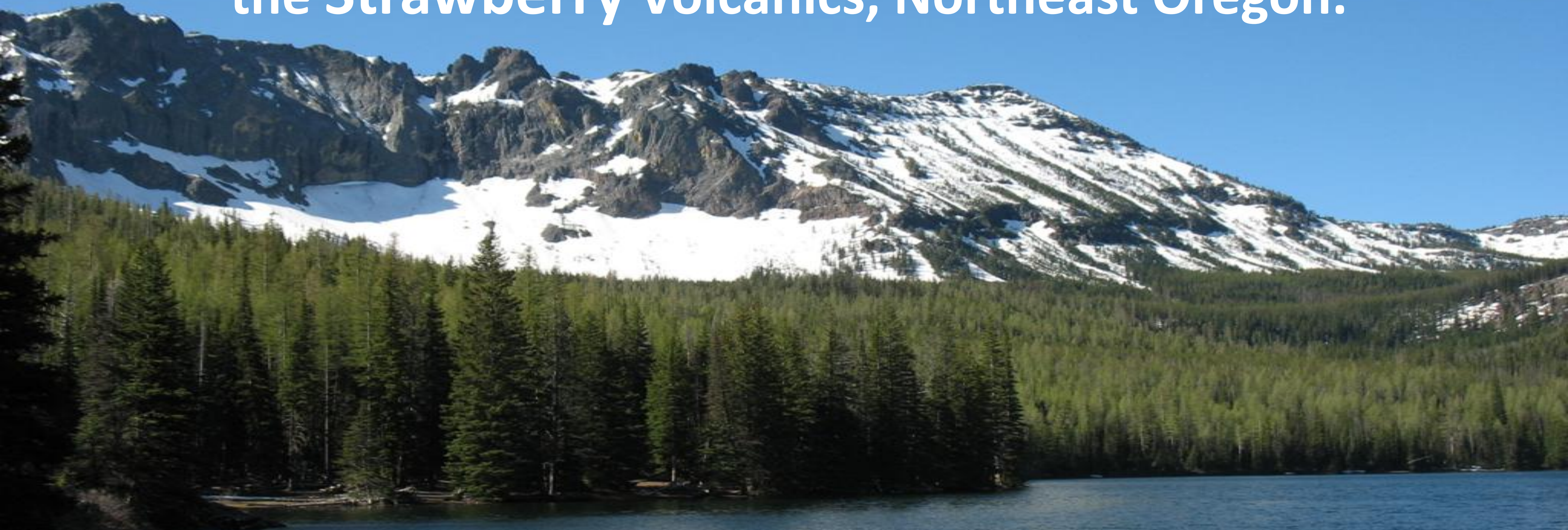
The Generation of Hot-Spot Related Calc-Alkaline Andesites of the Strawberry Volcanics, Northeast Oregon.



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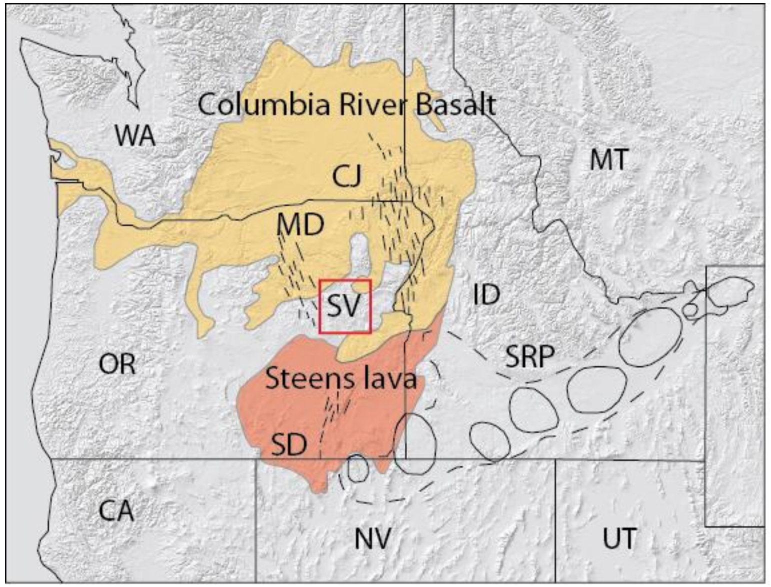
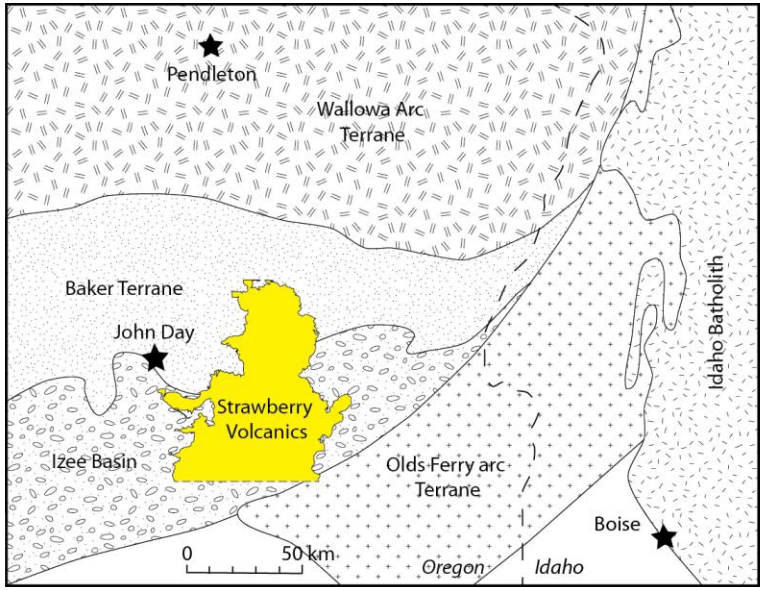
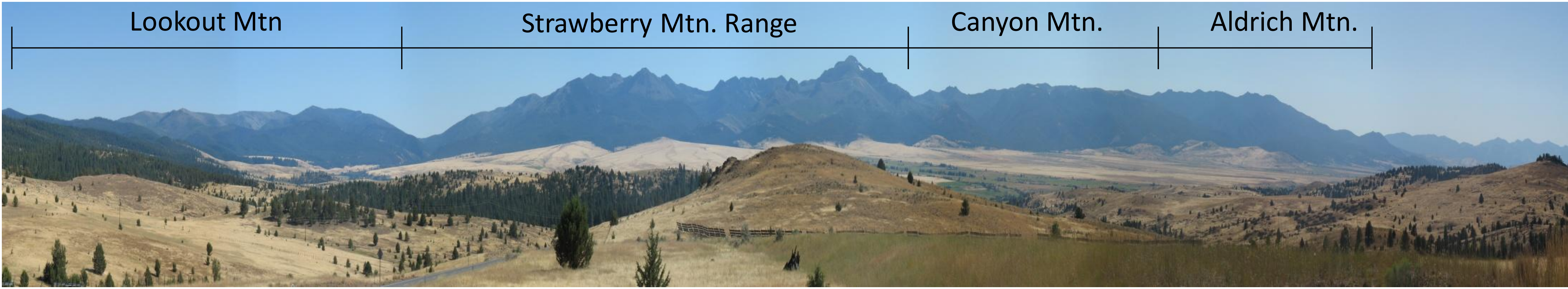
Washington State University
And Martin Streck
Portland State University

