

Hydrogeology of the San Agustin Plains, NM

A comprehensive geologic, geochemical and geophysical approach to understanding the hydrology of an enigmatic extensional basin

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22 September 2019
GSA Annual Meeting
Phoenix, AZ

We want to thank

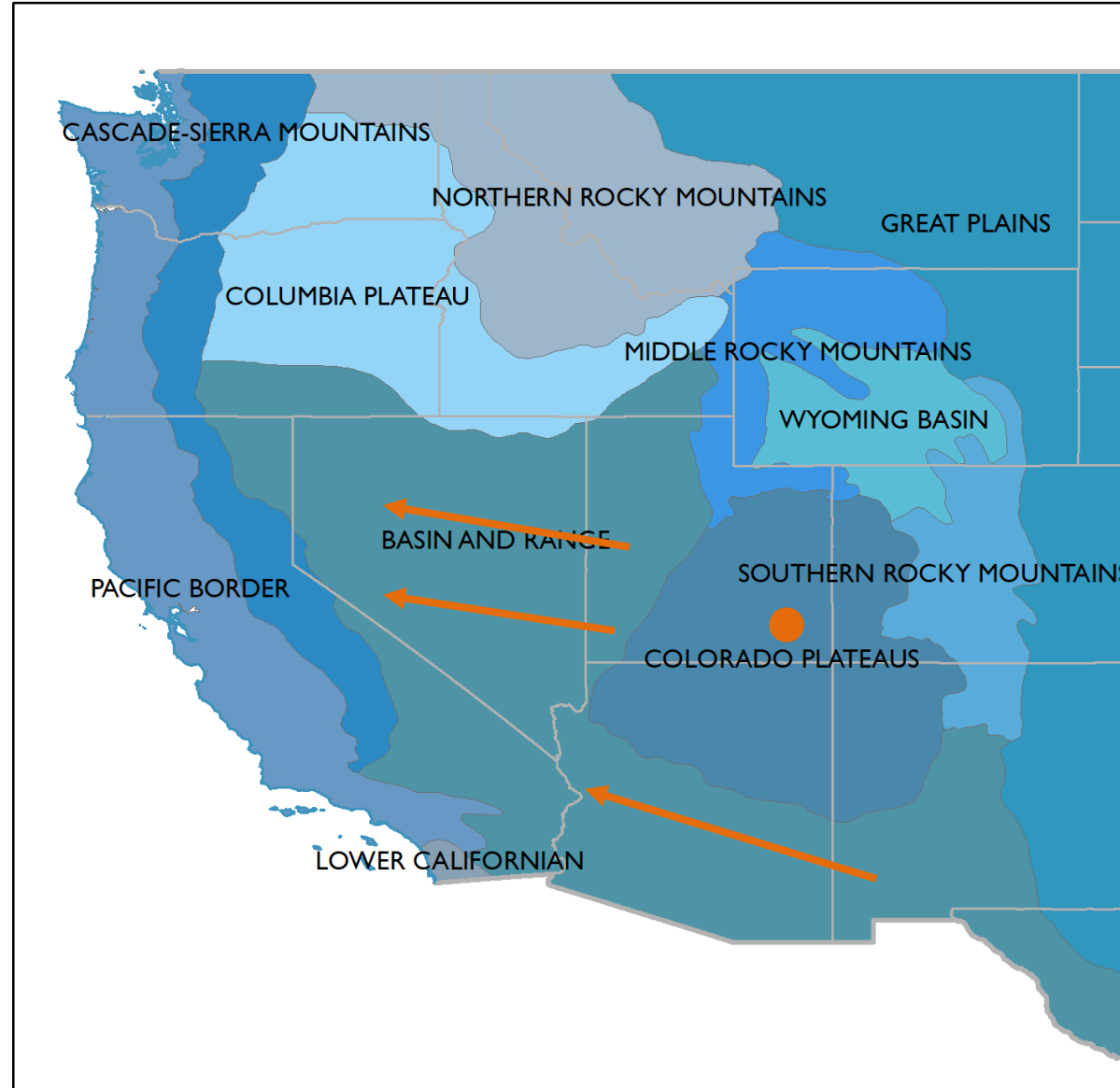
Local land owners and community members for access to wells and springs, and Eileen Dodds, Roy Farr and Carol Coker for paying for some recent analyses.

John Shomaker and Associates with permission from Agustin Plains Ranch LLC for access to well records and logs, and cuttings from pilot wells.

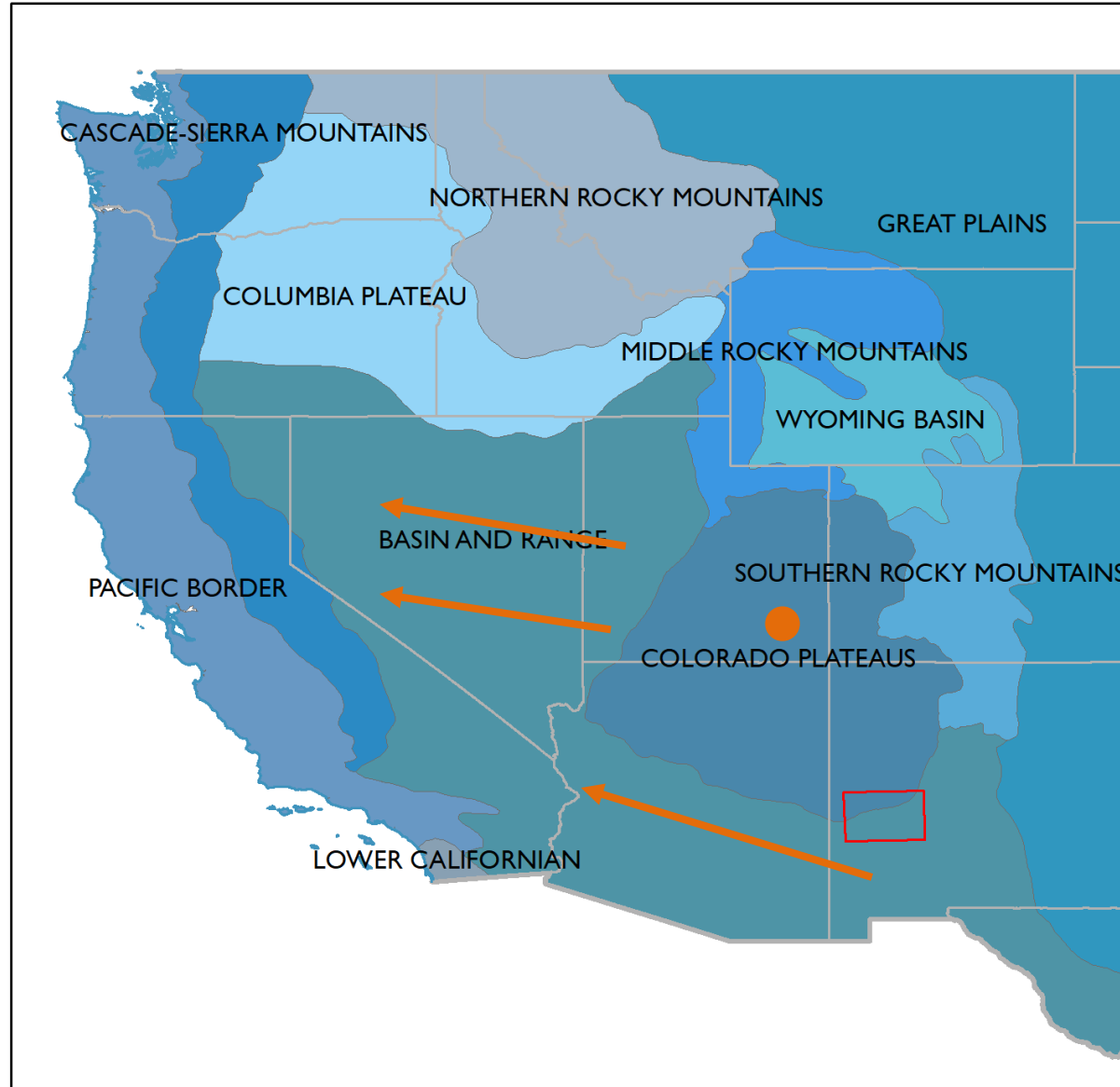
Fred Phillips, David Parkhurst, Trevor Kludt, Scott Christenson, Luna Brett, Brigitte Felix, Kitty Pokorny, Talon Newton and Sara Chudnoff.

Majority of funding provided through the Aquifer Mapping Program under the New Mexico Bureau of Geology state legislative budget, with some support from the Hydrology Bureau (M. Johnson) of the NMOSE.

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San Agustin Plains and Datil-Mogollon Volcanic Field in general have little previous work.

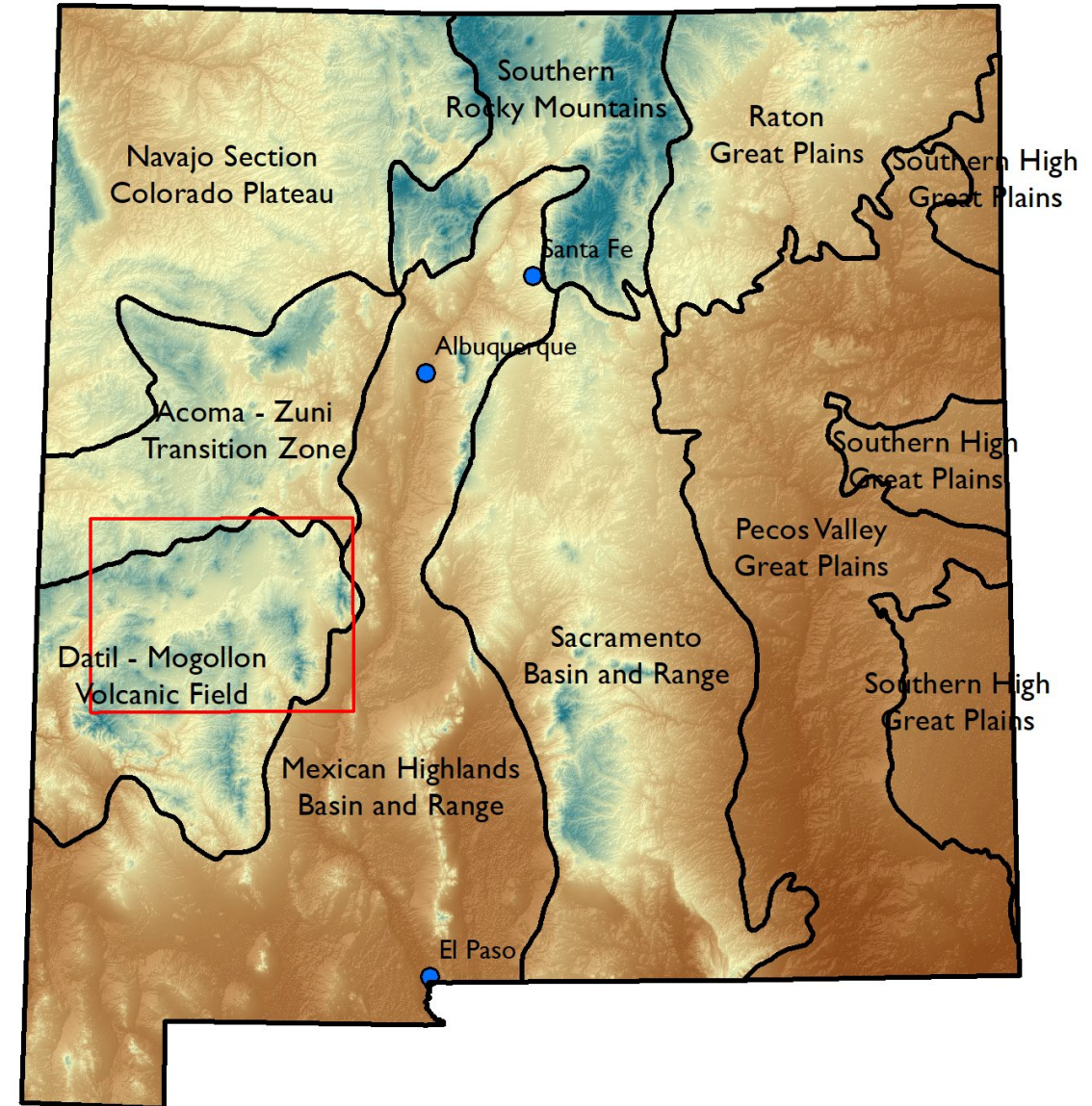
Extensional basin in transition between B&R and Colorado Plateau.

How many sub-basins are there?

What are the aquifers? The connection between the mountain blocks and basin? Between sub-basins?

How quickly is the water moving? What controls the chemistry?

What can the San Agustin Plains and neighboring open basin (Alamosa Creek) tell us about the hydrogeology in the rest of the Datil-Mogollon Volcanic Field?



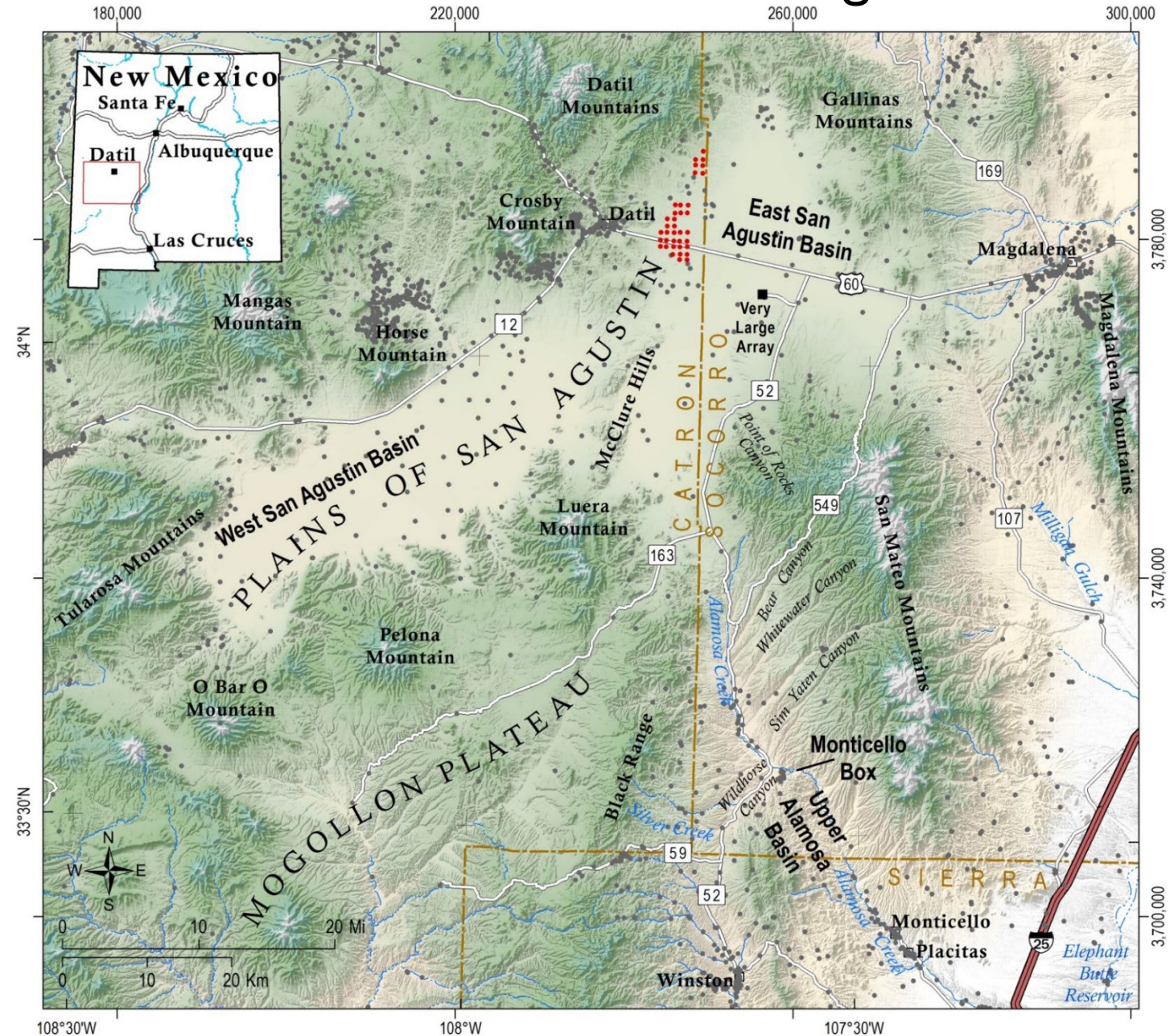
Low-relief semi-arid volcanic and volcanoclastic mountains next to high-elevation extensional basins.

