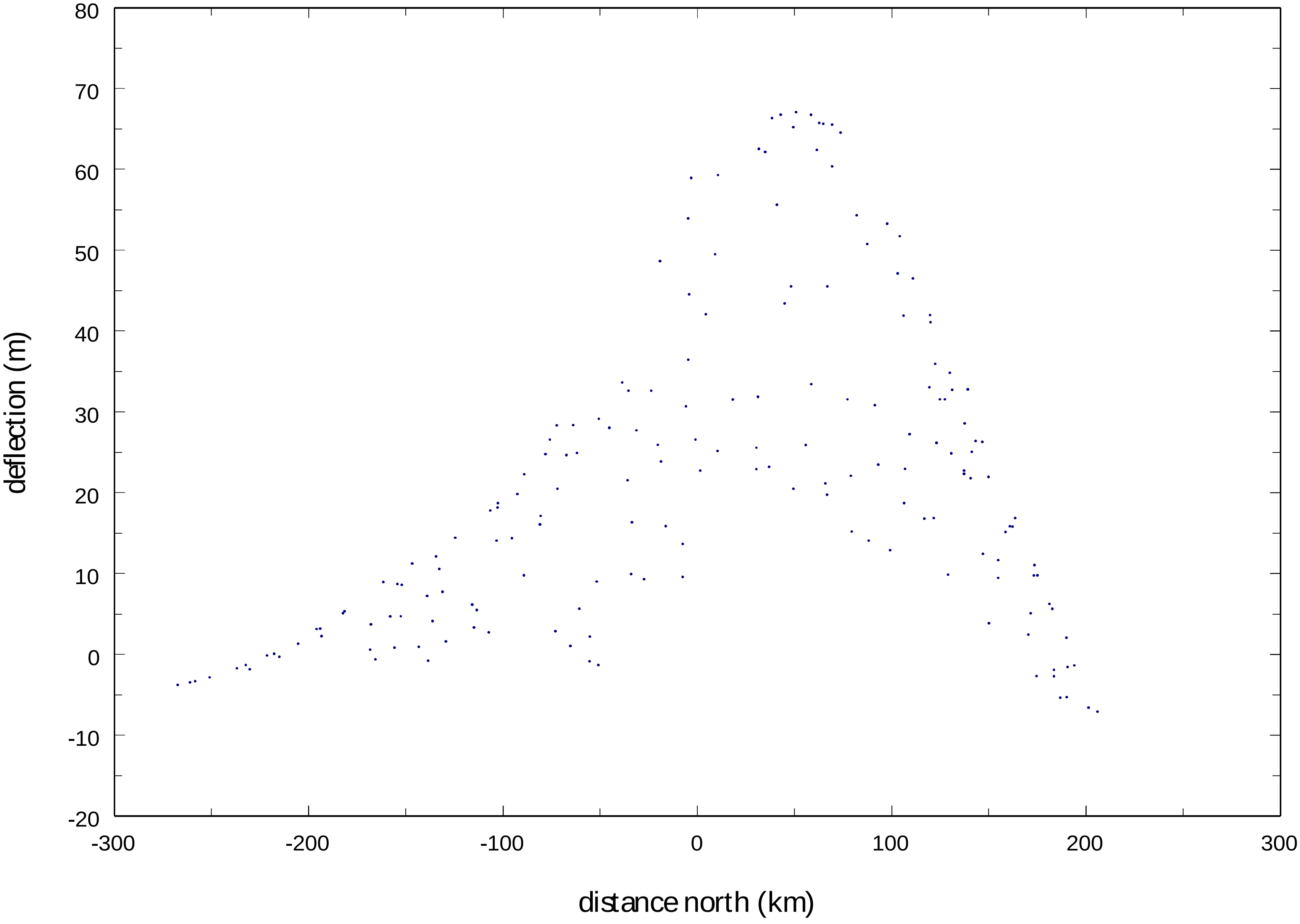


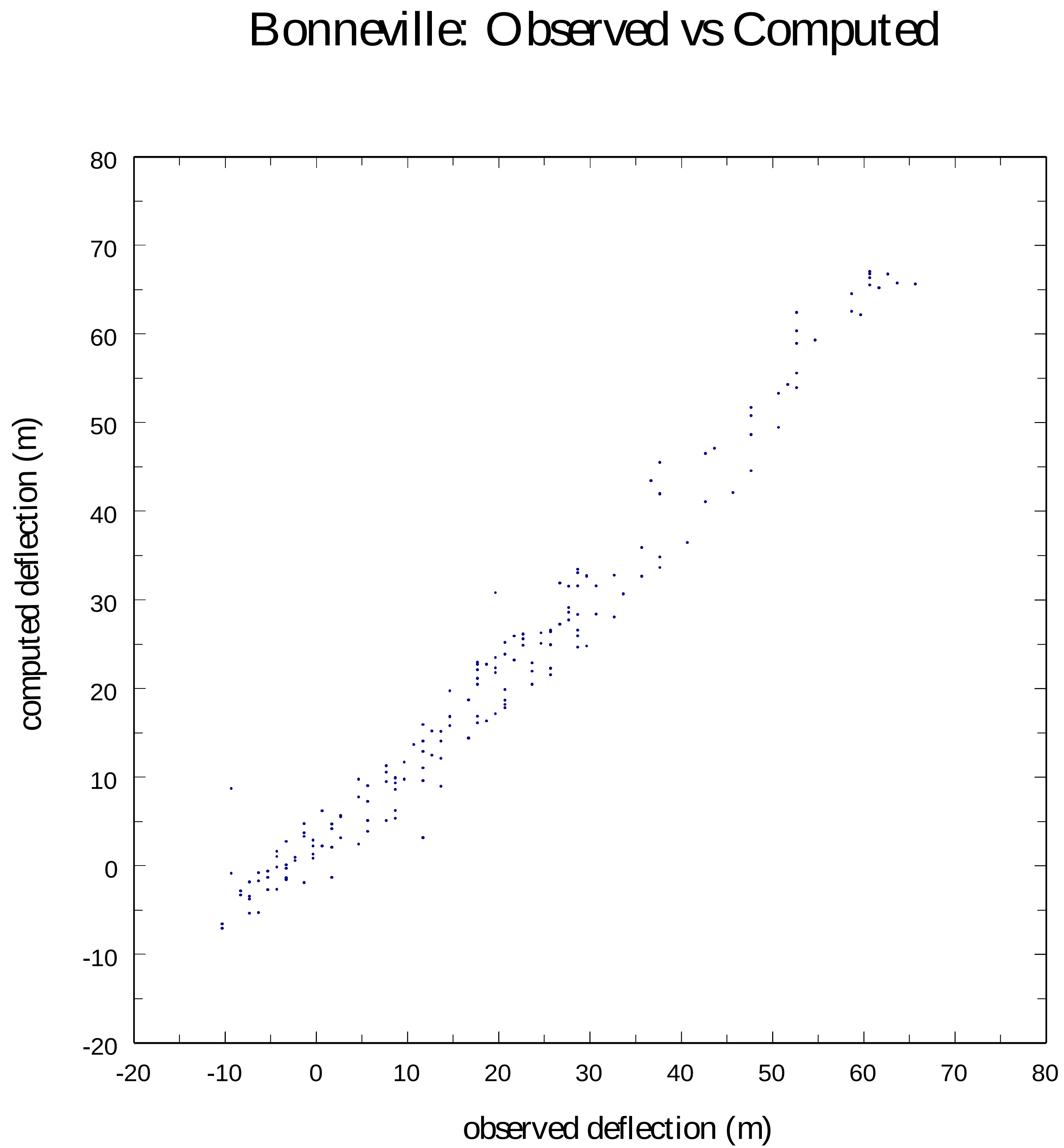
Bonneville: Observation Sites



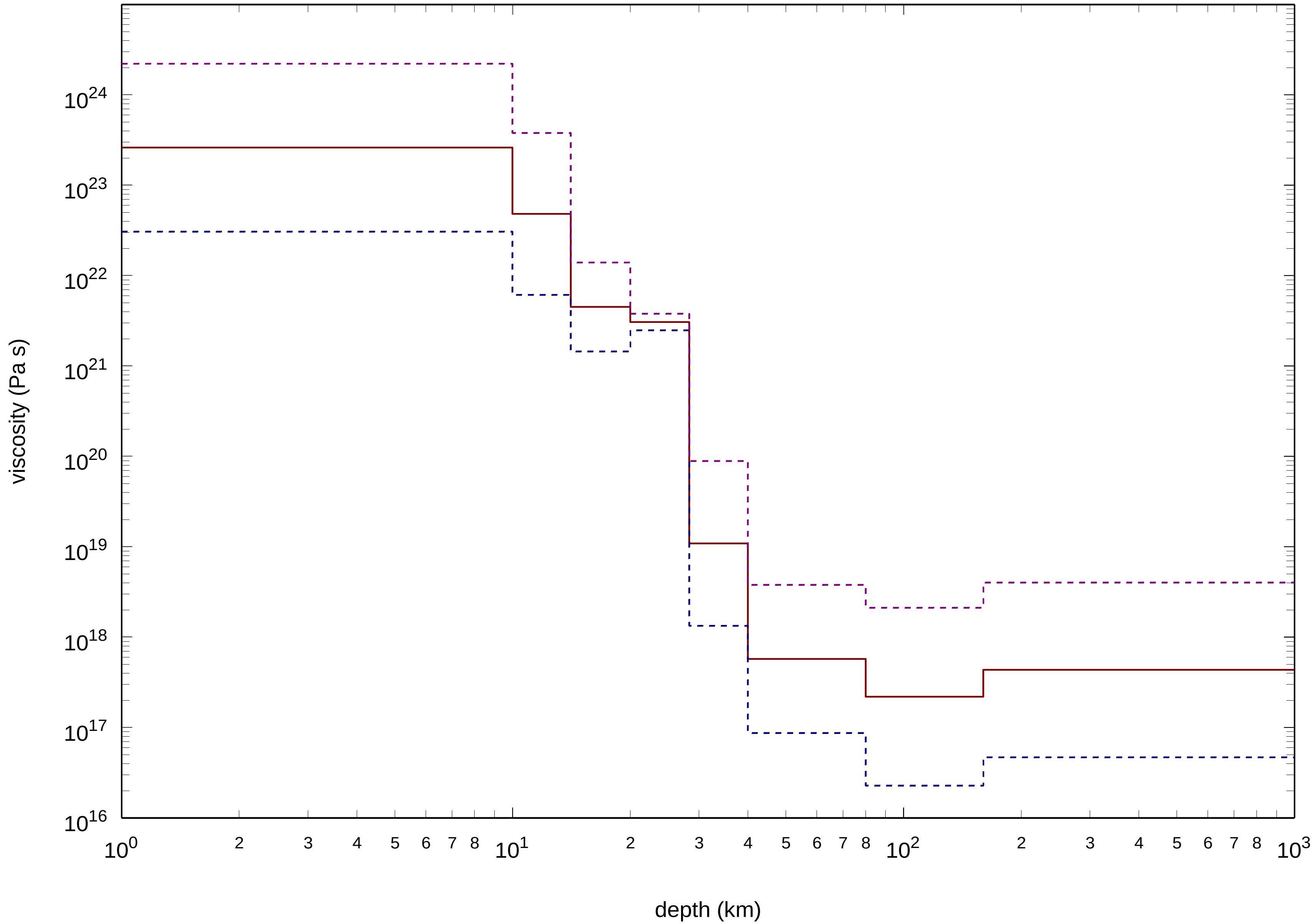

Bonneville: Observed
deflection (m)
distance north (km)
80
70
60
50
40
30
20
10
0
-10
-20
-300
-200
-100
0
100
200
300

Bonneville: Computed




Bonneville: Observed vs Computed
computed deflection (m)
observed deflection (m)
80
70
60
50
40
30
20
10
0
-10
-20
-20
-10
0
10
20
30
40
50
60
70
80

Bonneville Earth Model



what role for Gazing Imaging?