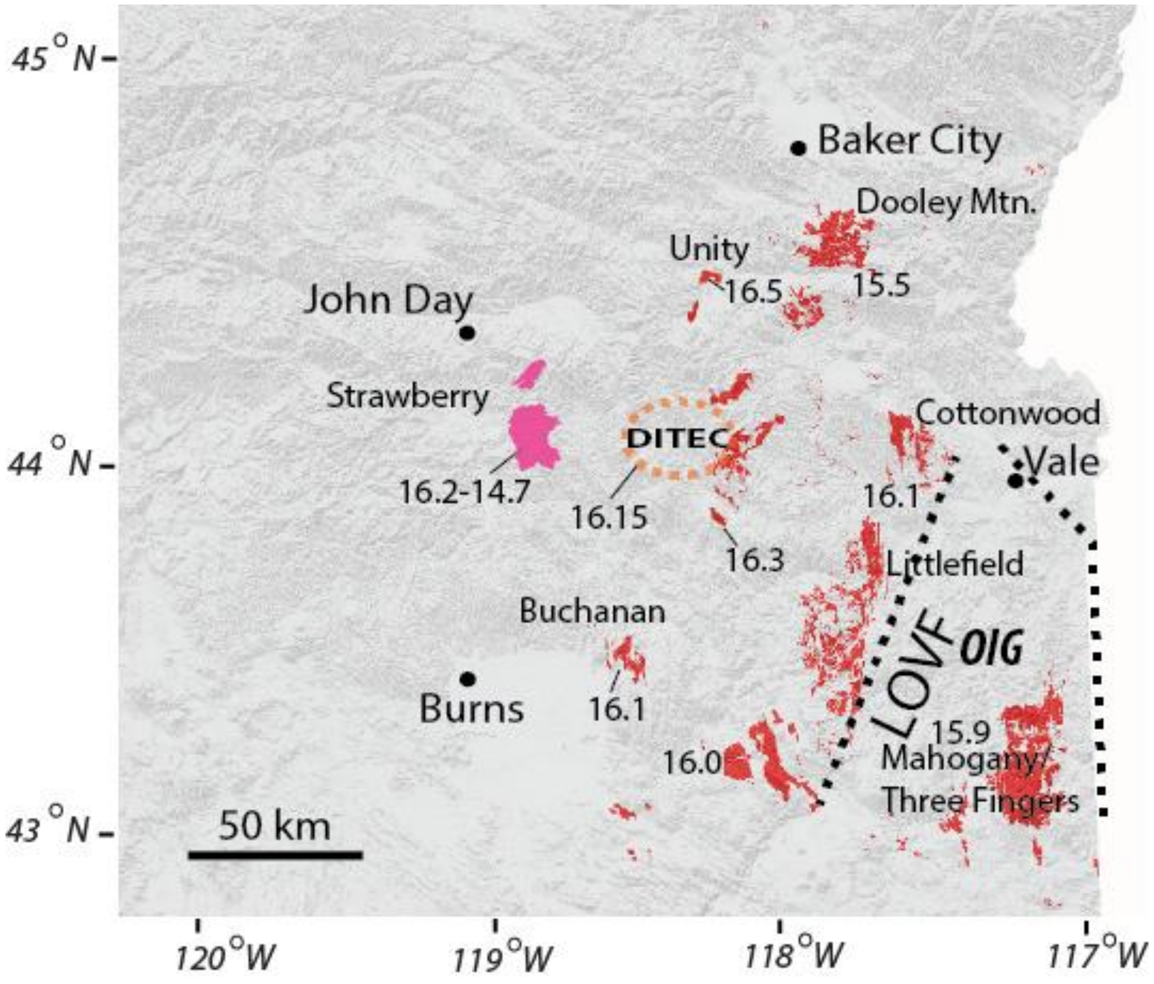
Introduction



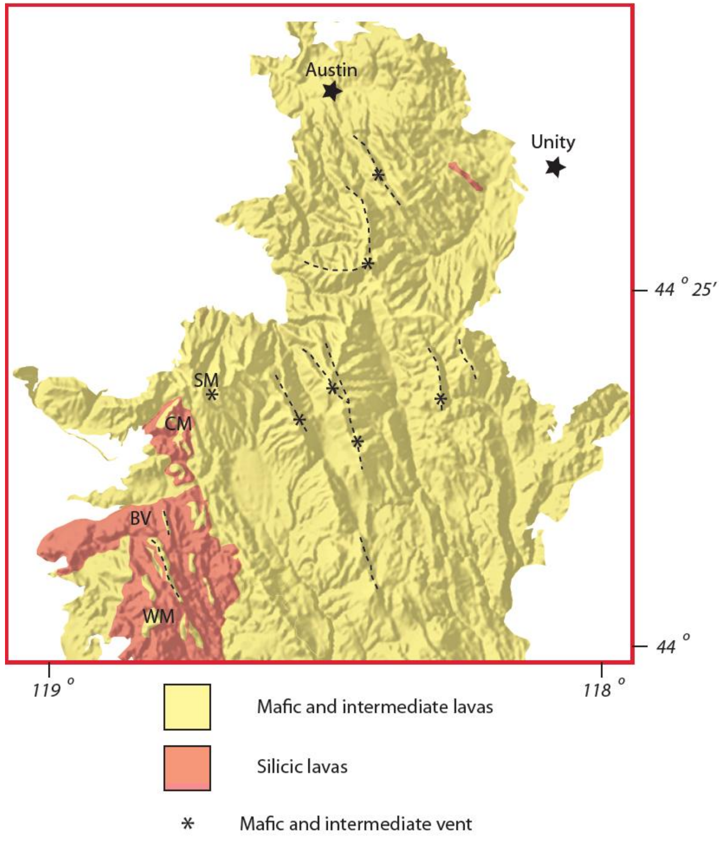




Rhyolites



Total volume ~ 100 km^3



Sample	Rock Type[a]	Material Dated[b]	Age (Ma)	± (2σ)	Steps Plateau	^{39}Ar, %
			Plateau			
AS-SV-151	R	GM	16.16	0.17	7	84.00
AS-SV-144	R	Plag	15.34	0.52	8	98.38
AS-SV-179	R	GM	15.30	0.1	7	89.20
AS-SV-190	R	Glass	14.79	0.12	10	100.00
AS-SV-173	R	Biotite	14.70	0.13	8	89.22

* repeat

[a] A, andesite; BA, basaltic andesite, R, rhyolite

[b] GM, groundmass, Plag, Plagioclase

Mafic and Intermediate Lavas

Typical Mafic/intermediate lavas with a total volume ~1,100 km^3

- Massive stacks of lavas up to ~1000 m in height
    - ~5-10 m thick

- Basalts are cohesive flows and can have columnar joints ophitic texture

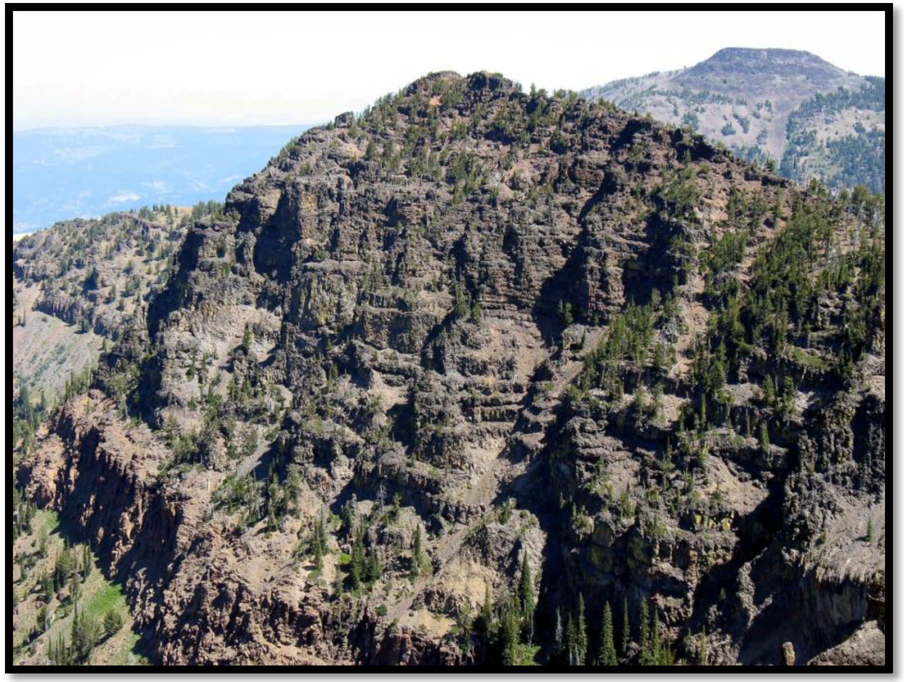
- Andesites tend to be platy
    - No visual differences between calc-alkaline and tholeiitic lavas

			Plateau			
Sample	Rock Type[a]	Material Dated[b]	Age (Ma)	± (2σ)	Steps Plateau	^{39}Ar, %
AS-SV-291	A	GM	15.59	0.36	4	72.07
AS-SV-159c	BA	GM	15.57	0.16	8	94.37
AS-SV-156	A	GM	14.87	0.13	6	87.43
AS-SV-188	A	GM	14.59	0.26	8	99.20
AS-SV-82	A	GM	14.21	0.26	-	88.91
AS-SV-14	BA	GM	13.76	0.16	9	85.41
AS-SV-230	BA	GM	13.53	0.24	5	70.78
AS-SV-109	B	GM	12.61	0.08	13	47.27
AS-SV-192	A	GM	12.52	0.12	9	98.84