In valley, 8 to 13 in of precip., 60% as rainfall.

About 15 in precip. in uplands, mostly rainfall.

Basin elevations: 6800 ft amsl (SW corner) to 7000 ft amsl (northern tip).

Most mountain peaks 8500 ft amsl to over 10,000 ft amsl.



Basin is filled by a Pleistocene fan-delta-lake complex.

Basin-fill underlain by 2k – 5k ft of volcanics (Mogollon-Datil Group, Oligocene) and volcaniclastic (Spears Group, Oligocene) rocks. Mountains made of Mogollon-Datil Group and Spears Group.

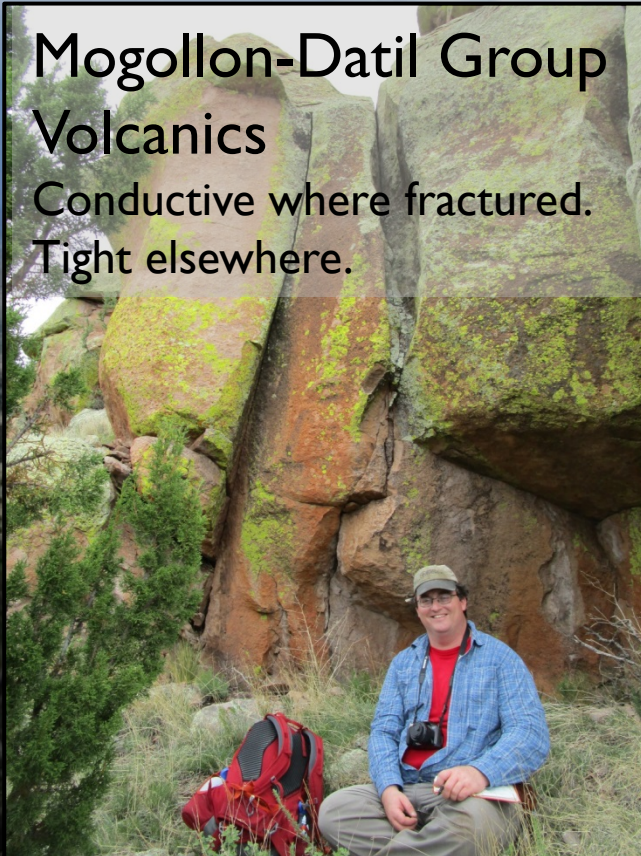


Basin is filled by a Pleistocene fan-delta-lake complex.

Basin-fill underlain by 2k – 5k ft of volcanics (Mogollon-Datil Group, Oligocene rhyolitic tuffs and basaltic andesites) and volcanoclastic (Spears Group, Oligocene) rocks. Mountains made of Datil Group and Spears Group.

Mogollon-Datil Group Volcanics

Conductive where fractured.
Tight elsewhere.



Spears Group Volcanoclastic

Mostly tight, but
some units can be
conductive.

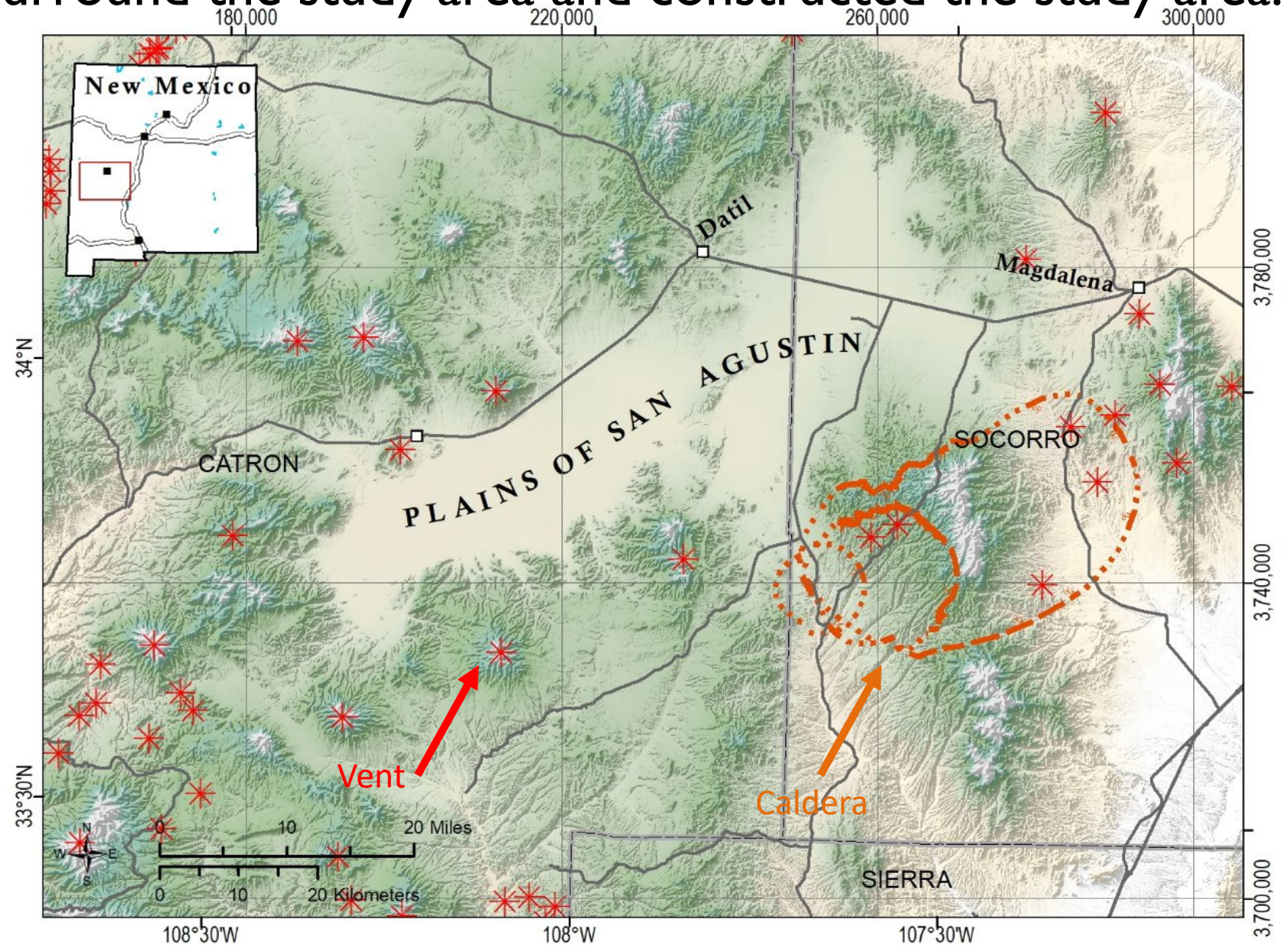


Volcanic features both surround the study area and constructed the study area.

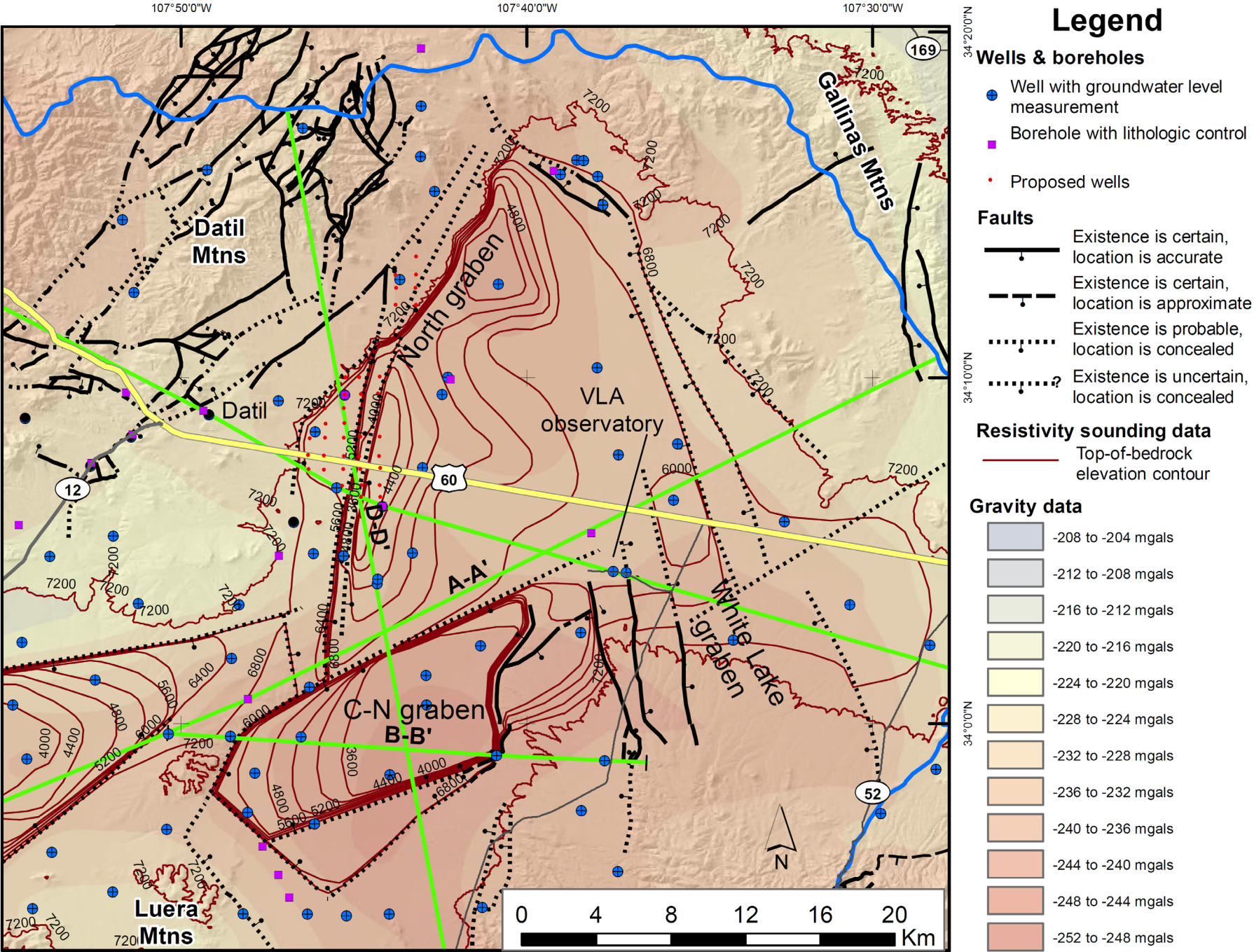
Highest mountains are formed by large Oligocene calderas.

Many small shield volcanoes and other vents scattered across the region, often at the top of current lower mountains.

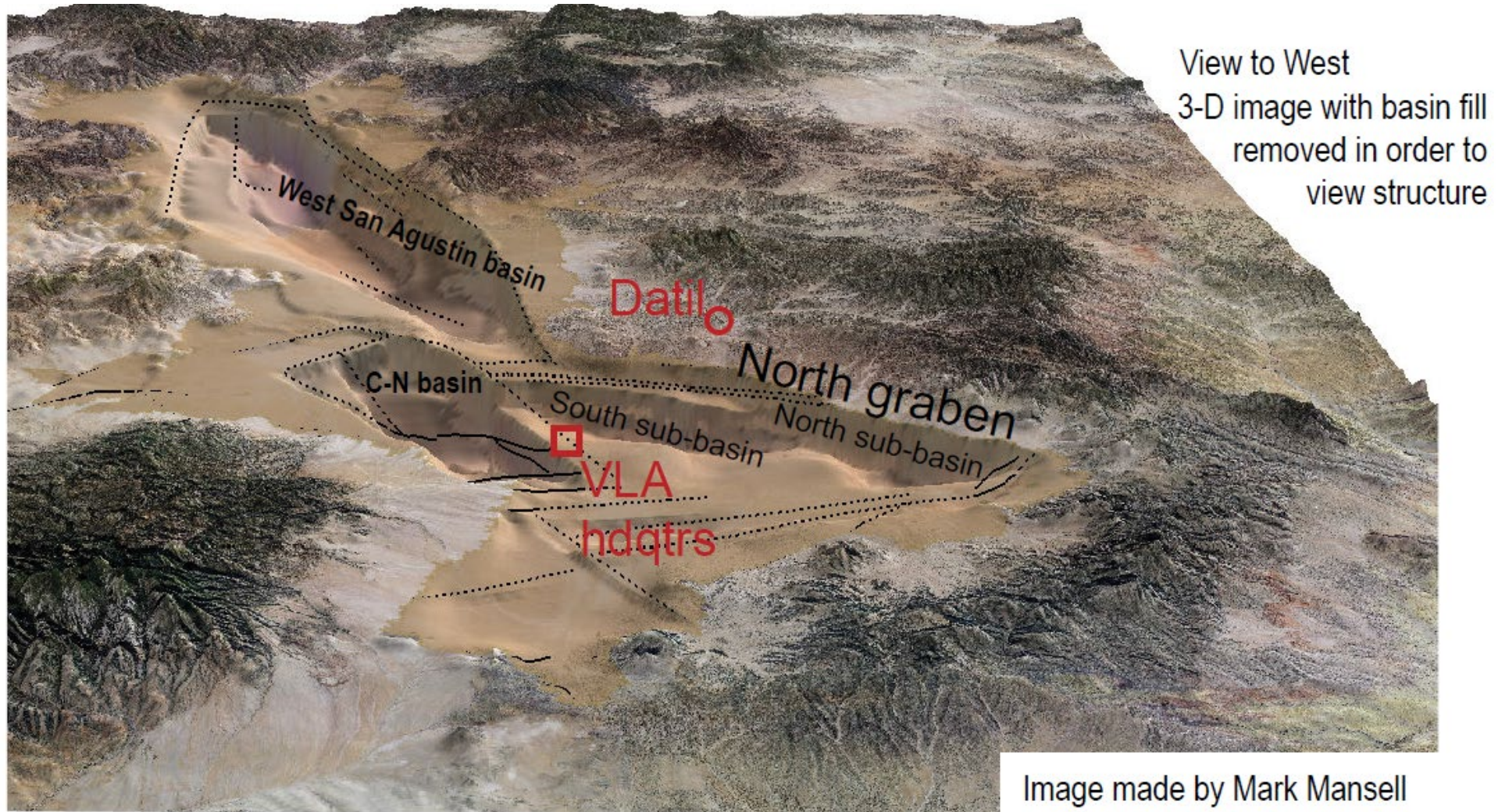
Mountain blocks are interbedded volcanics and volcaniclastics.