Bonneville basin needs much more topographic data

current sampling

averages 1 survey point every 20 km along shoreline

only has samples on 2 prominent shorelines

elevation accuracy ± 2 m

future sampling

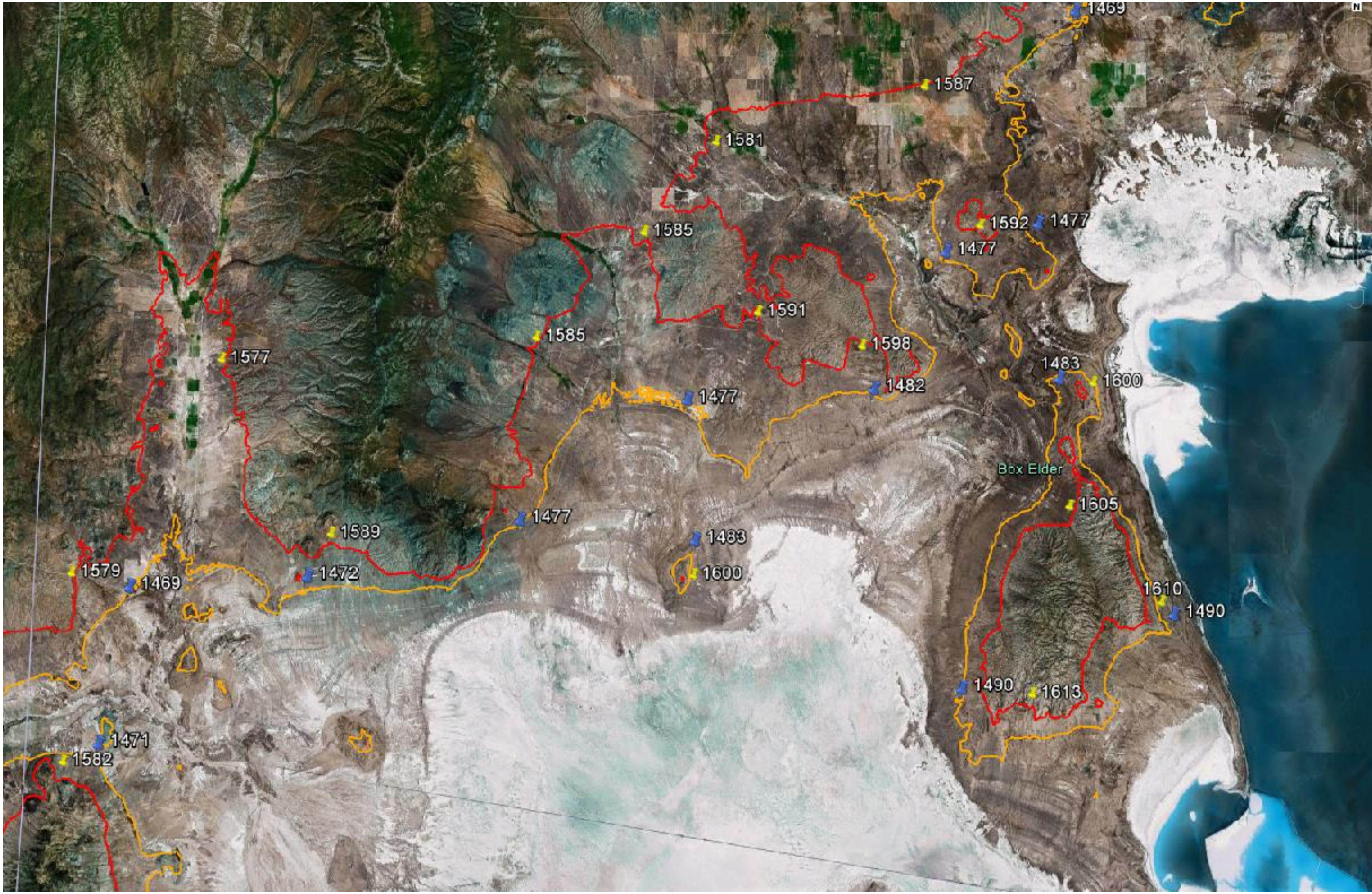
1 point per km, or better

dozens of intermediate shorelines

other lake basins,

(Nevada, Bolivia, Mongolia, ….)

some in quite remote locations


1469
1587
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1483
1600
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Box Elder
1605
1477
1589
1483
1579
1469
1472
1600
1610
1490
1490
1613
1471
1582

what role for Staring Images?

other characteristics of shorelines

shoreline ridges often have larger grain-sizes
than the surrounding area

this leads to contrast in
- thermal inertia
- BRDF

this could help to map shorelines, basin wide

what role for Staring Images?

The most conspicuous shorelines, as seen in LandSat data,
in Utah and Nevada, are those at the north end of
Spring Valley.

In satellite images, there are pronounced light and dark ridges.

Topographically, they are very subtle, with only ~1 m of relief.

The dark features are gravel, with little vegetation.
The light features are sand, with some grass.

Staring Images would likely see very significant differences
in these features, and could aid in mapping them.

shorelines at north end of Spring Valley, Nevada

10 km