* repeat

[a] A, andesite; BA, basaltic andesite, R, rhyolite

[b] GM, groundmass, Plag, Plagioclase

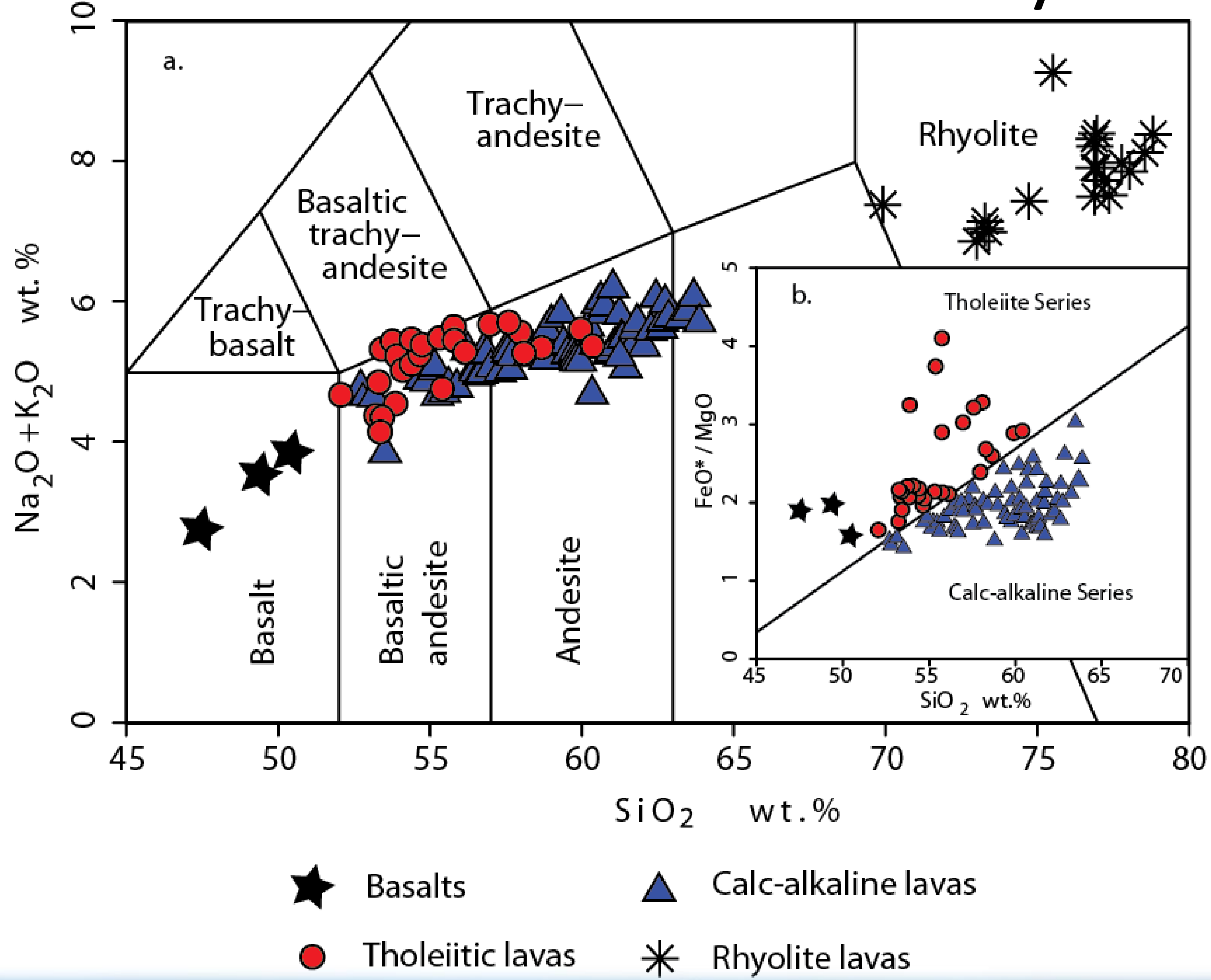


Mafic and Intermediate Pyroclasts

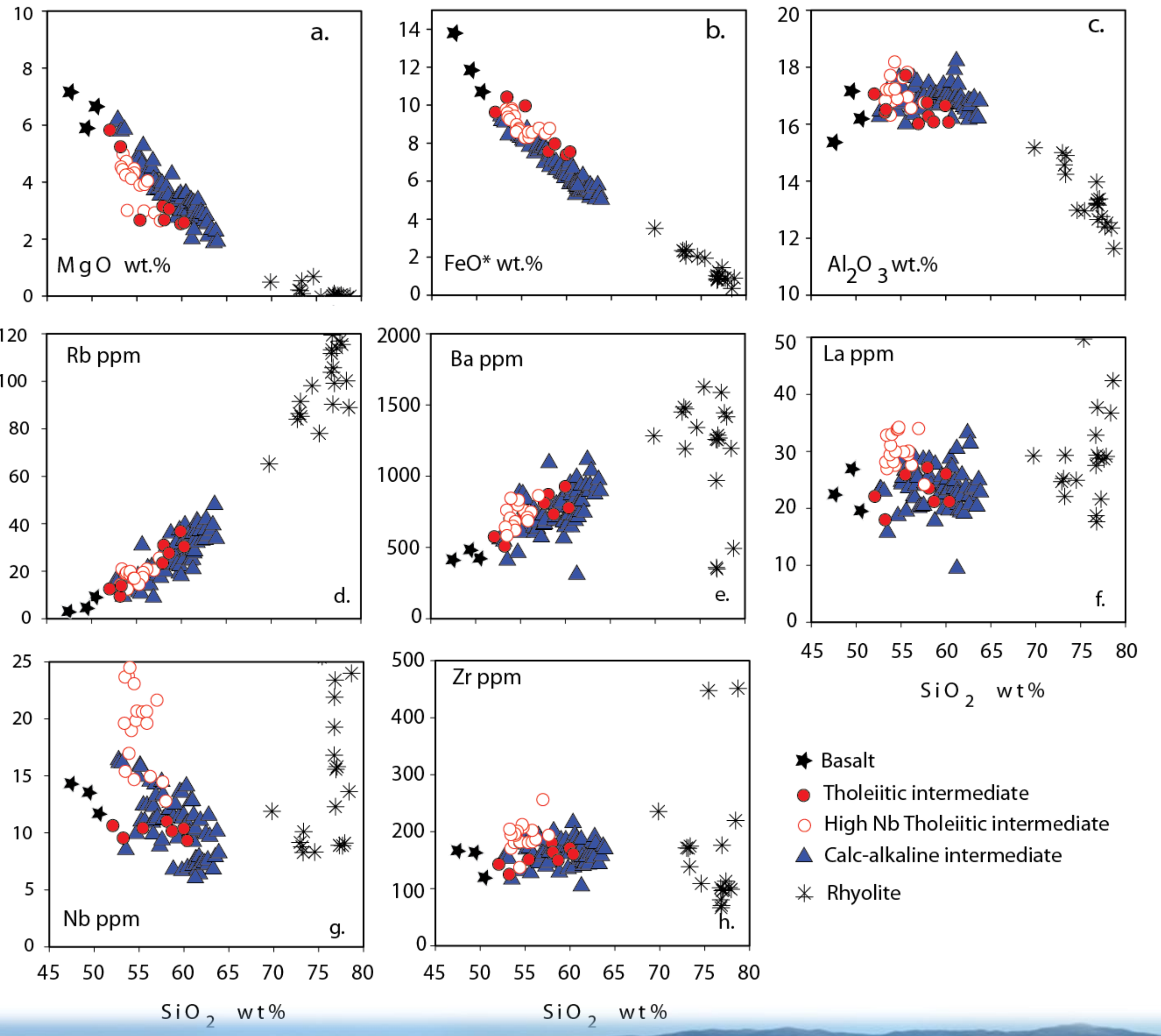
Phreatomagmatic Eruption

Palagonite and bomb sags

Whole Rock Geochemistry



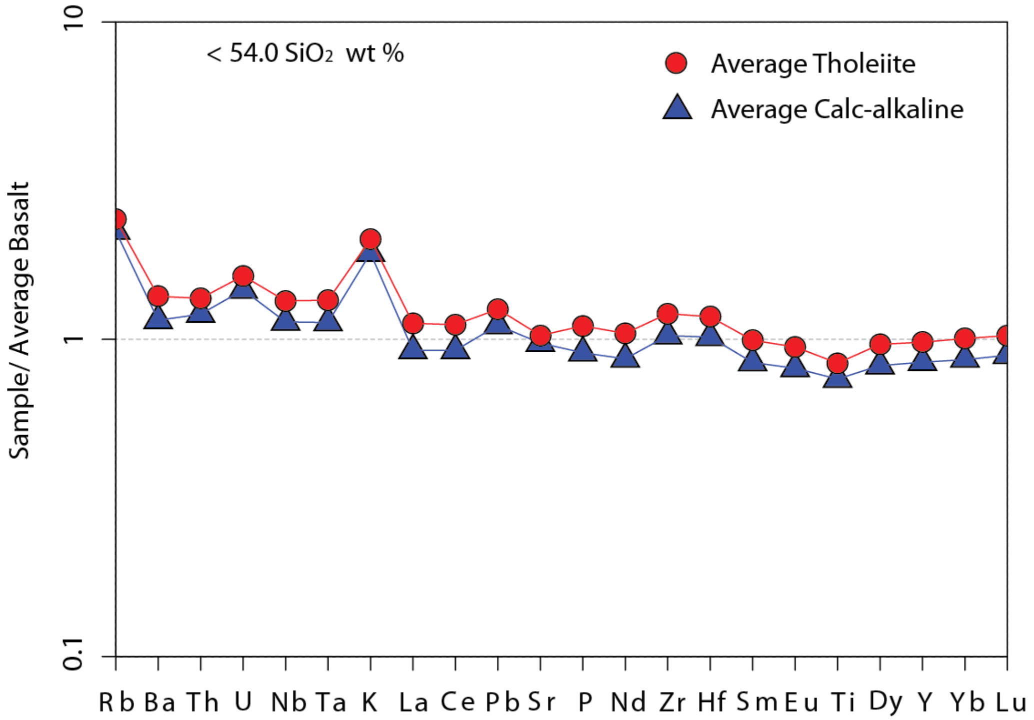
Whole Rock Geochemistry

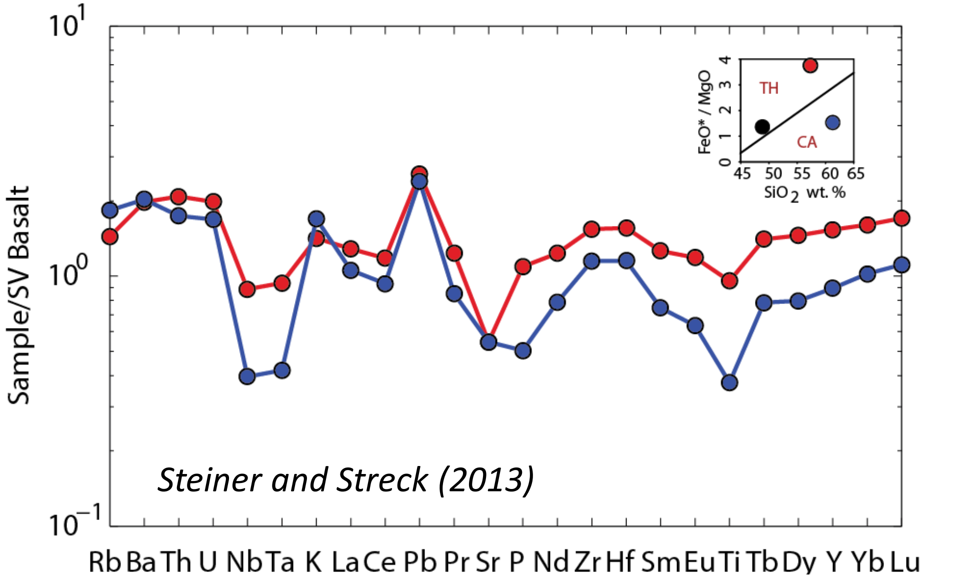


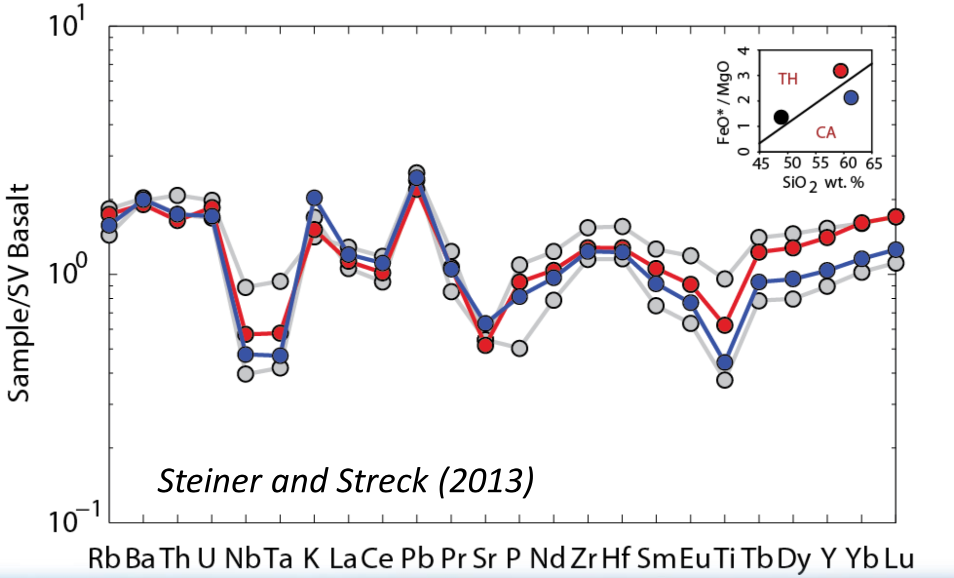
LILEs (Rb,Ba Pb and Cs) increase with increasing silica

HFSE (Nb, Ta, Zr, Hf, and Y) and REEs decrease of remain the same with increased silica