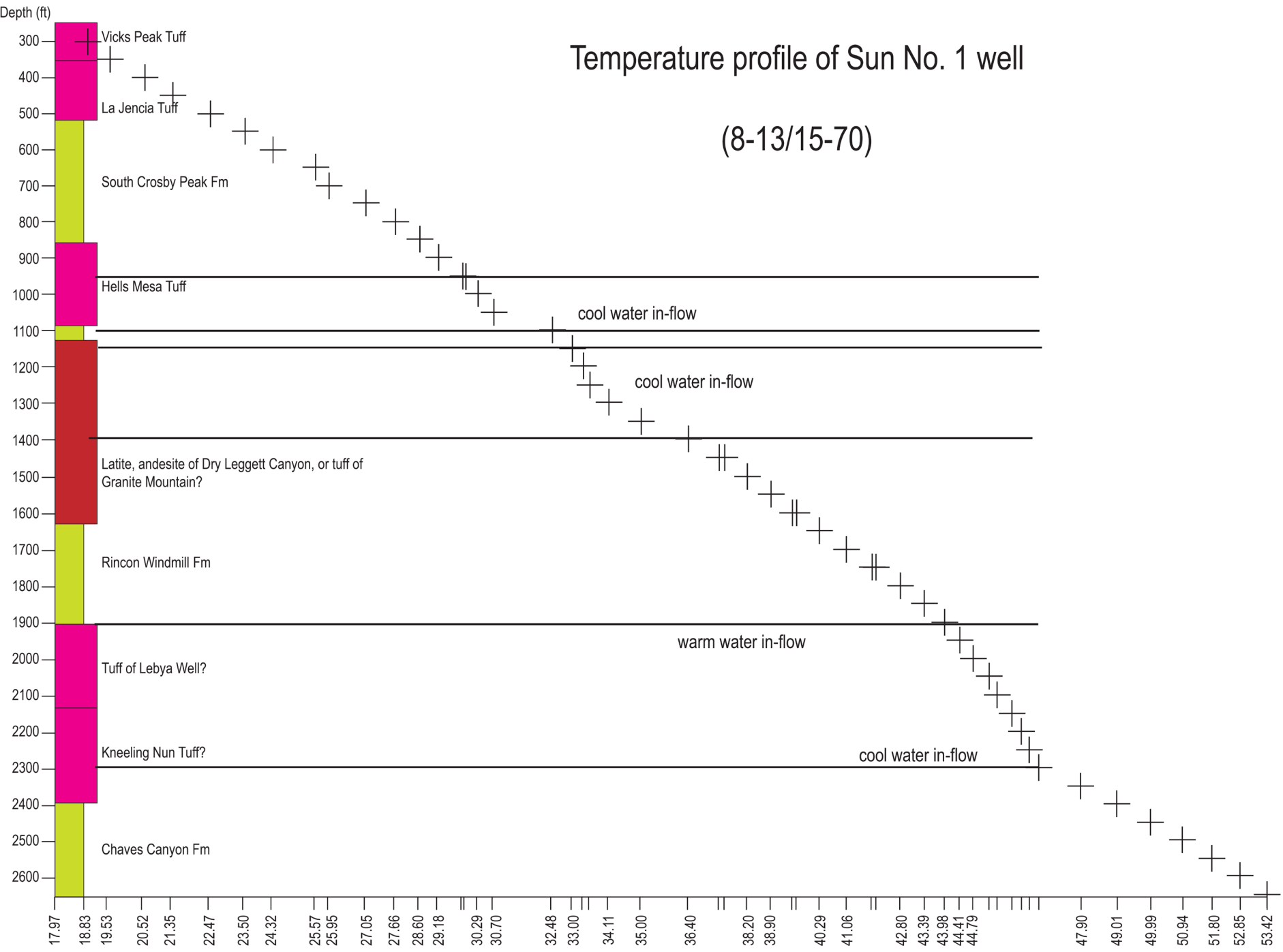


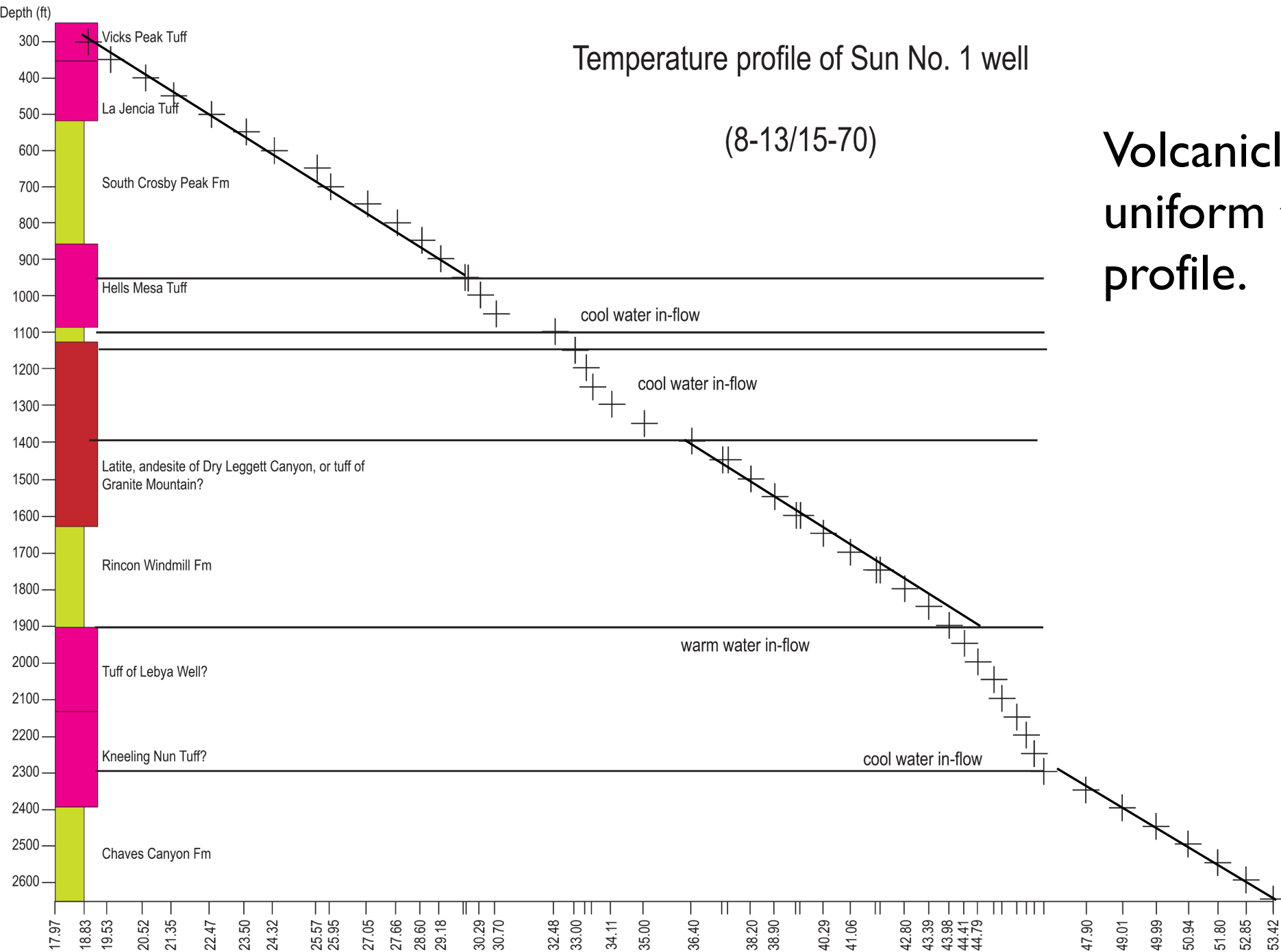
Compilation of mapping, well logs, historical electrical resistivity maps and terrain-corrected Bouguer anomaly.



Two surface basins are made of separate three grabens





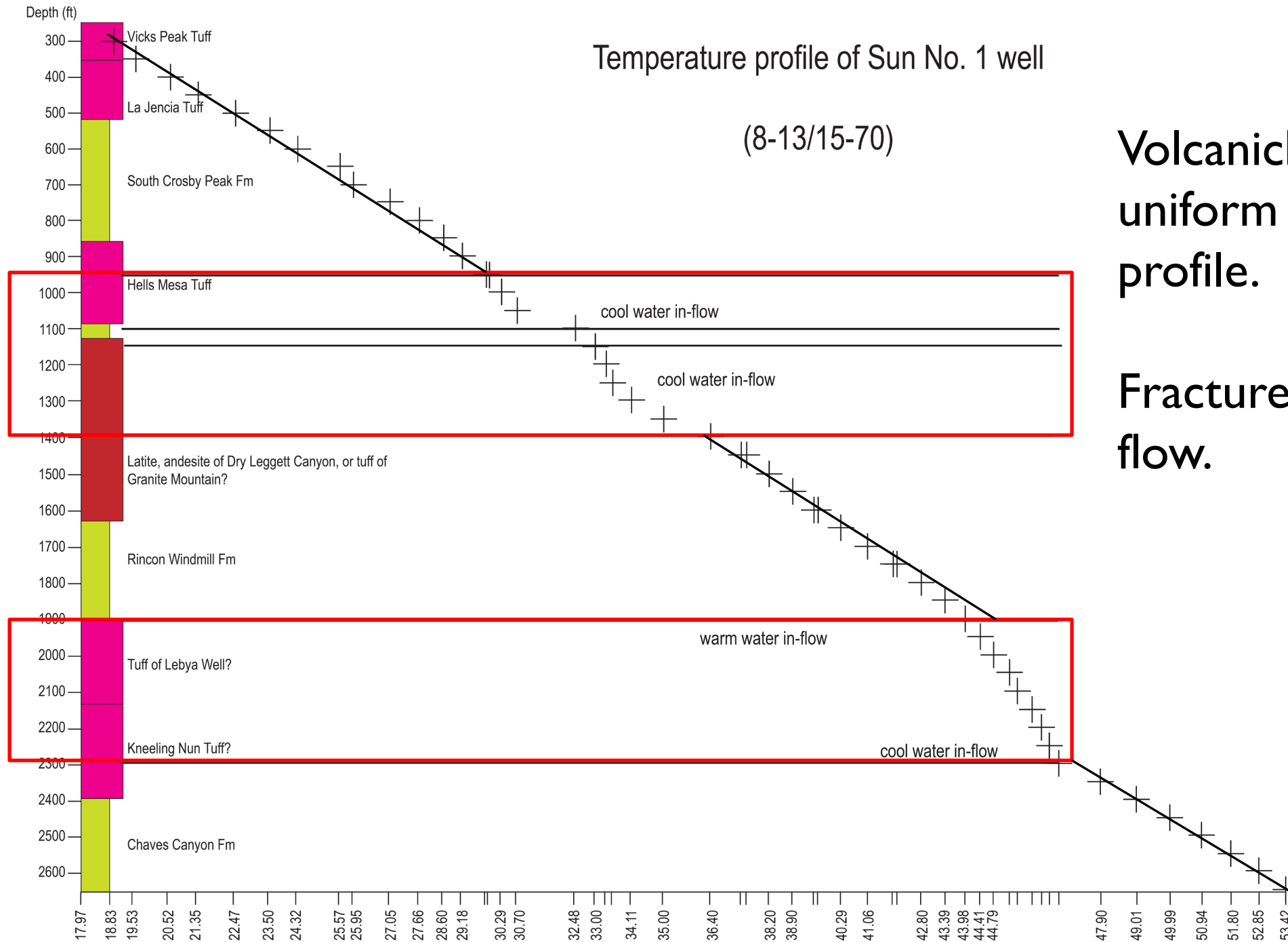


**Volcaniclastics have
uniform temperature
profile.**

Temperature profile of Sun No. 1 well (8-13/15-70)

Volcaniclastics have uniform temperature profile.

Fractured tuffs have lateral flow.



Measured water levels since 2007, mostly in basin-fill and alluvium.

Rock type at well depth

- Basin-fill
- Alluvium
- Basalts
- Rhyolite-Dacite
- Intrusive
- Volcaniclastic
- Unknown

0 5 10 15 Miles
0 5 10 15 Kilometers

W N E S

San Agustin Basin

West San Agustin Basin

East San Agustin Basin

Very Large Array

Mogollon Plateau

Tularosa Mountains

Mangas Mountain

Horse Mountain

Pelona Mountain

O Bar O Mountain

San Mateo Mountains

Magdalena Mountains

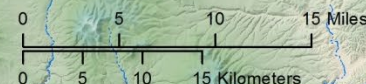
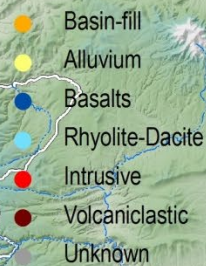
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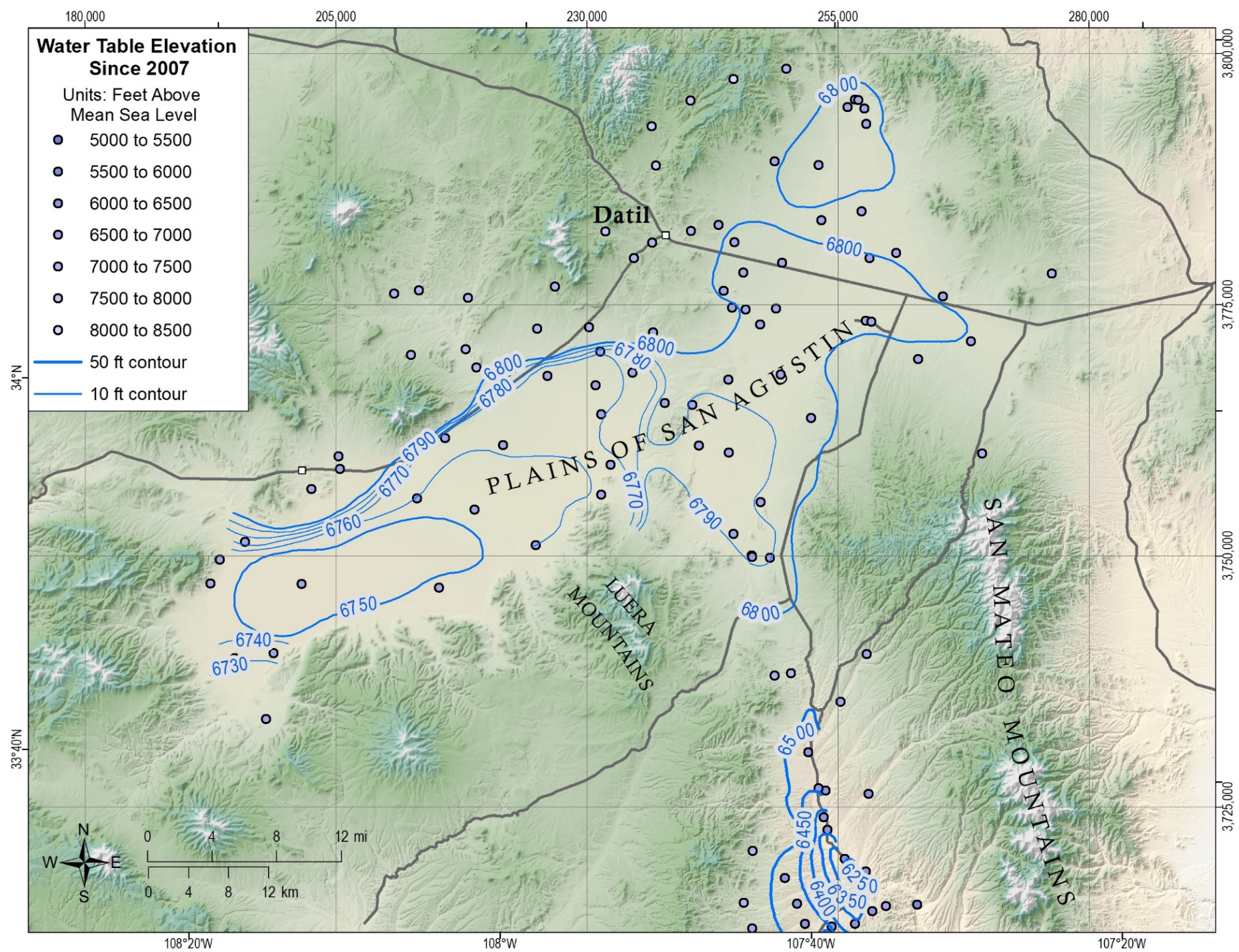
Magdalena

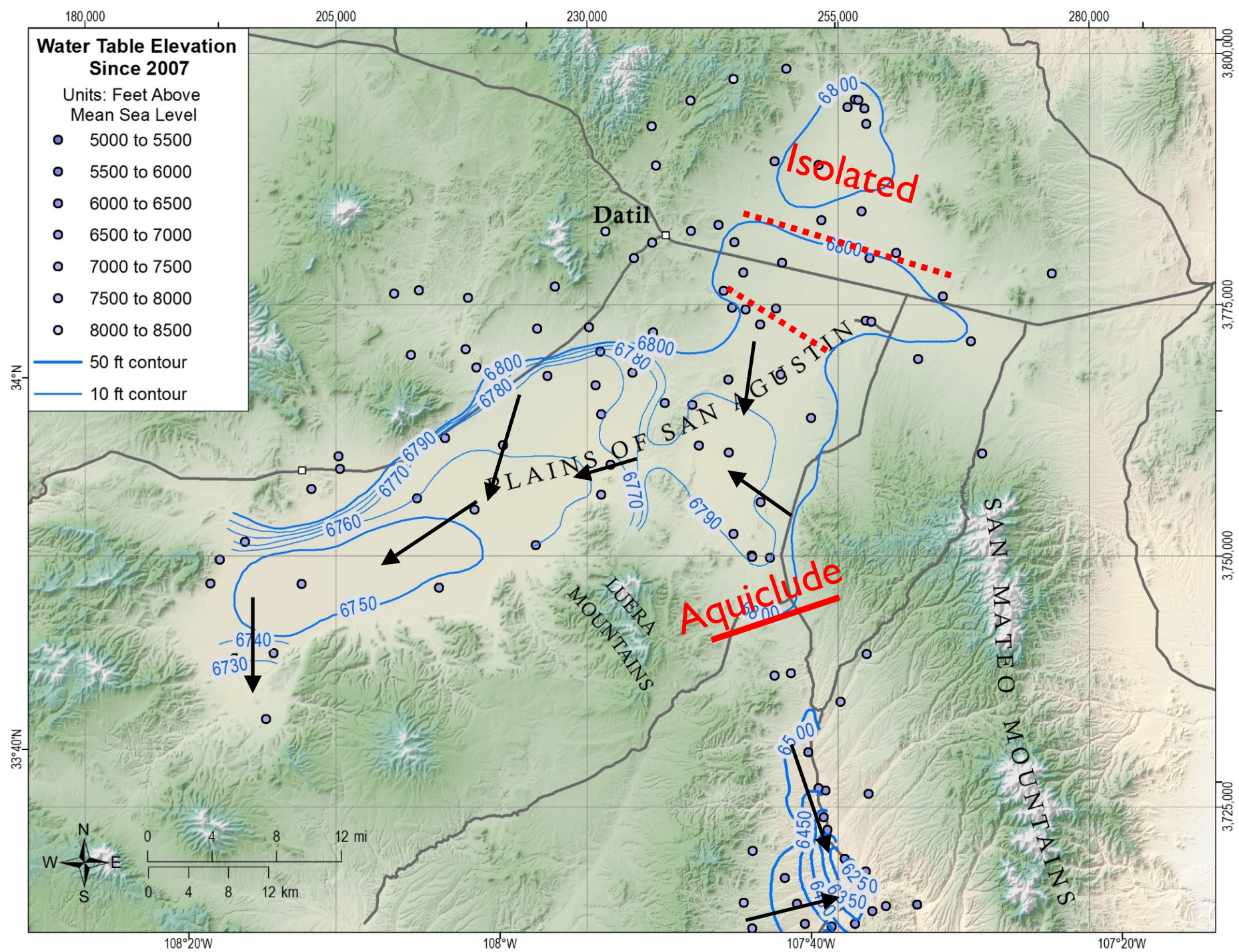
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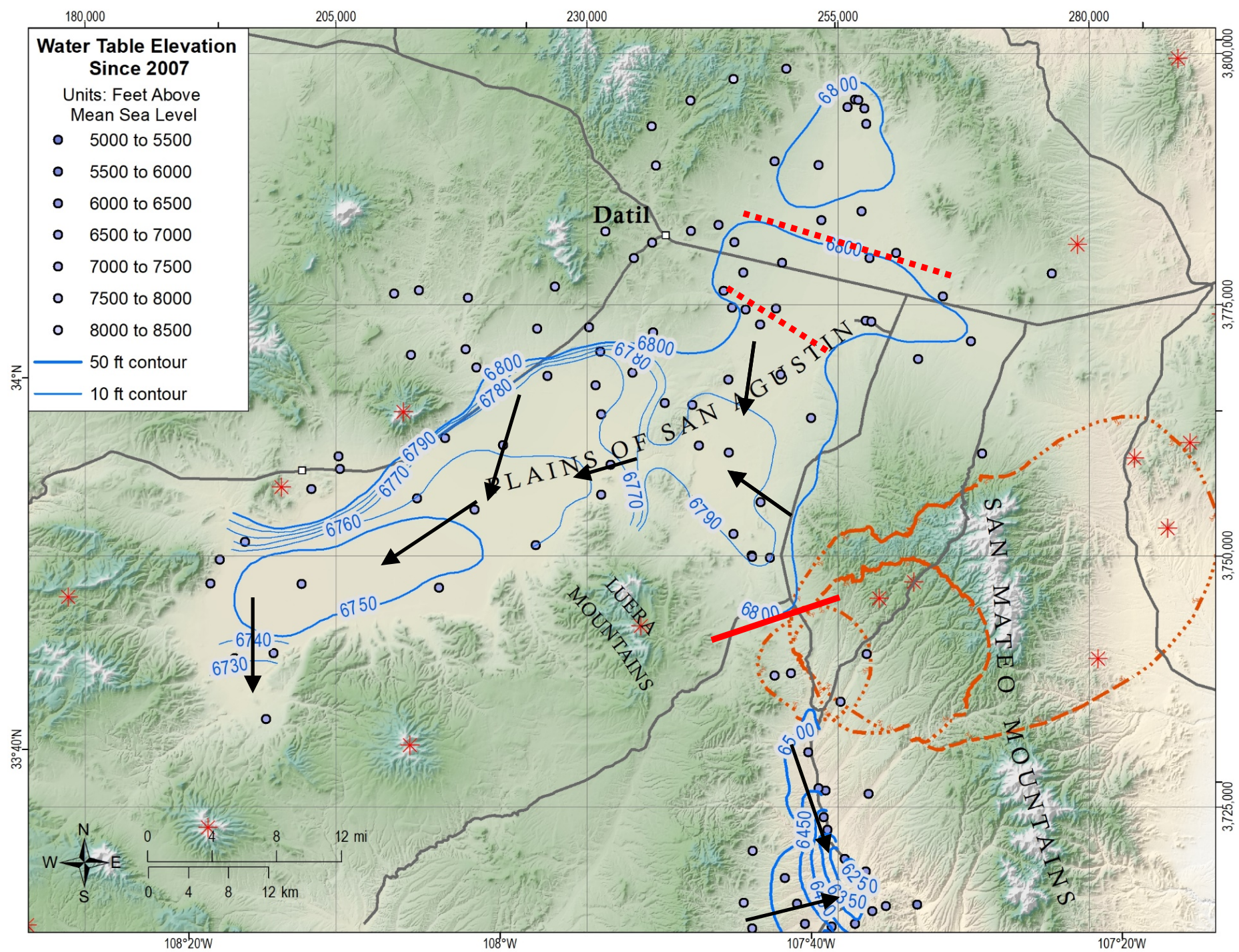
Winston

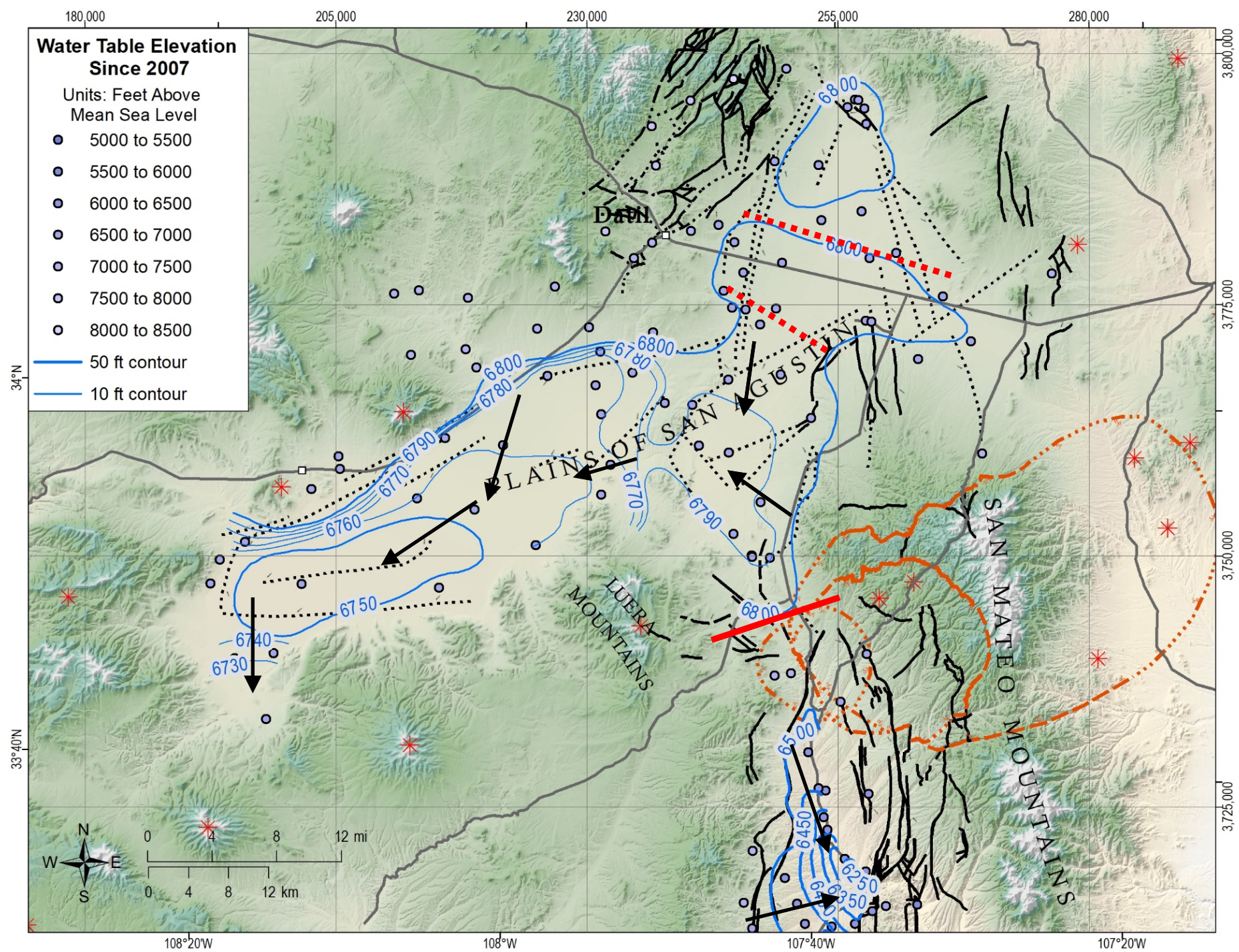
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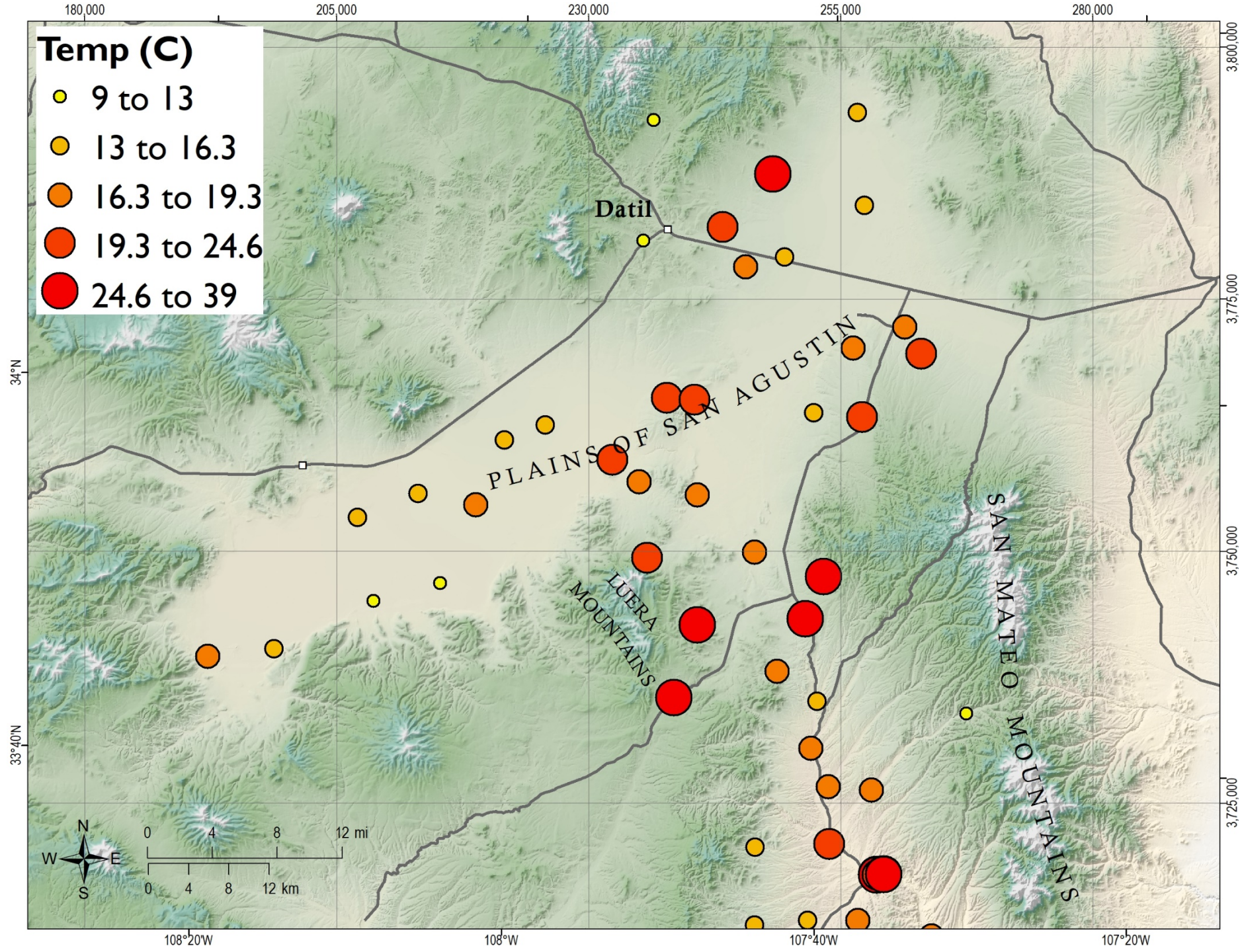
Water levels reflect the grabens, faulting + recharge/discharge.