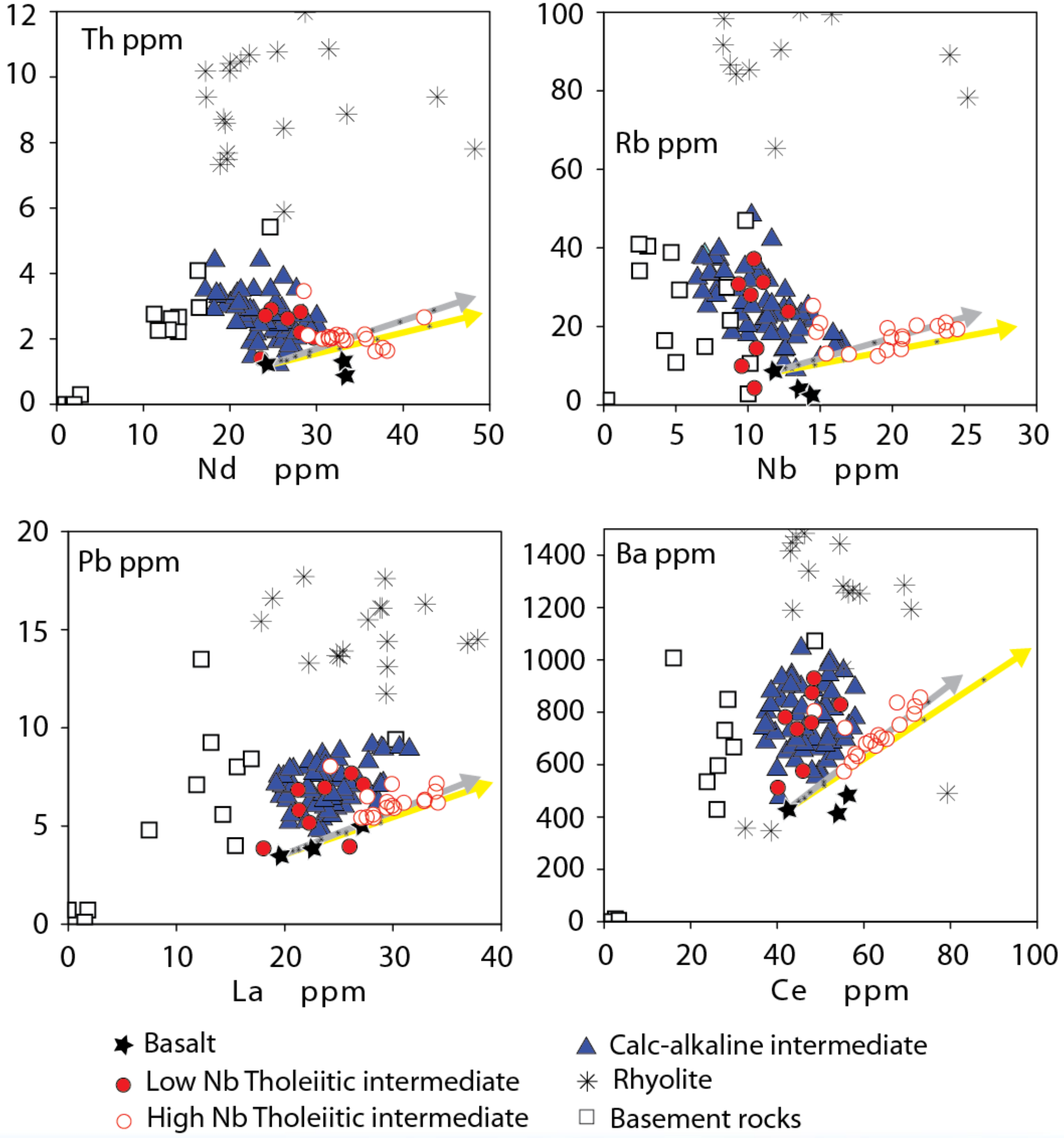
Calc-alkaline vs. Tholeiitic lavas







Open or Closed System Processes?



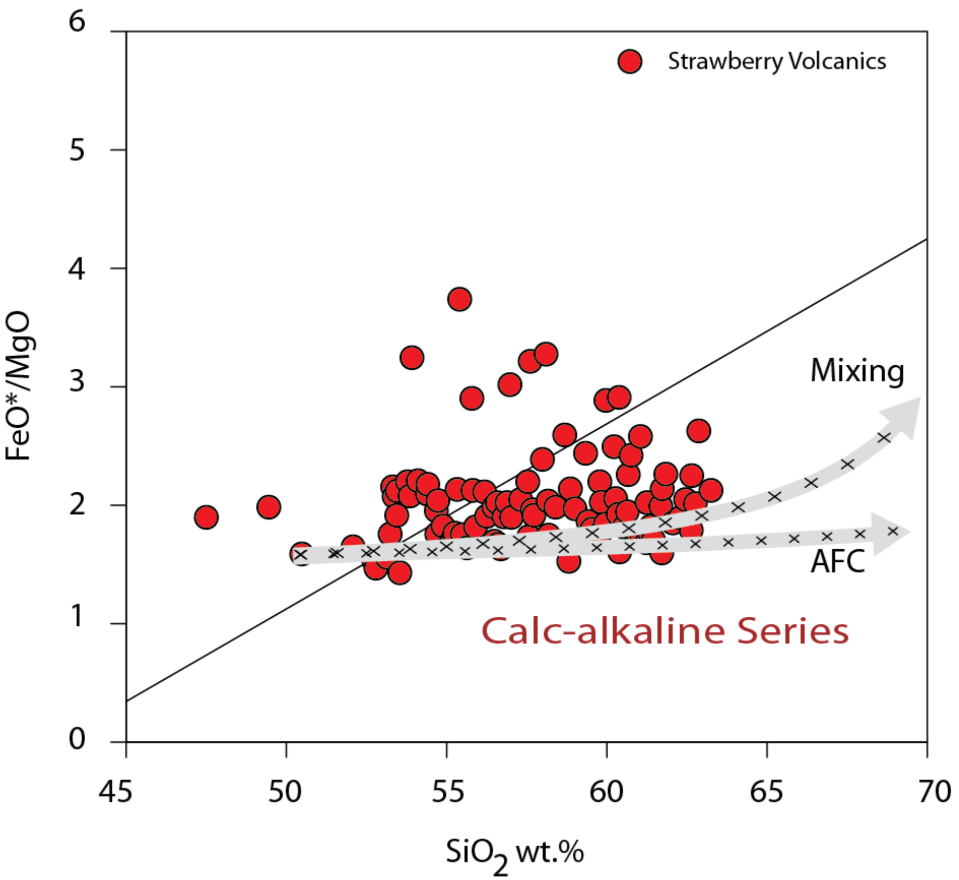
Incompatible trace elements argue for both FC and mixing processes.

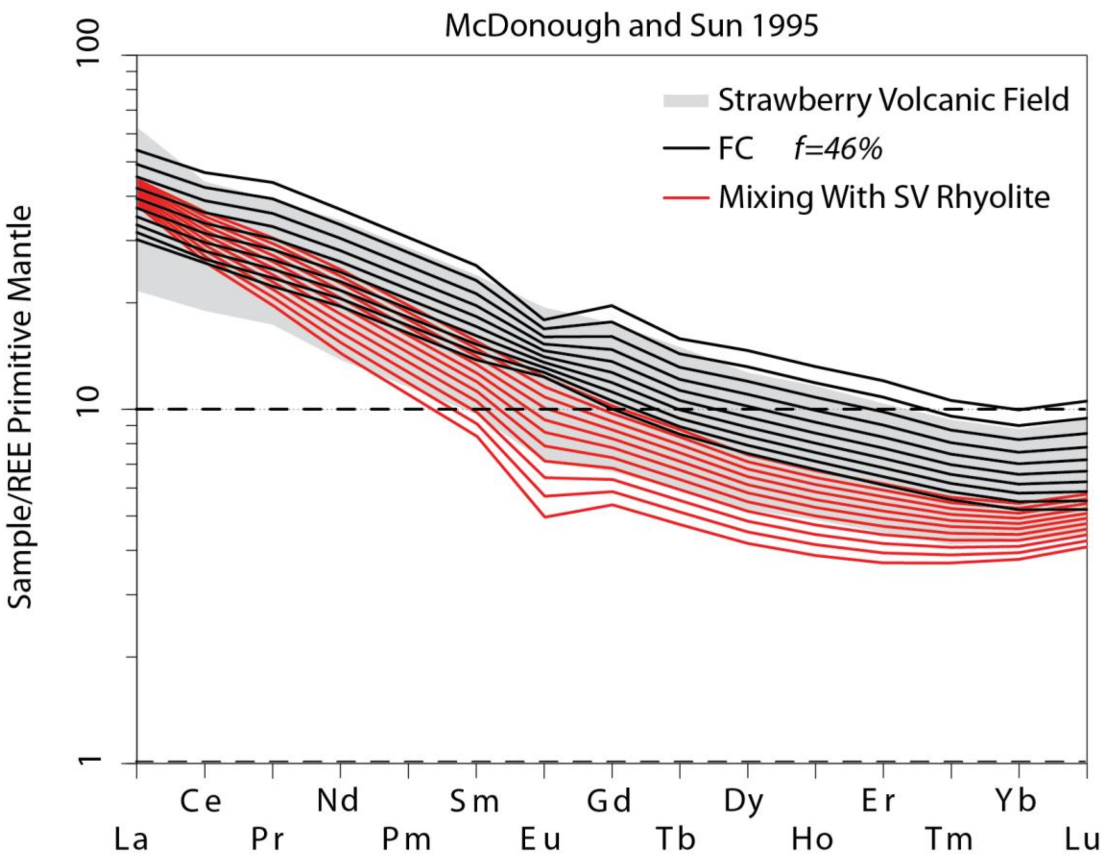
High Nb group falls along FC trend

As the silica enriches and the transition to calc-alkaline occur, FC processes cannot produce this trend.

Mixing with rhyolite and/or contamination from the basement rock can generate the trace elements

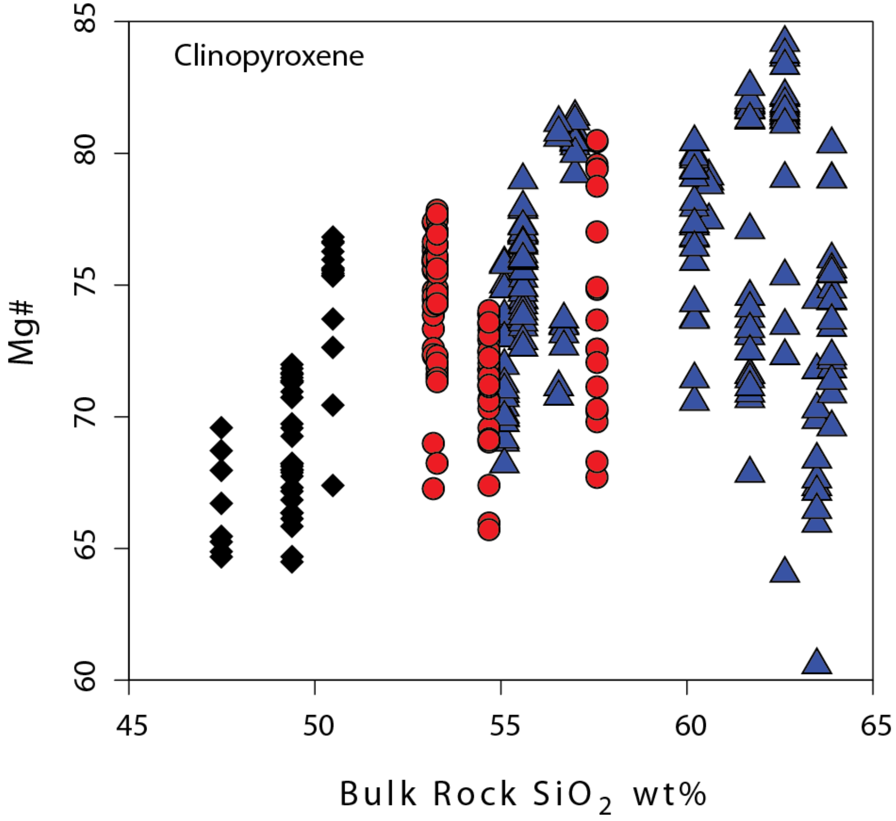
Open or Closed System Processes?