Basin is at steady state.

Extensional structure + calderas + vents restrict flow out of San Agustin Plains
Mountain block flow is in fractured tuffs.

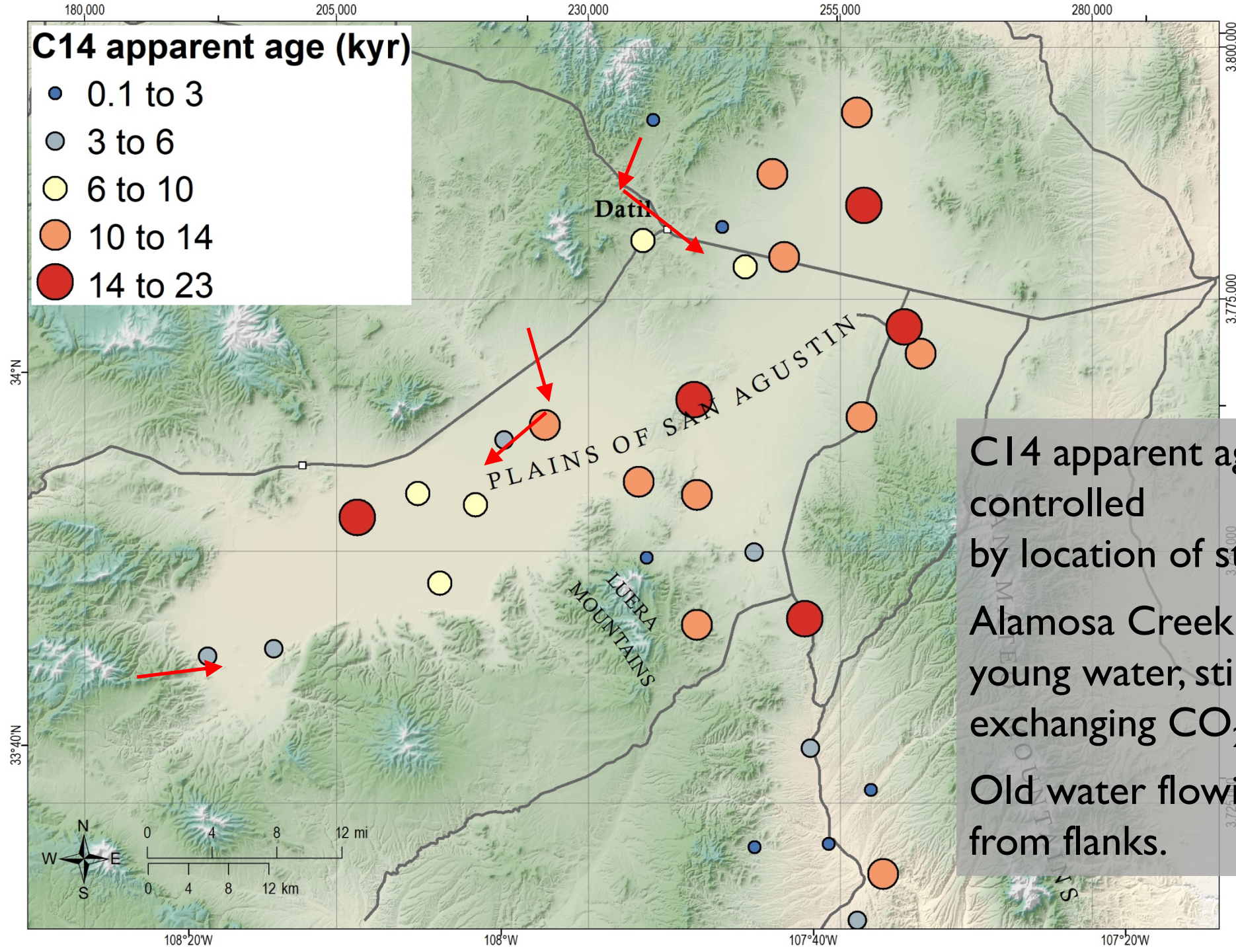
Stream valley recharge > mountain block recharge. Both significant volumes.

What will the chemistry data reveal?



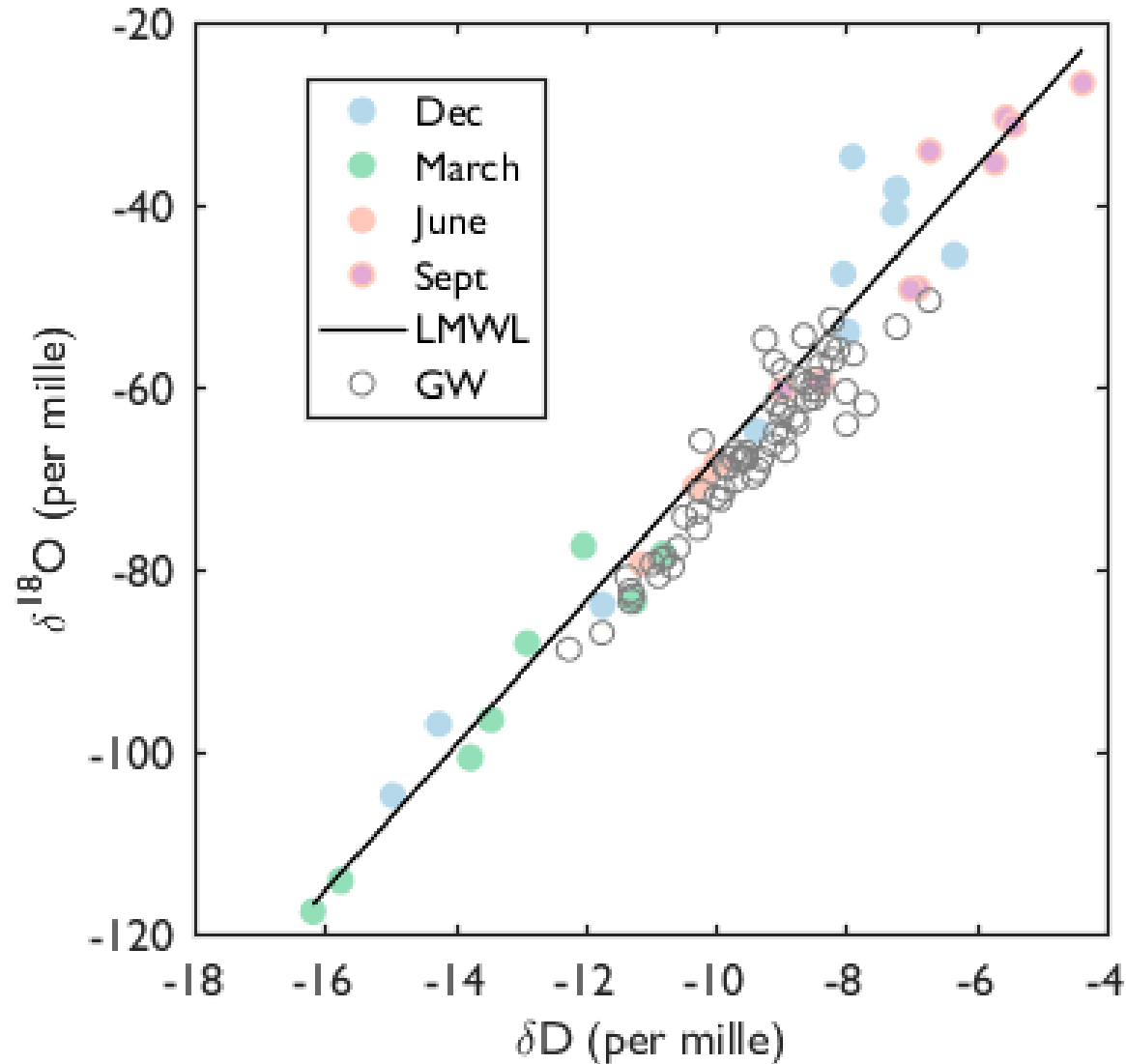
C14 apparent age (kyr)

- 0.1 to 3
- 3 to 6
- 6 to 10
- 10 to 14
- 14 to 23

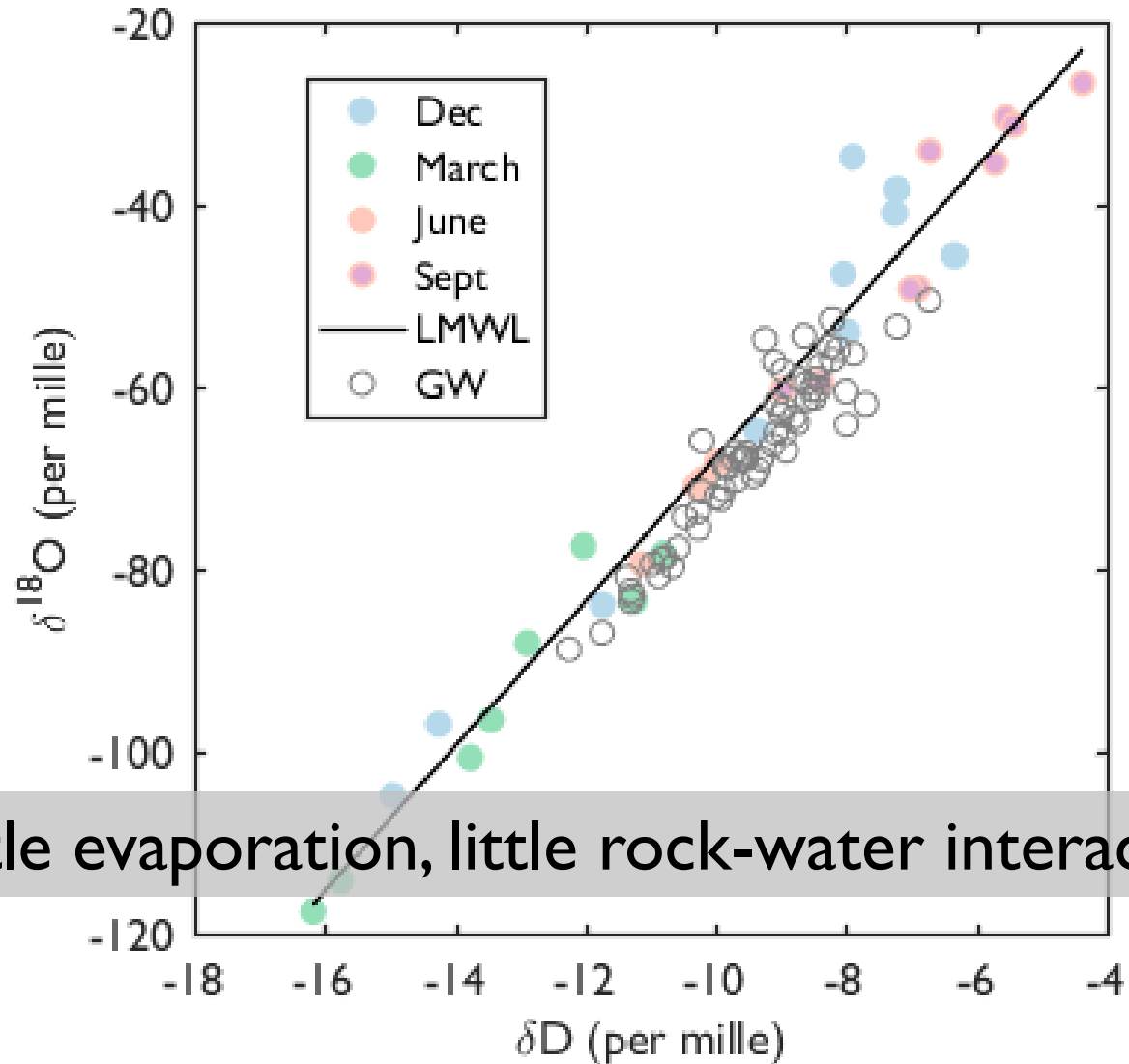


C14 apparent age
controlled
by location of streams.
Alamosa Creek has
young water, still
exchanging CO₂.
Old water flowing in
from flanks.

All groundwater isotopes are near local meteoric water line, but do not extend toward 'Ice Age' values found in San Juan Basin, northern Rio Grande ($\delta D < -90$ per mille SMOW).



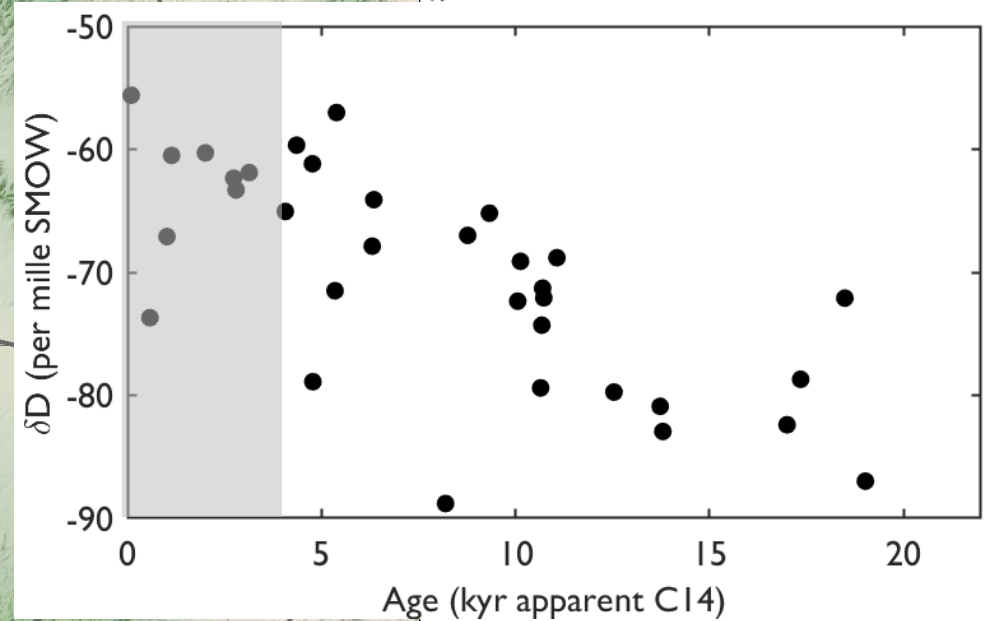
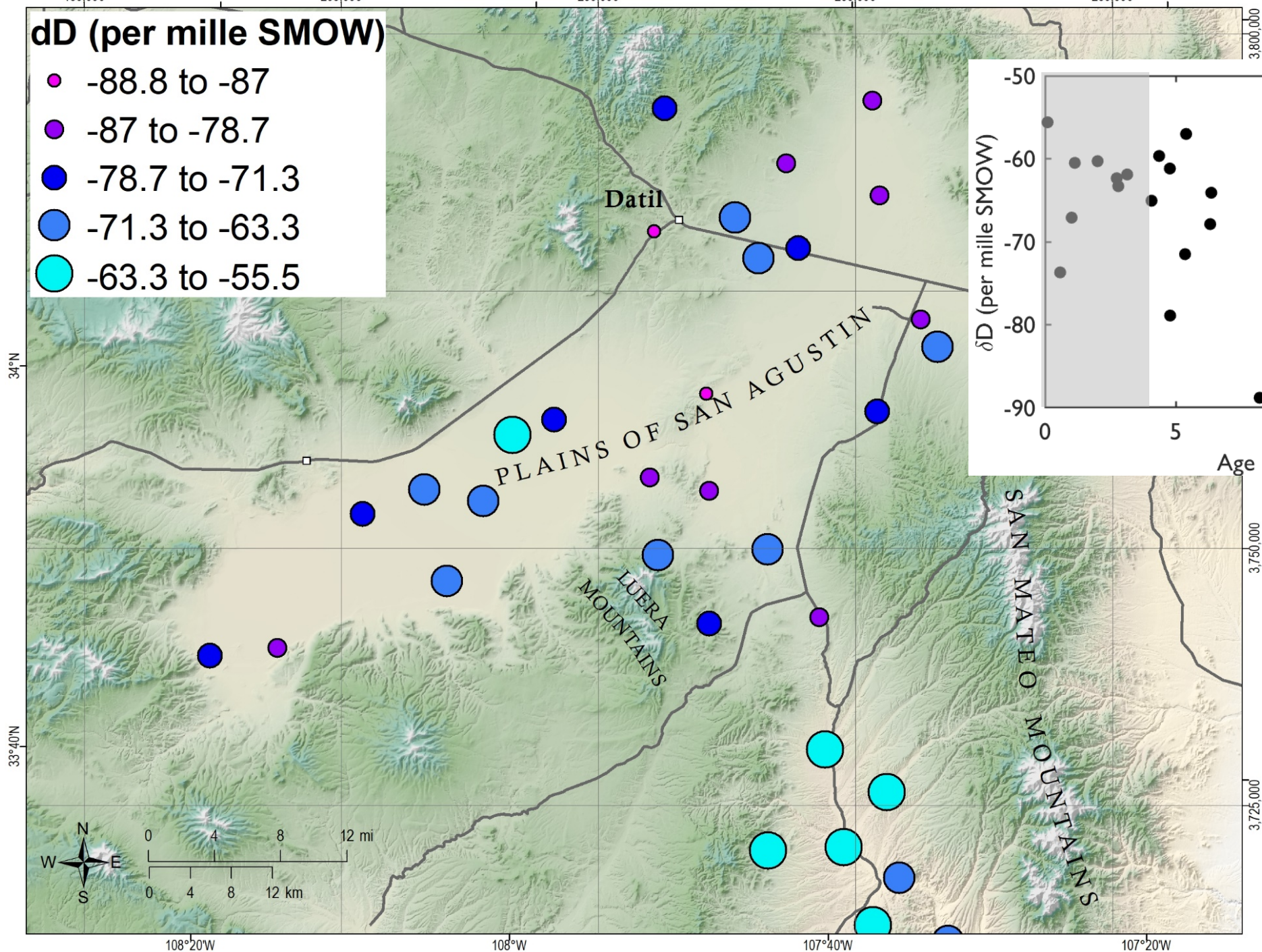
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Little evaporation, little rock-water interaction.

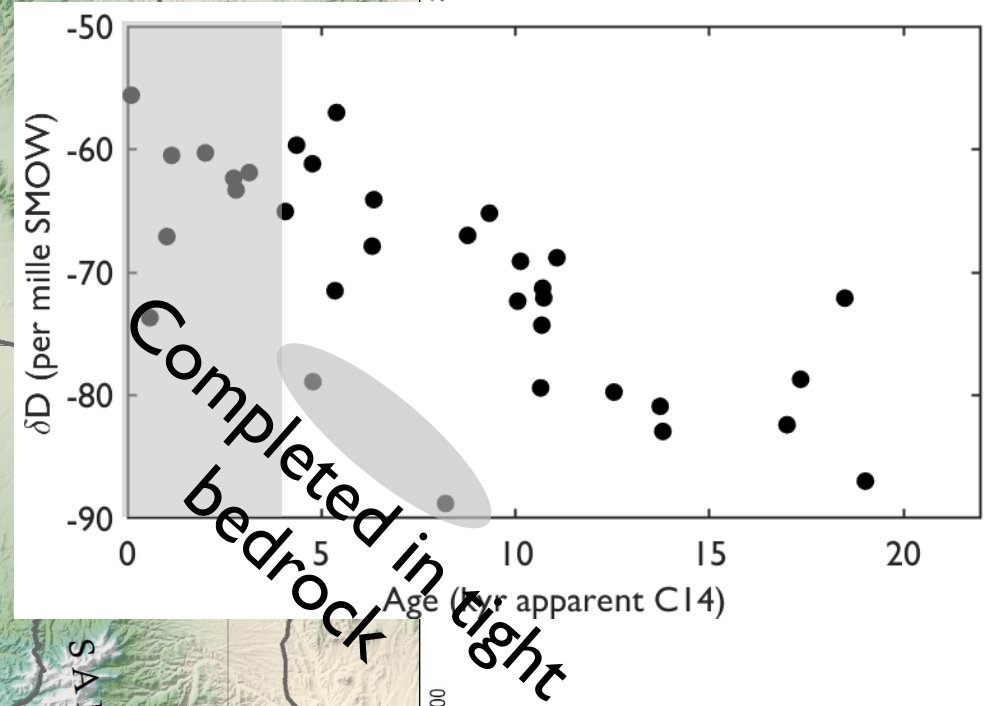
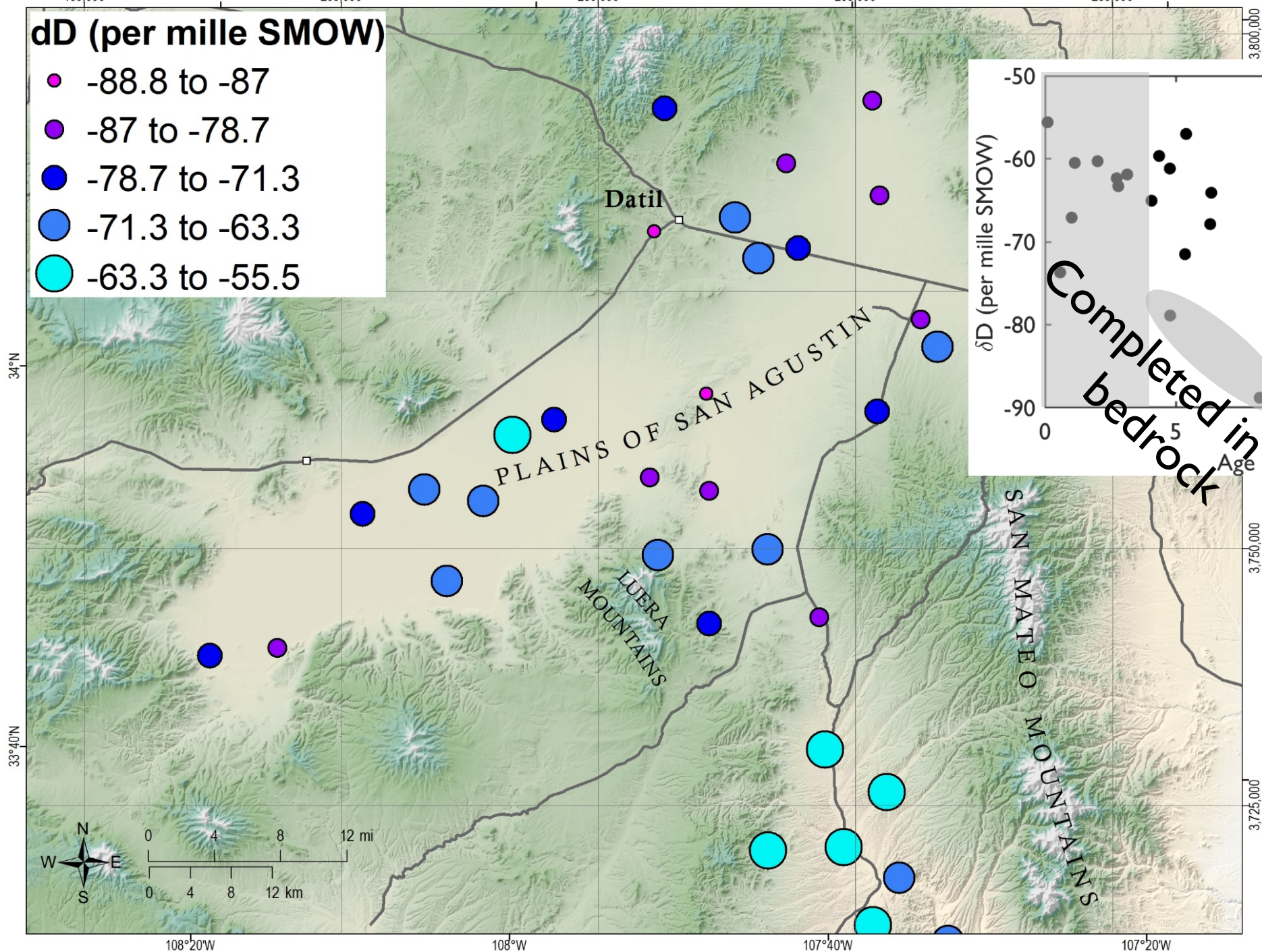
dD (per mille SMOW)

- 88.8 to -87
- 87 to -78.7
- 78.7 to -71.3
- 71.3 to -63.3
- 63.3 to -55.5



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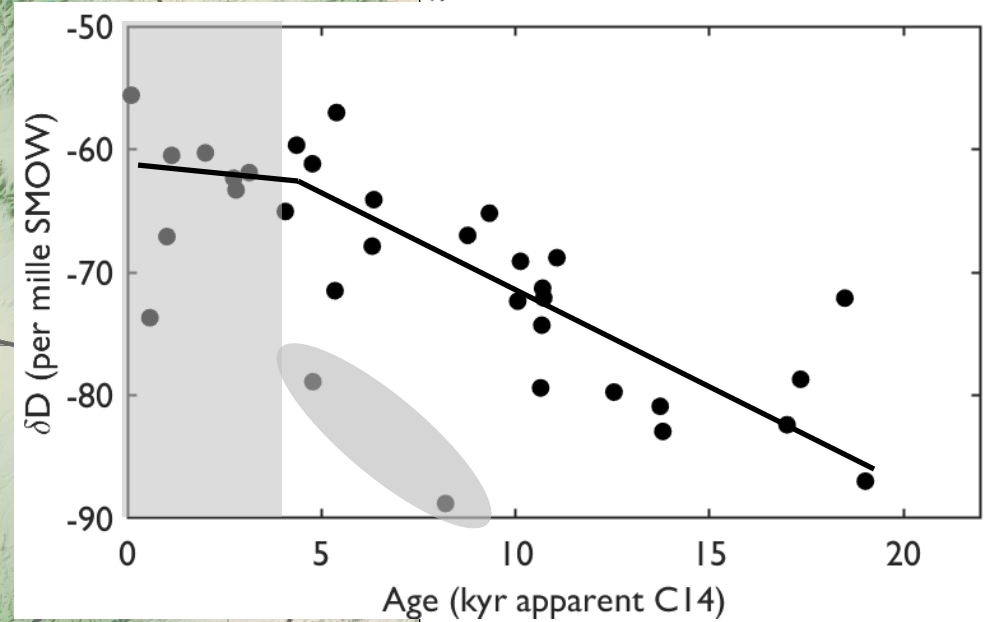


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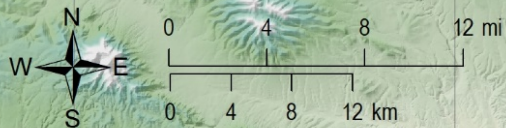
Datil

PLAINS OF SAN AGUSTIN



SA Plains groundwater has conserved the paleoclimate signal.

Older, lighter waters around margin of basin => piston-like flow.



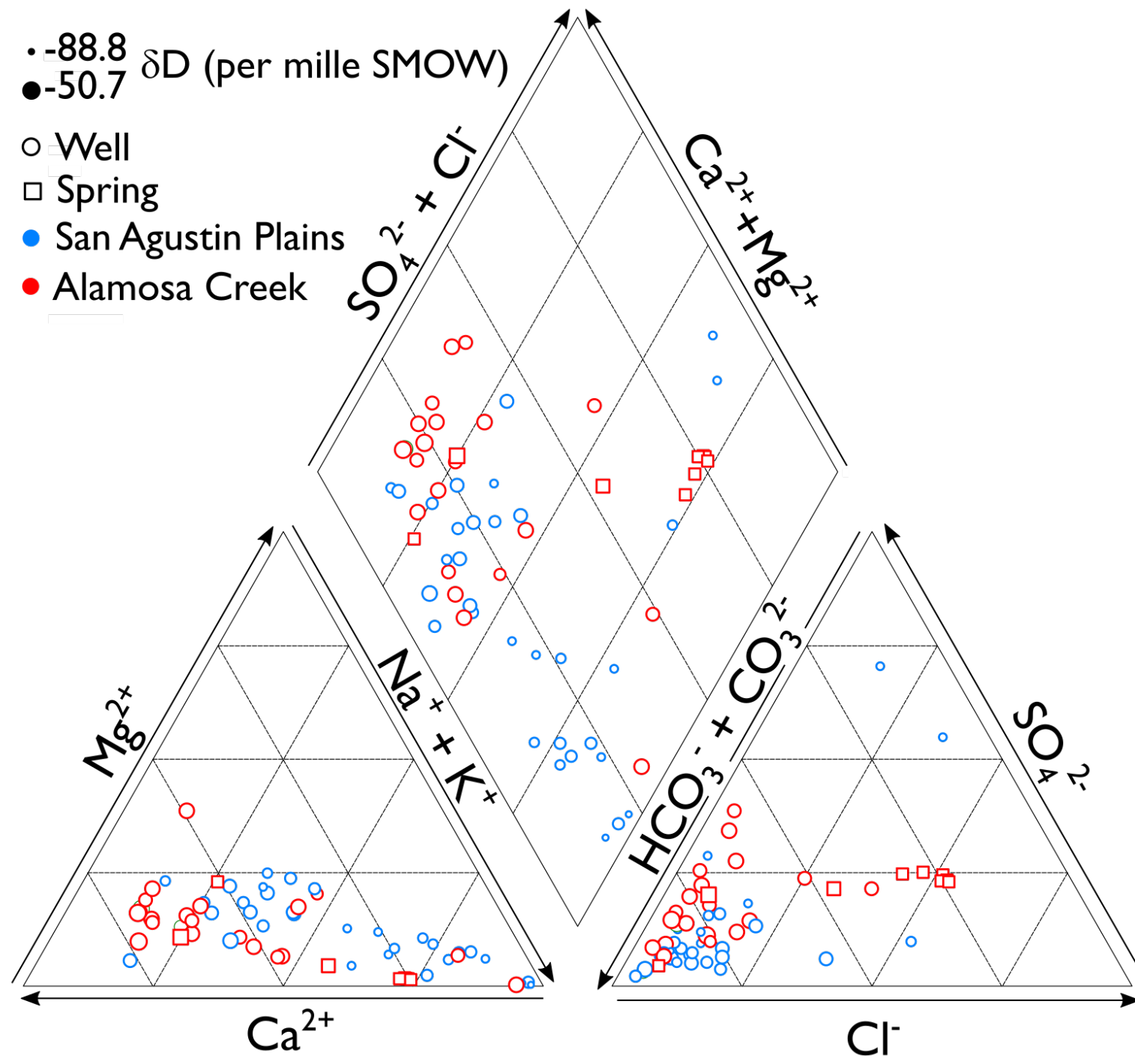
• -88.8
● -50.7 δD (per mille SMOW)