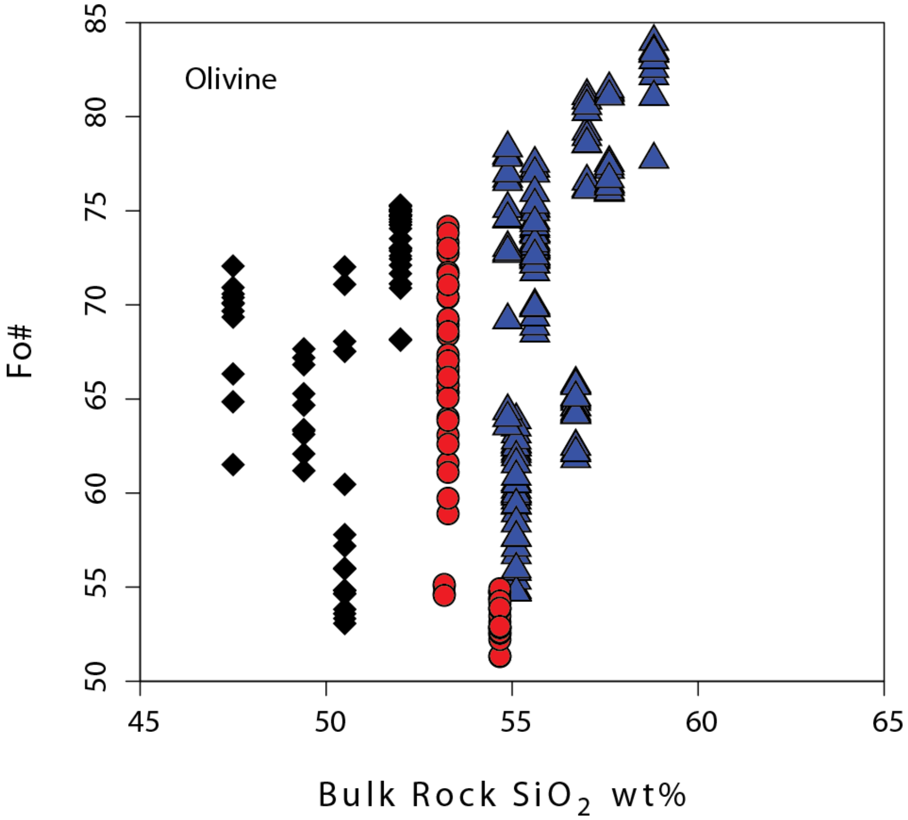




- FC from a parental basalt can produce the enriched trace elements
- Mixing with an SV type rhyolite can produce the low abundance trace elements

Open or Closed System Processes?

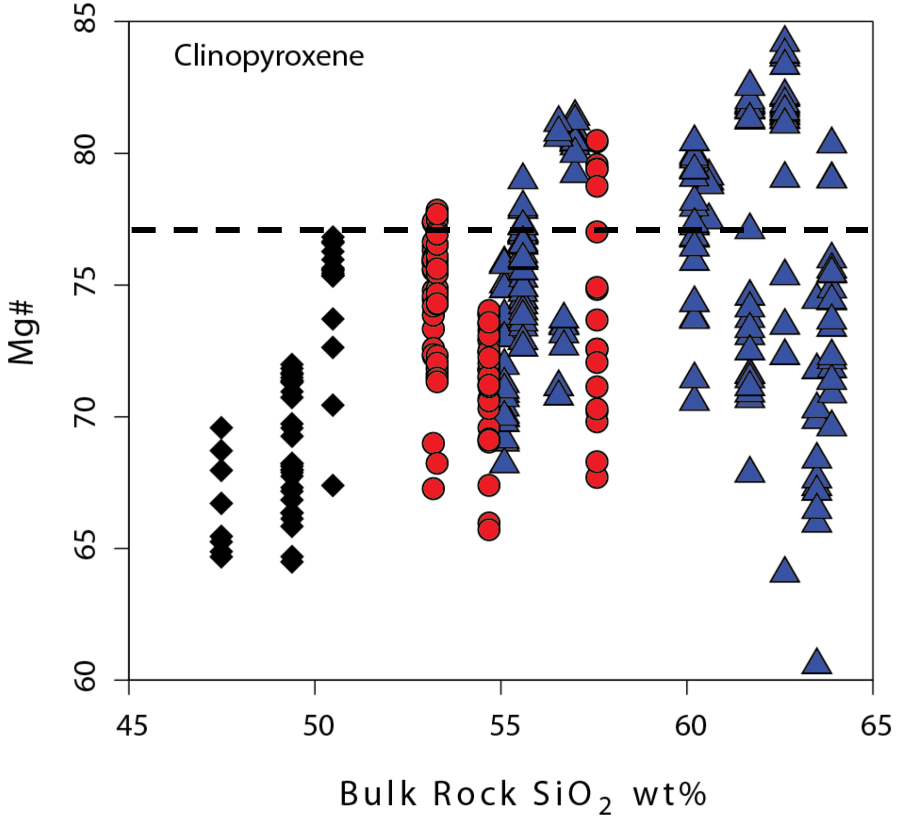


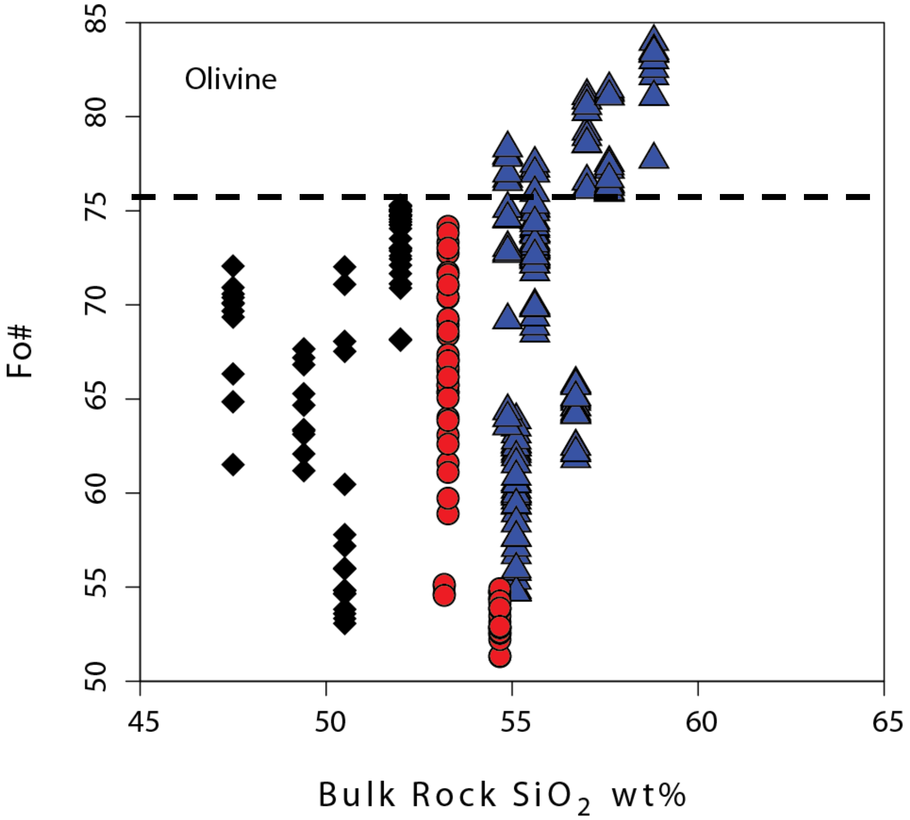


Mineral Data

- Basalts
  - CPX Mg#s 76 – 65
  - Olivine Fo#s 75 – 53
- Tholeiitic
  - CPX Mg#s 80 – 65
  - Olivine Fo#s 73 – 51
- Calc-alkaline
  - CPX Mg#s 85 – 60
  - Olivine Fo#s 85 – 55

Open or Closed System Processes?





Mineral Data

- Basalts
    - CPX Mg#s 76 – 65
    - Olivine Fo#s 75 – 53
- Tholeiitic
    - CPX Mg#s 80 – 65
    - Olivine Fo#s 73 – 51
- Calc-alkaline
    - CPX Mg#s 85 – 60
    - Olivine Fo#s 85 – 55

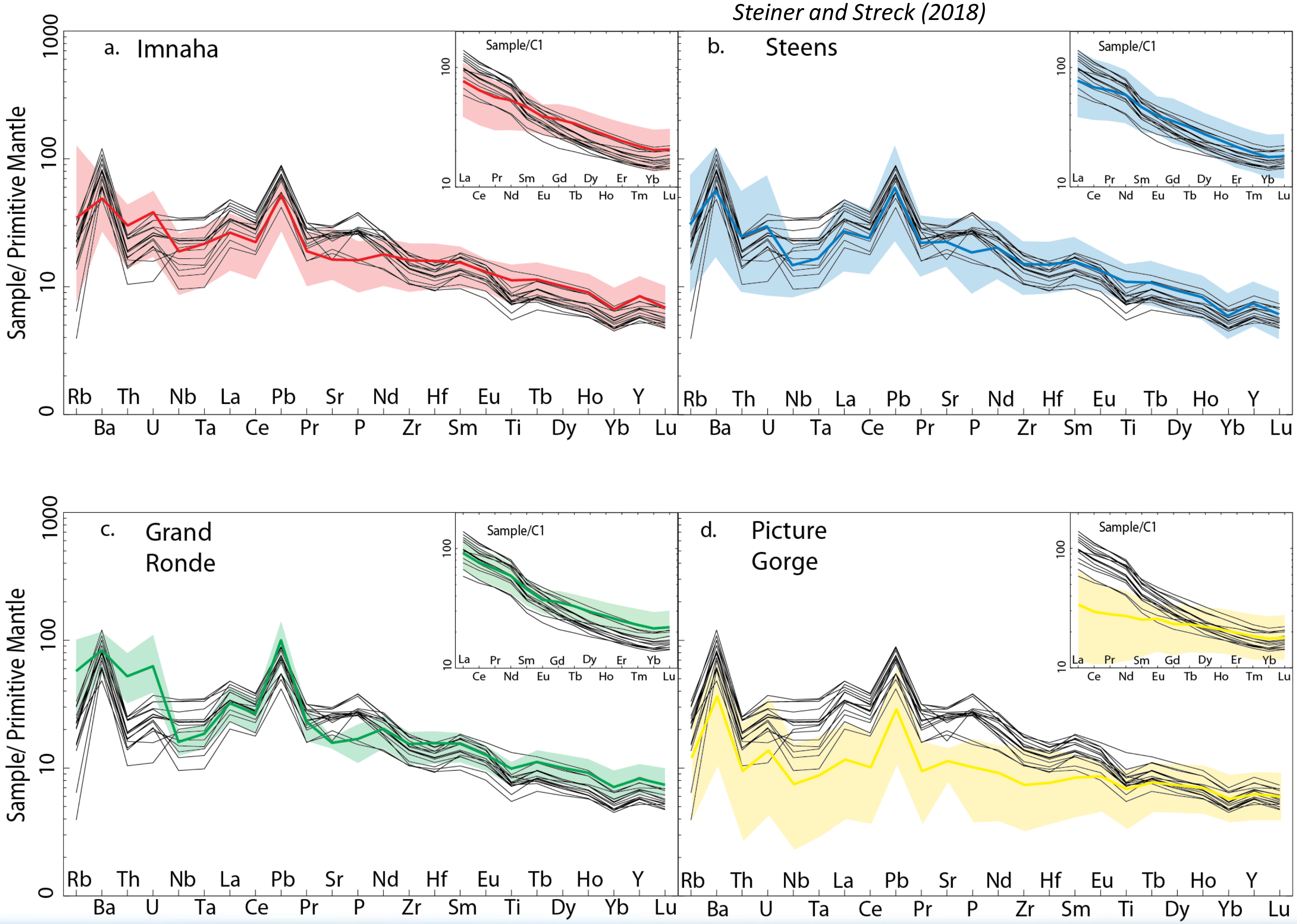
Calc-alkaline olivine and pyroxene are generally not in equilibrium with the melt but is in equilibrium with the basalt and tholeiitic intermediates