○ Well

□ Spring

● San Agustín Plains

● Alamosa Creek



• -88.8 δD (per mille SMOW)
 ● -50.7

- Well
- Spring
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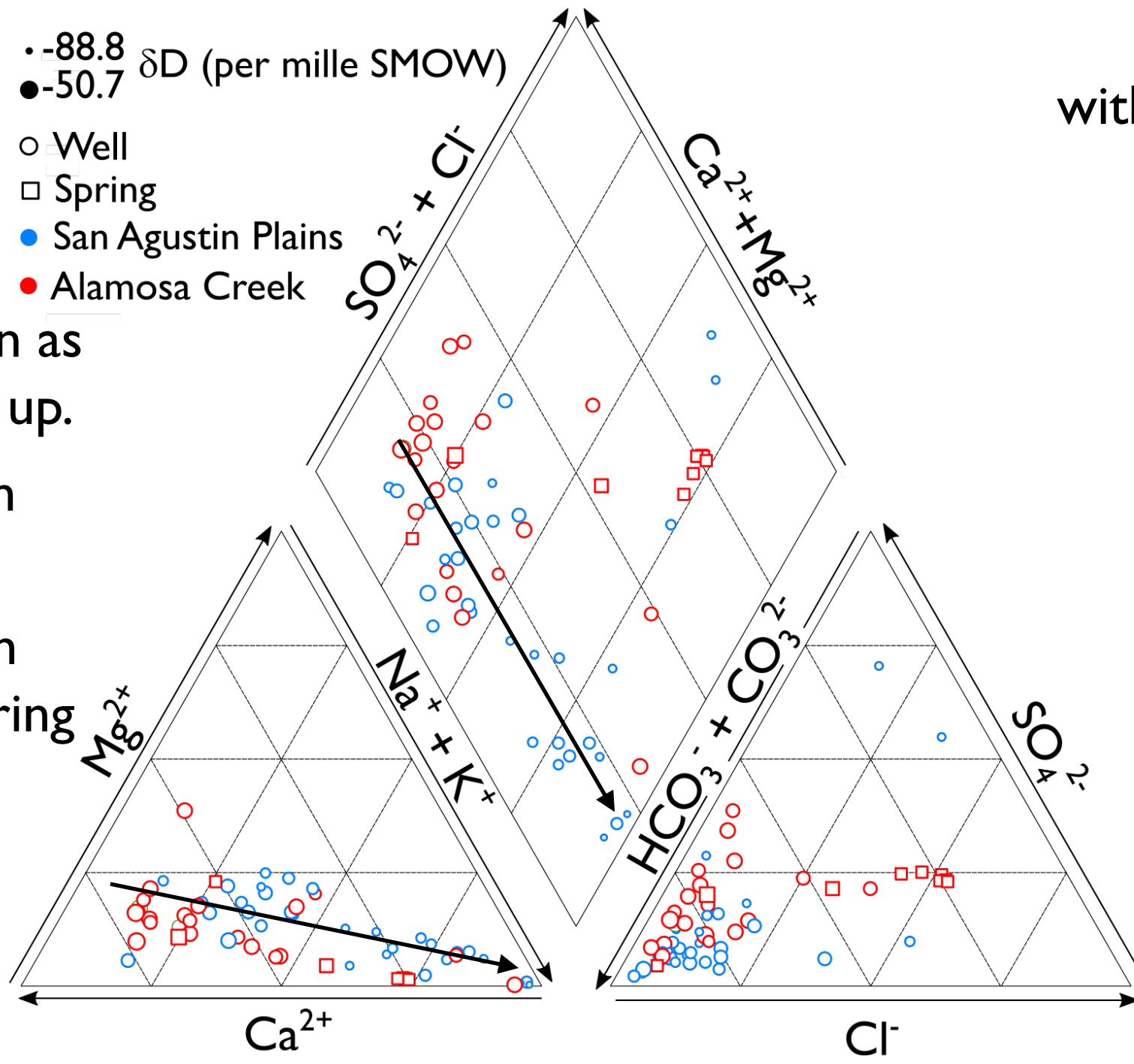
Ca^{2+} goes down as
 $(\text{Na}^+ + \text{K}^+)$ goes up.

Lighter δD with
 lower Ca_{2+}

Consistent with
 silicate weathering
 sequence.

Supersaturated
 with kaolinite, silica,
 clay minerals.

Strongly
 undersaturated
 with feldspars,
 carbonates.



• -88.8
● -50.7 δD (per mille SMOW)

○ Well

□ Spring

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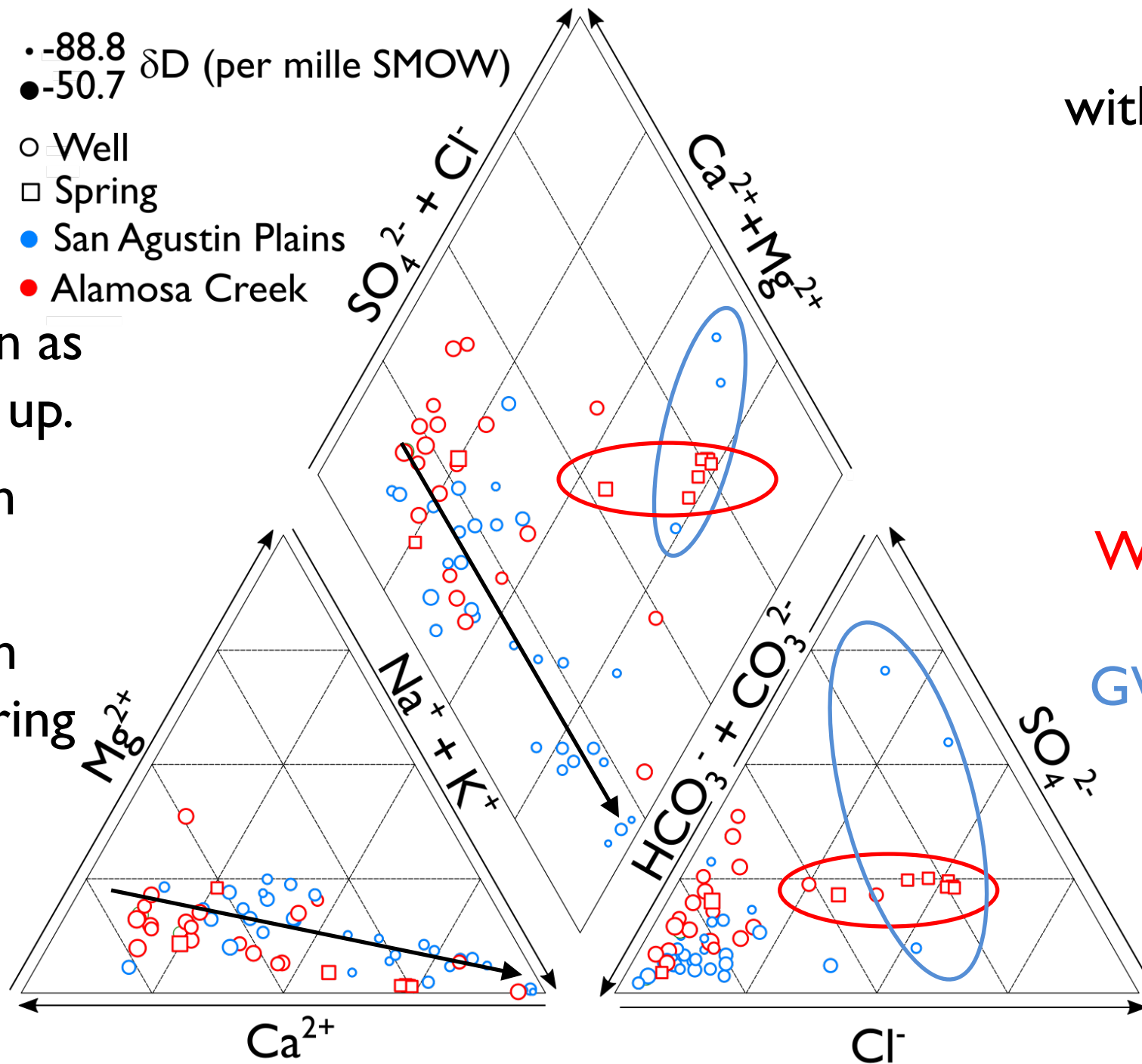
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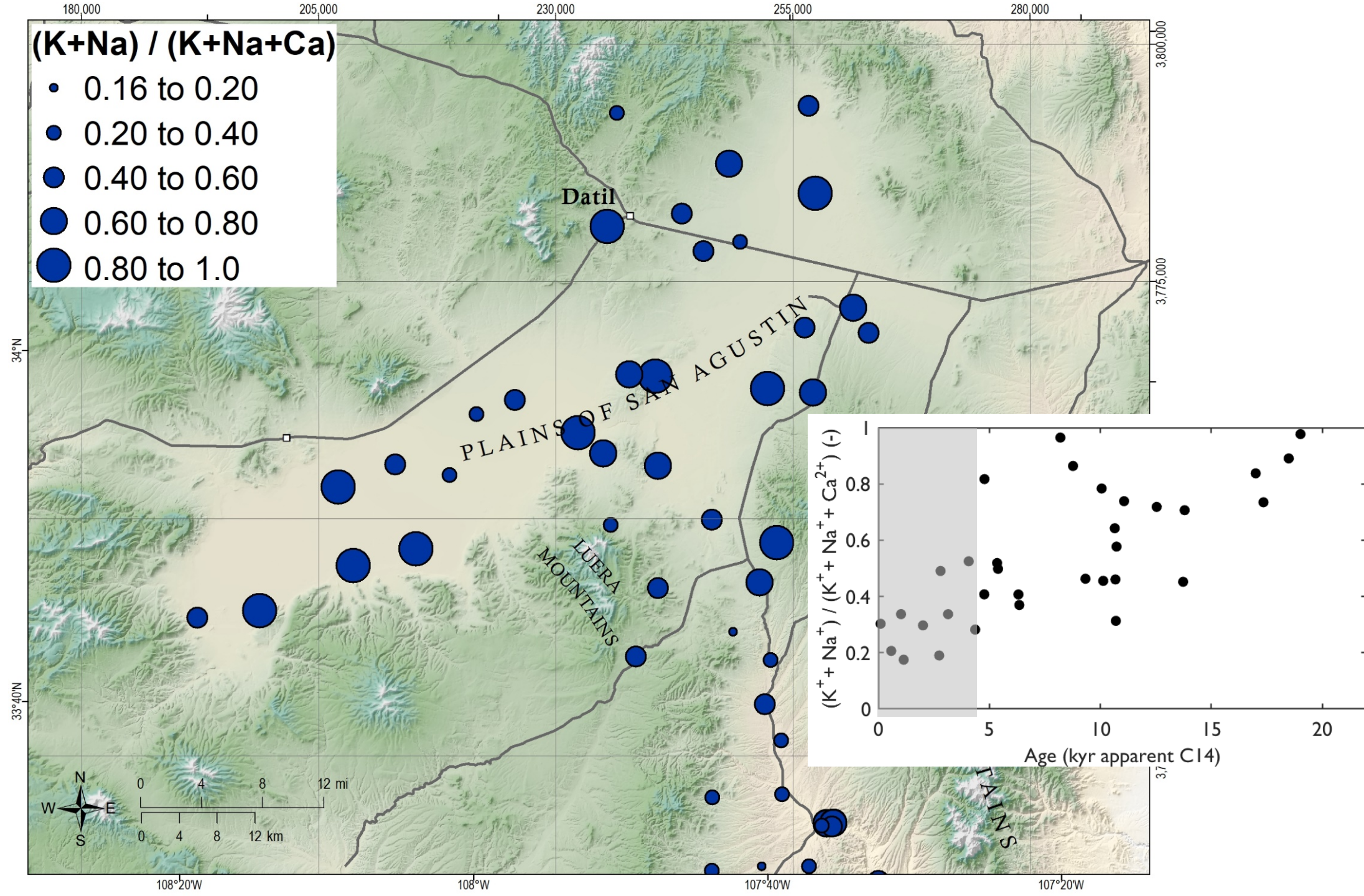
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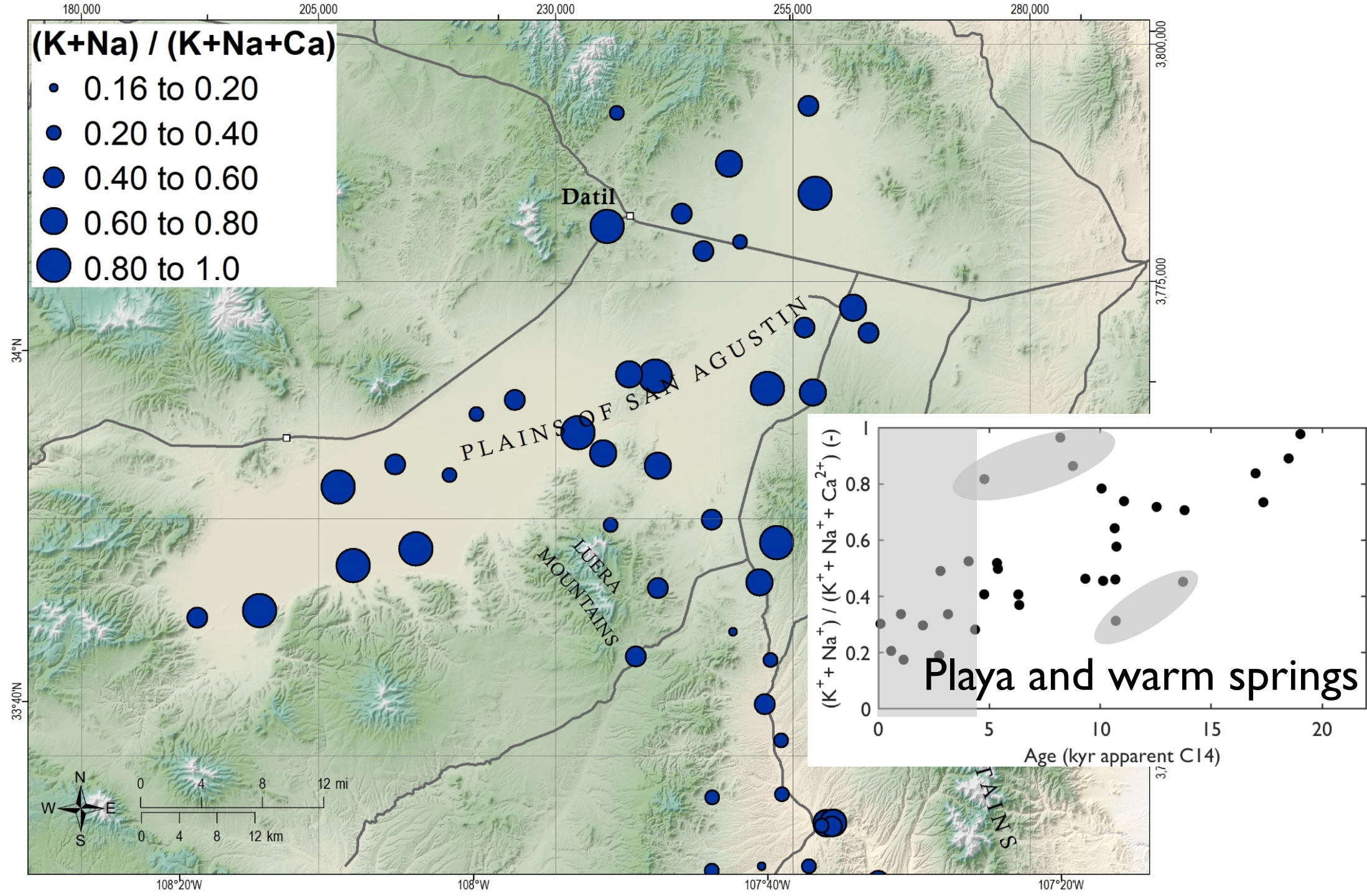
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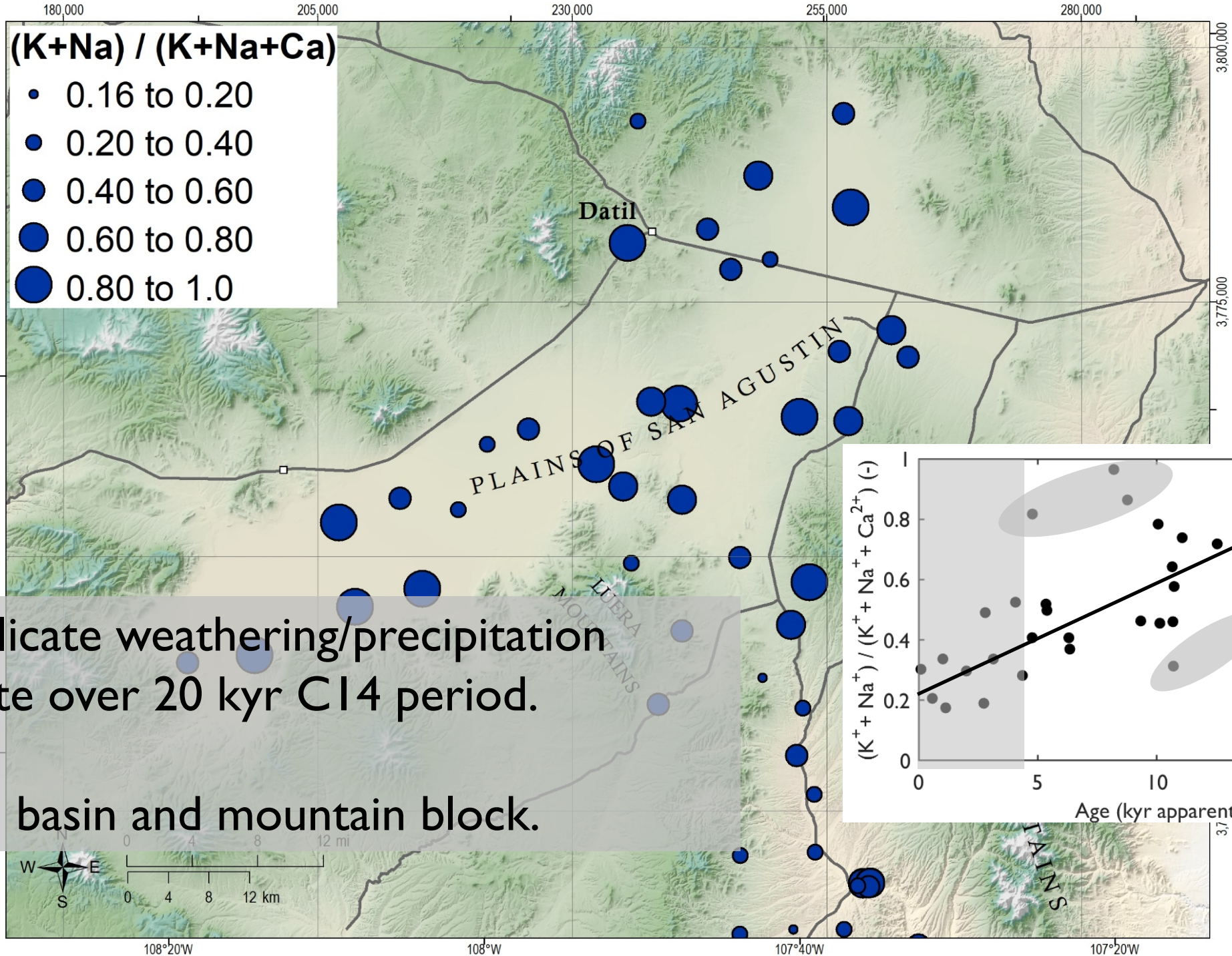
Strongly
undersaturated
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carbonates.