Generation of Calc-alkaline Lavas of the Strawberry Volcanics

- Parental lavas of the SV are tholeiitic
- Trace element patterns are nearly identical between the tholeiitic lavas and the calc-alkaline lavas
- FC can produce the High Nb tholeiitic group
- Calc-alkaline lavas become more depleted with silica enrichment
- Mixing with co-eruptive rhyolite can dilute the trace elements and cover compositional range

Comparison to the CRBG

Steiner and Streck (2018)



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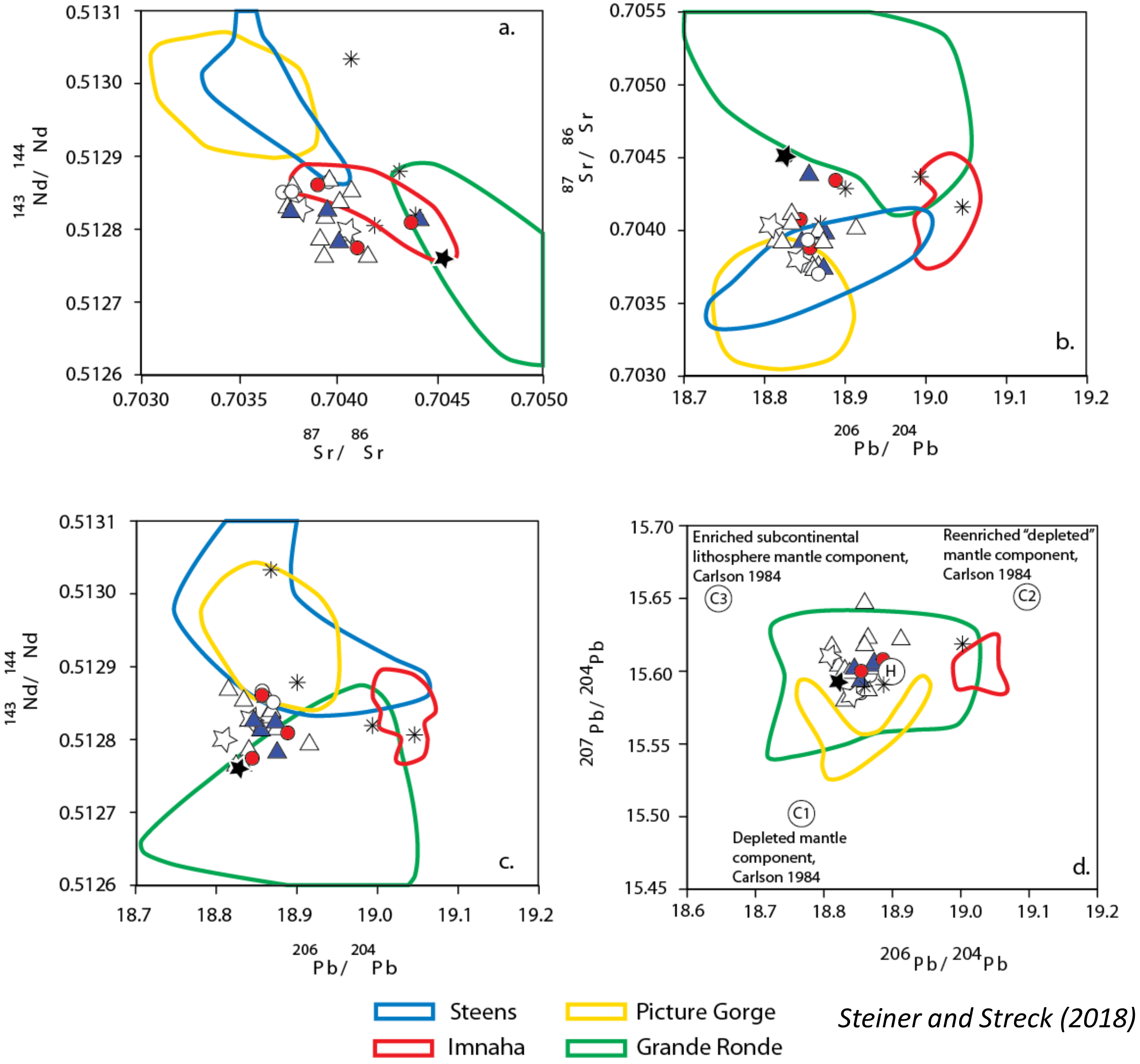

Steiner and Streck (2018)

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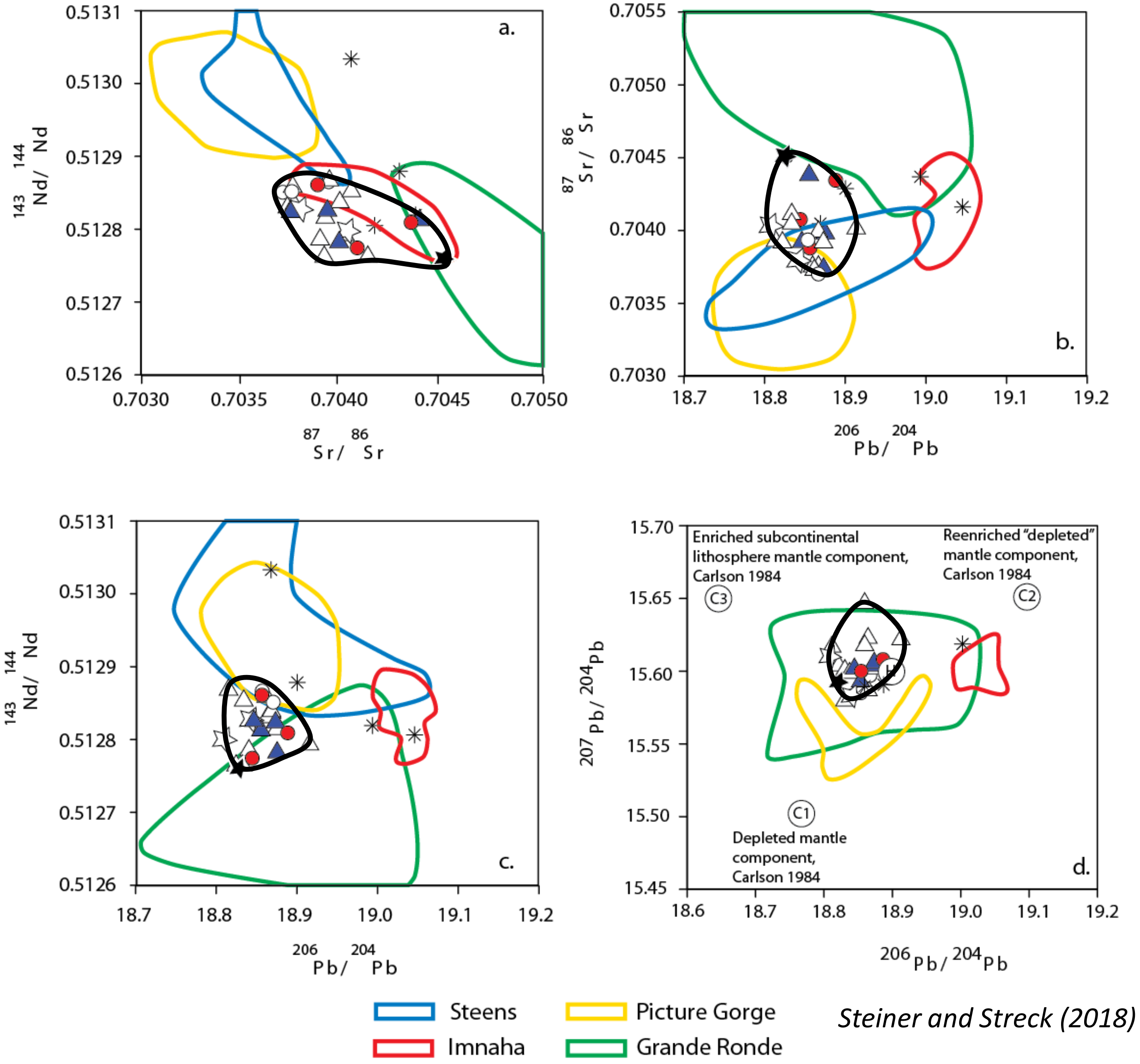

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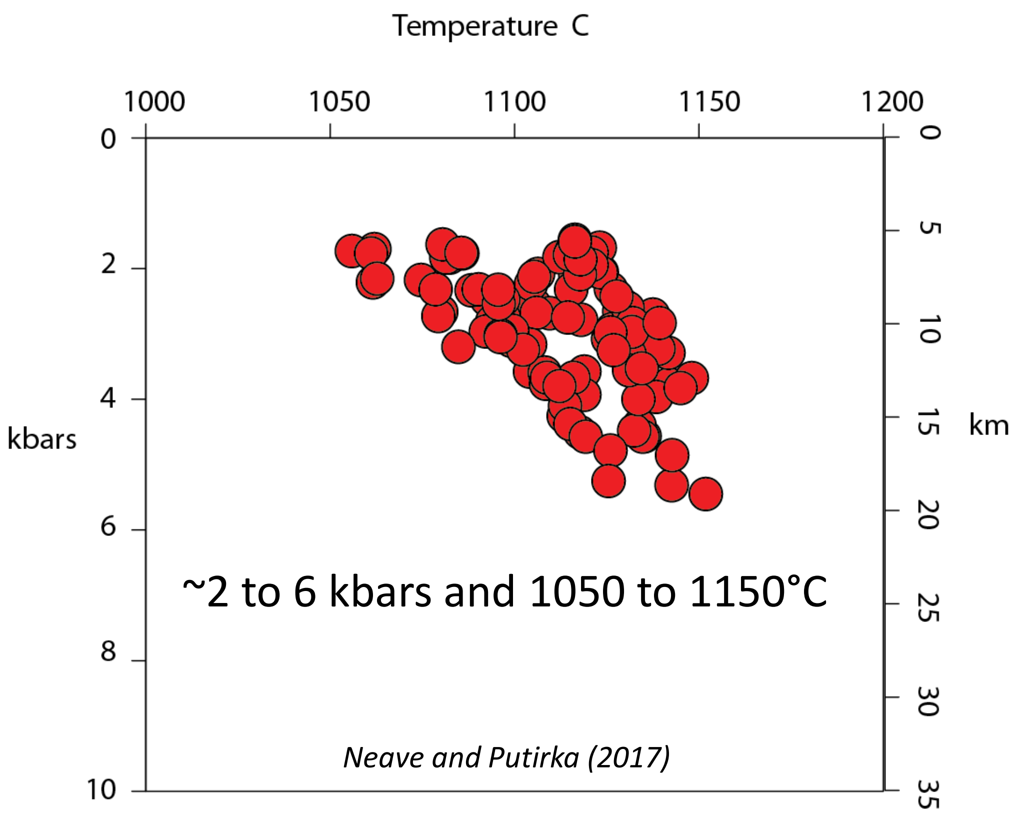
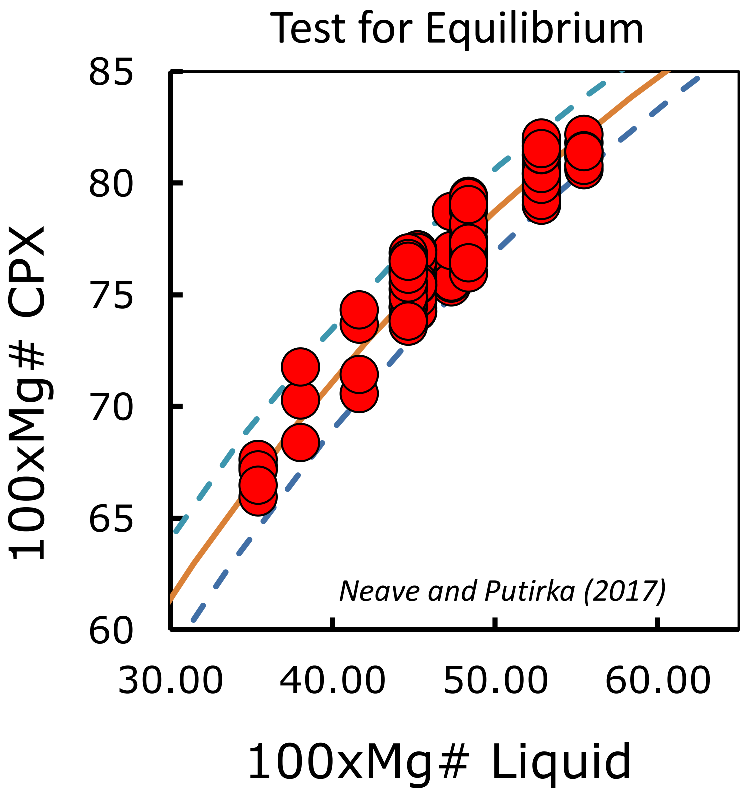
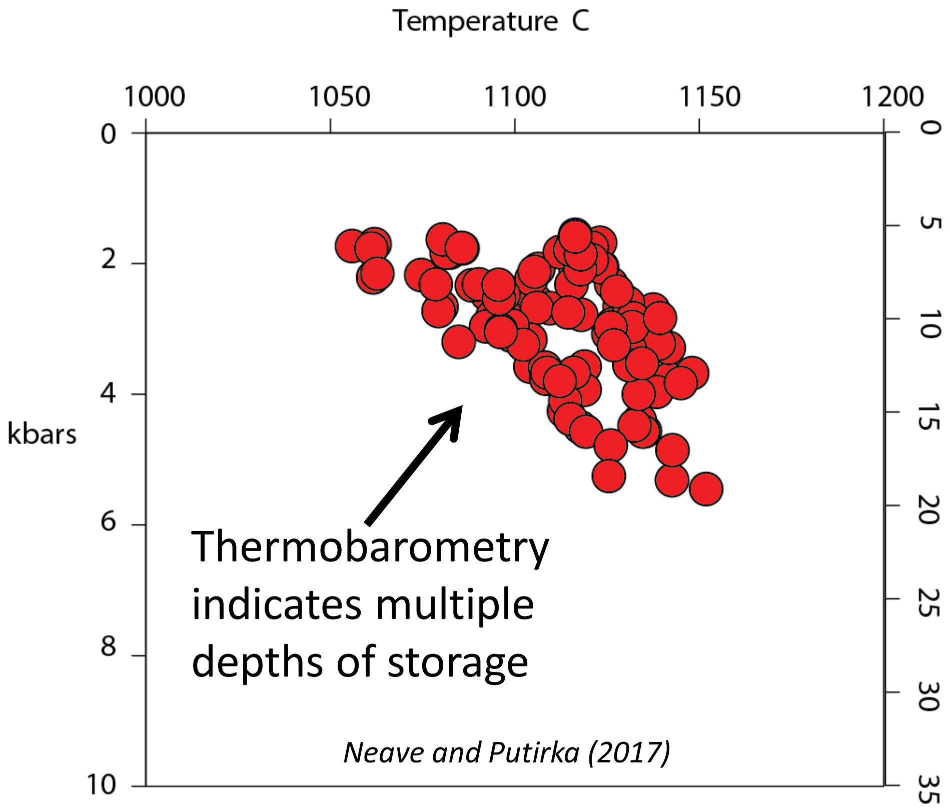
CPX Thermobarometry

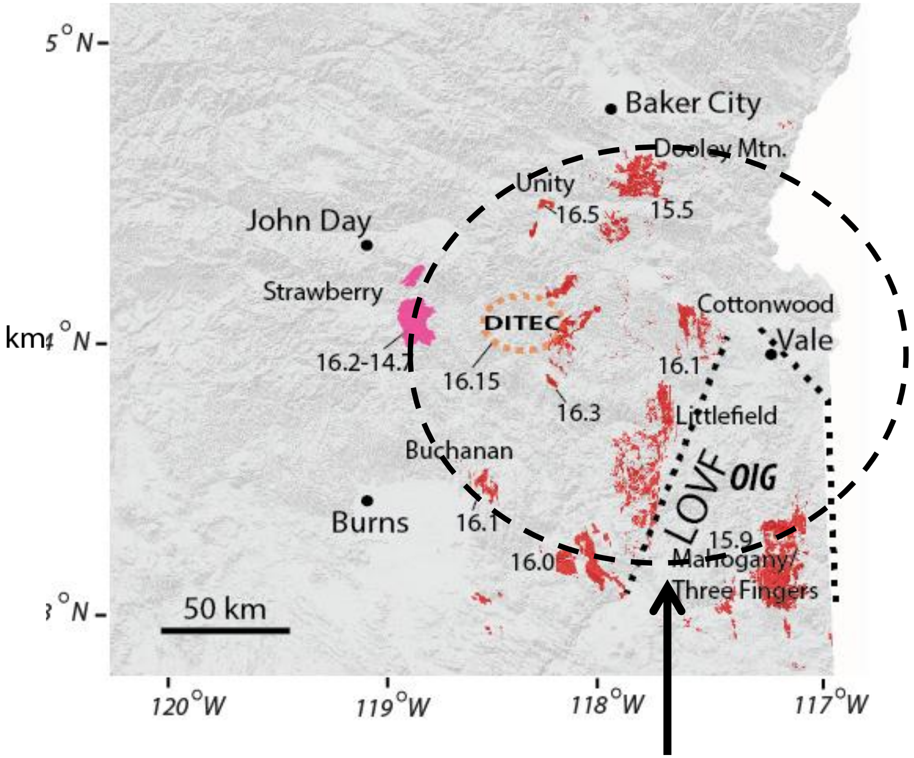




CPX Thermobarometry



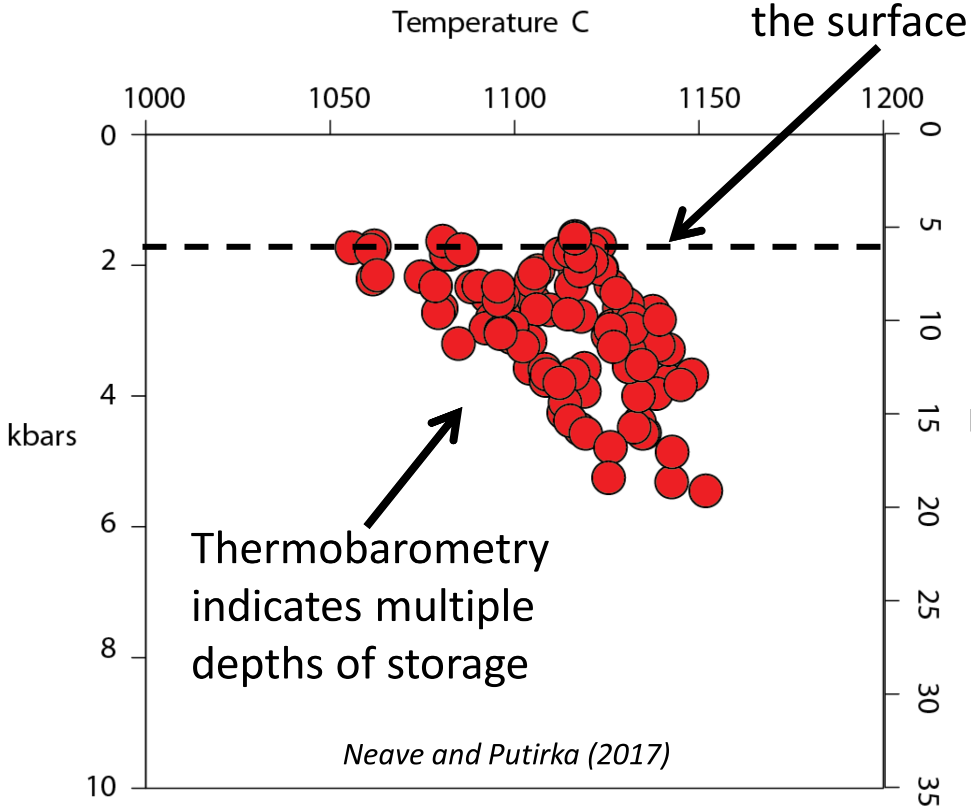
Hiatus of mafic/intermediate activity between ~16 to 15.5 Ma.