Warm springs and
oldest well and
GW in playas have
higher Cl^{-} , SO_4^{2-}



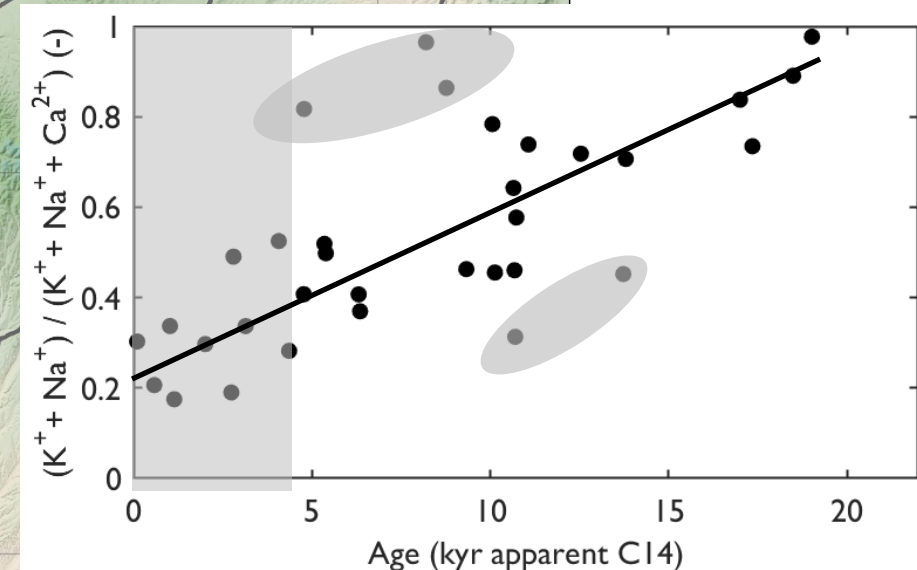


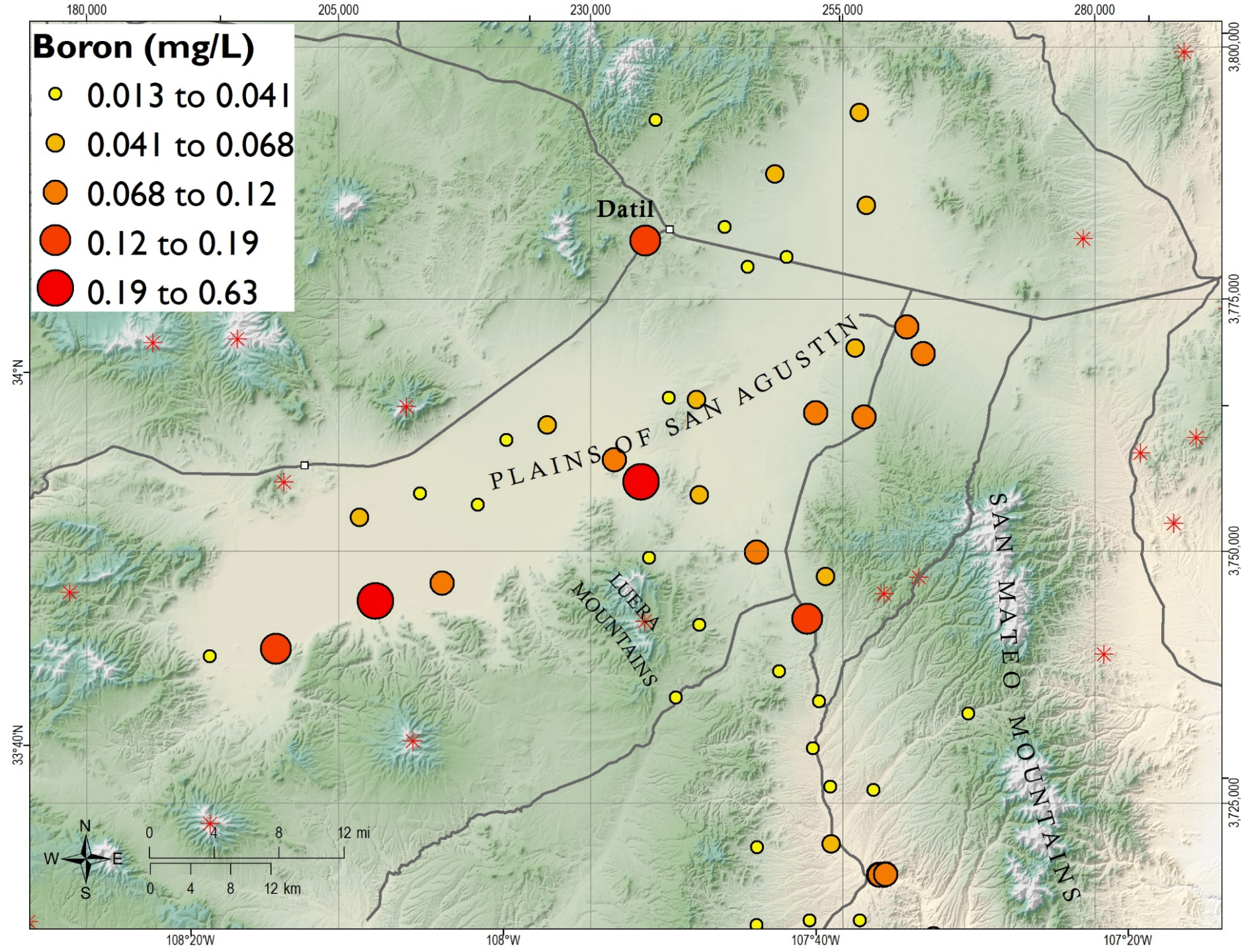


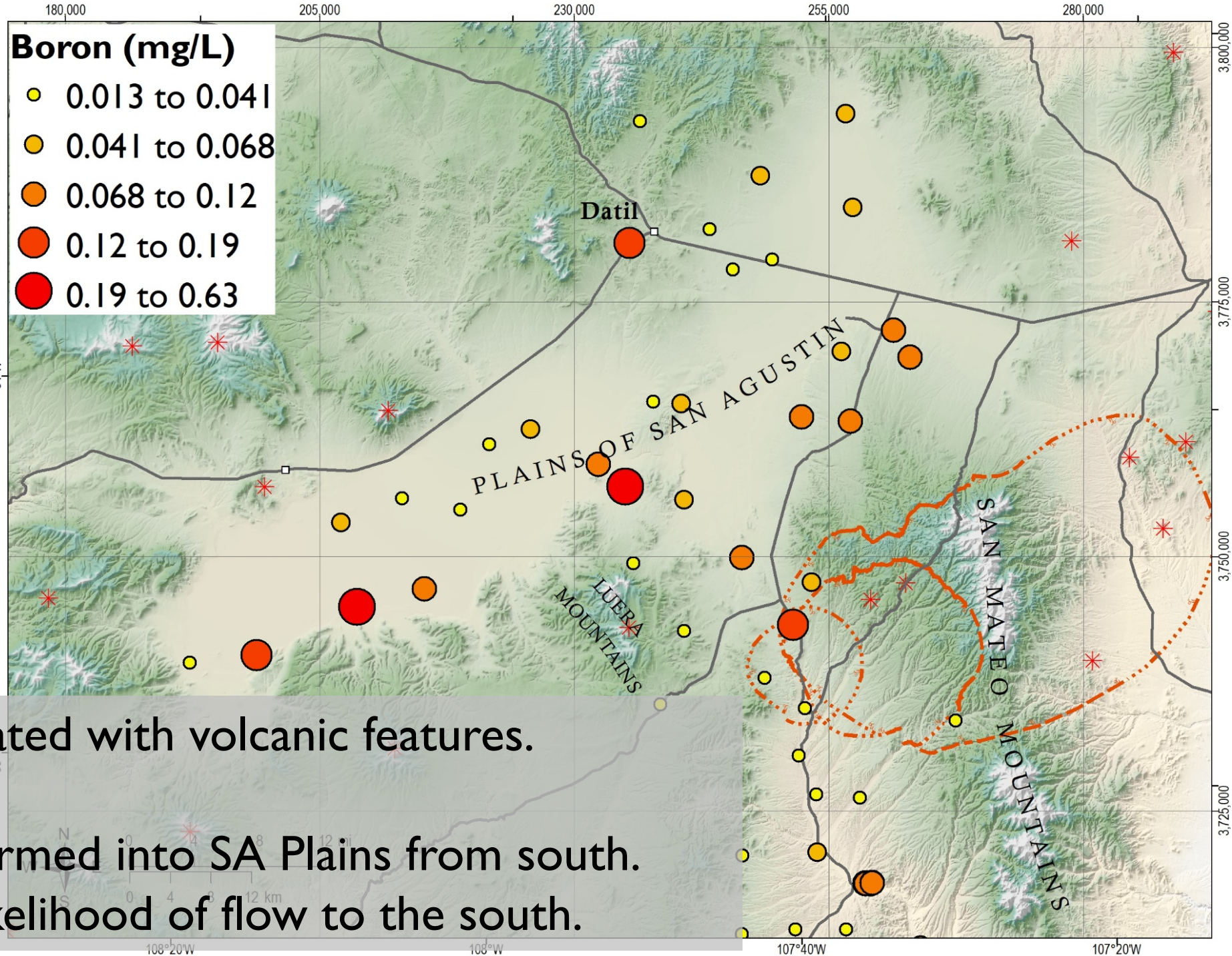


Uniform silicate weathering/precipitation process rate over 20 kyr C14 period.

Uniform in basin and mountain block.







F, B correlated with volcanic features.

Flow confirmed into SA Plains from south.
Restrict likelihood of flow to the south.

Water levels reflect the grabens, faulting + recharge/discharge.

Basin is at steady state.

Extensional structure + calderas + vents restrict flow out of San Agustin Plains to the south in general.

Mountain block flow is in fractured tuffs.

Stream valley recharge > mountain block recharge. Both significant volumes.

Flow in basin, mountain block occur with little mixing.

Relatively uniform rates of silicate weathering/precipitation over 20 ky C14, everywhere in the basin.

Heightened (but low) F, B concentrations correlate with volcanic features.

Water levels reflect the grabens, faulting + recharge/discharge.

First comprehensive examination of San Agustin Plains and drainage to the south.

Extensional structure + calderas + vents restrict flow out of San Agustin Plains to the south

One of the first (maybe the first) comprehensive look at aqueous chemistry in Mogollon-Datil Volcanic Field.

Stream valley recharge > mountain block recharge. Both significant volumes.

Chemical, physical process interpretation likely transferable into the rest of MDVF.

Relatively uniform rates of silicate weathering/precipitation over 20 ky C-14, everywhere in

Mountain block flow controlled by cooling fractures, faults and volcanic features.

Heightened (but low) F, B concentrations correlate with volcanic features.