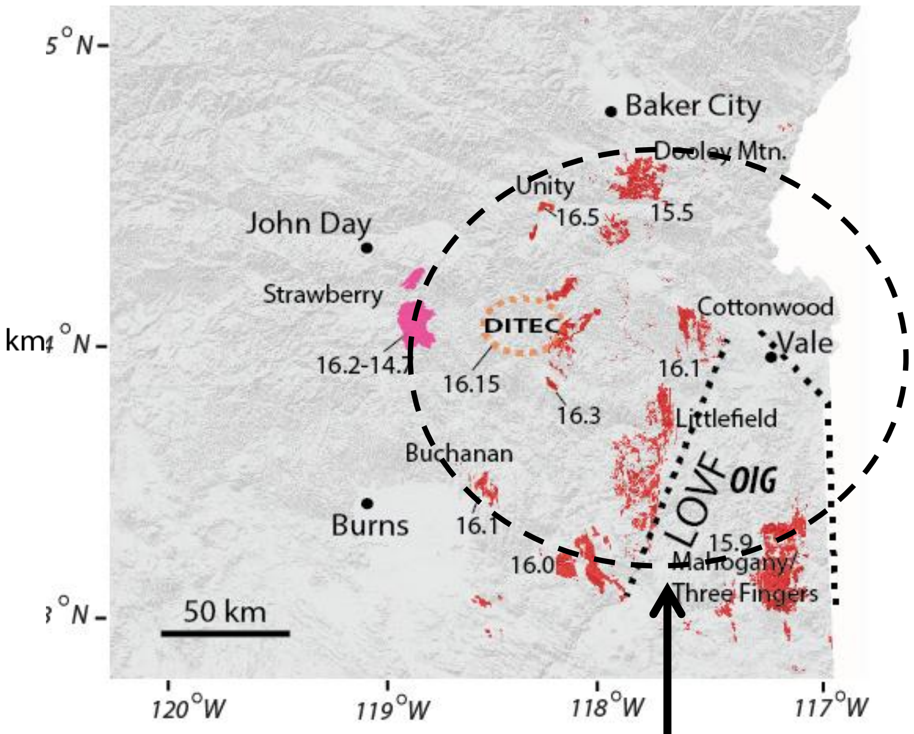


Proposed outline of crustal reservoirs.
(Wolff et al., 2008 and Streck et al., 2015)

CPX Thermobarometry

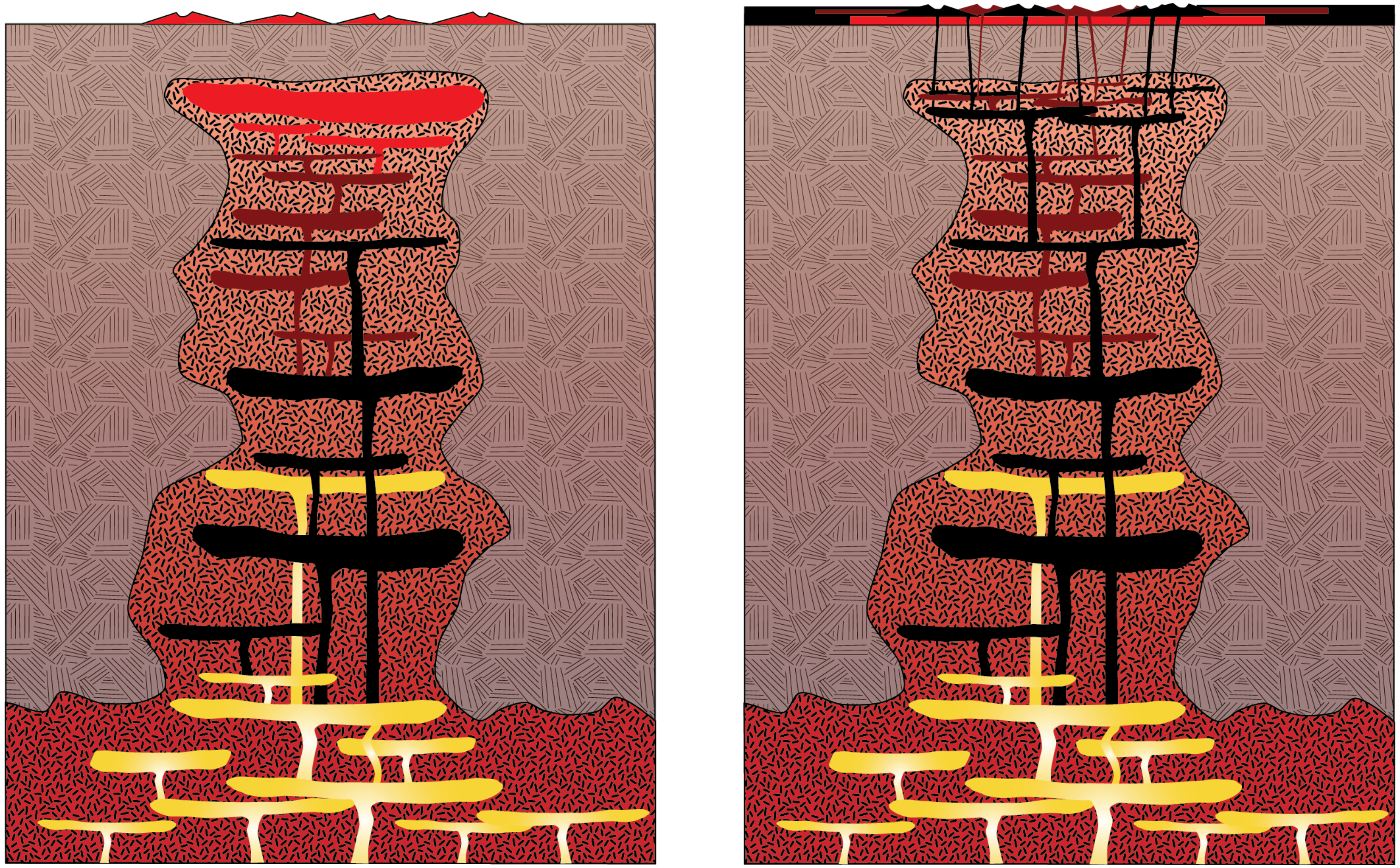
Rhyolites prevent CRB magmas from erupting to the surface

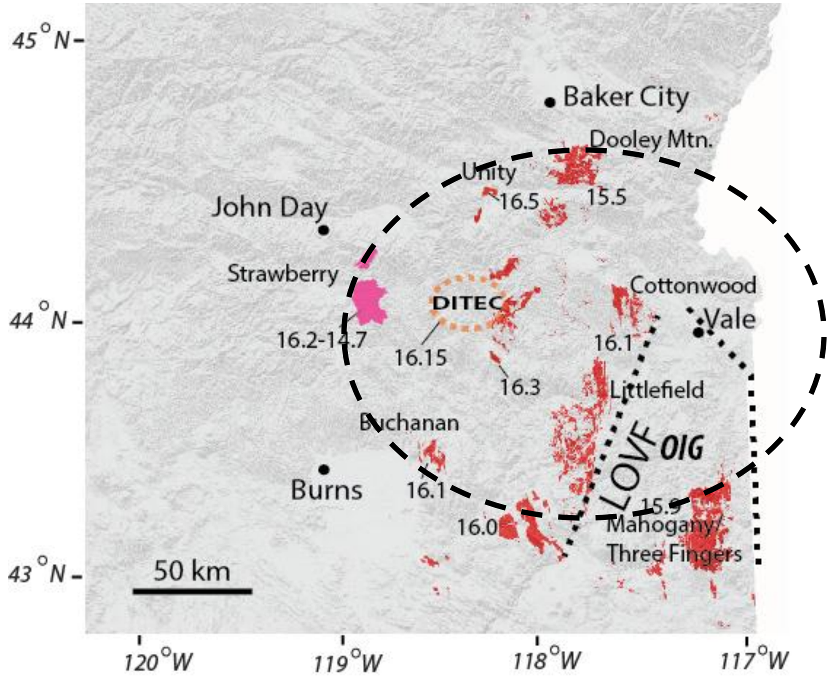




Strawberry, Powder River, Weiser Volcanics and CRB erupt after silicic eruptions.

Proposed outline of crustal reservoirs.
(Wolff et al., 2008 and Streck et al., 2015)

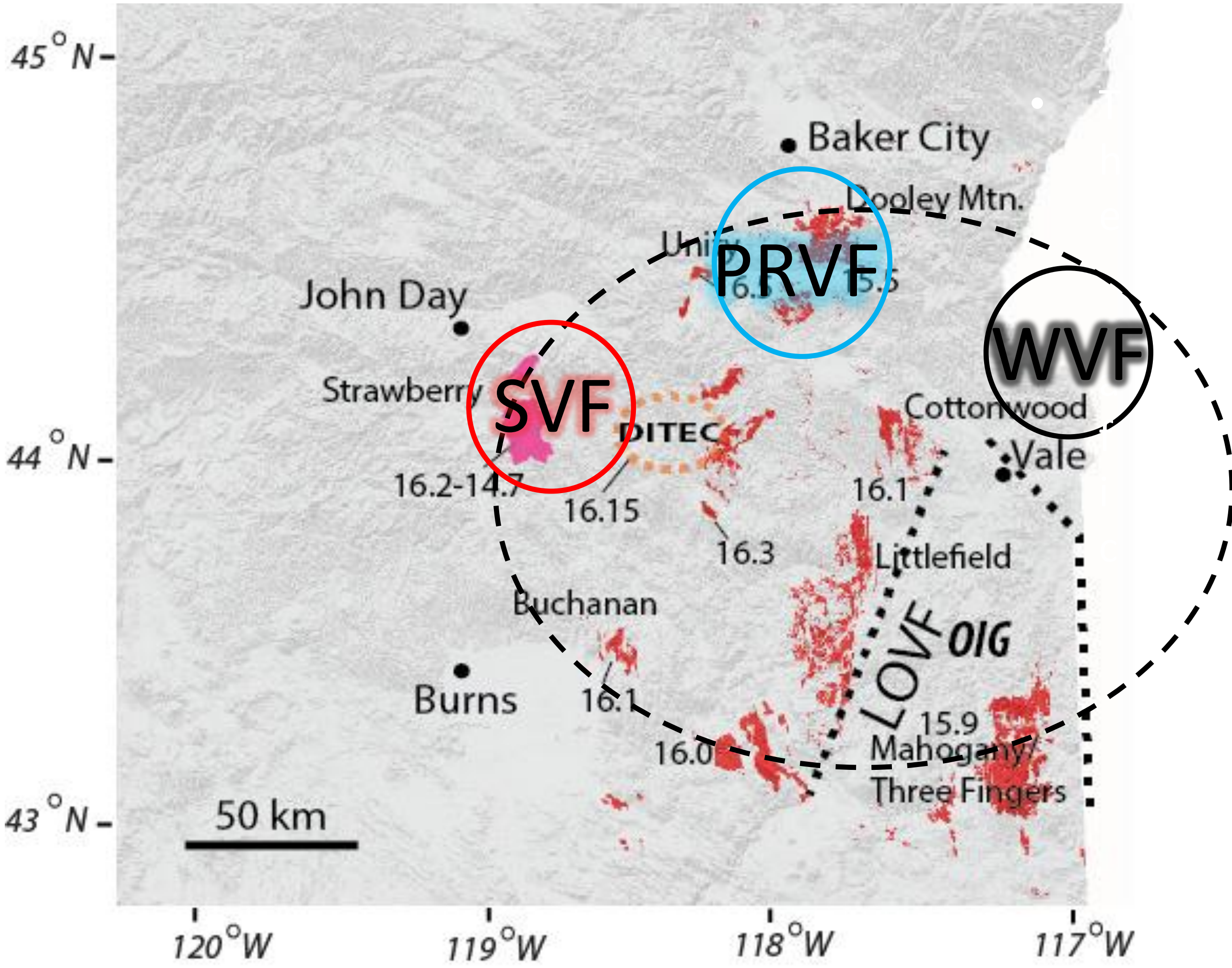



45° N
44° N
43° N
Baker City
Dooley Mtn.
Unity
16.5
15.5
John Day
Strawberry
DITEC
16.2-14.7
16.15
16.3
Cottonwood
Vale
16.1
Littlefield
Buchanan
OIG
LOVF
Burns
16.1
15.9
16.0
Mahogany/
Three Fingers
50 km
120°W
119°W
118°W
117°W

What's Left to do?
The Other Calc-Alkaline Volcanism.

No ICPMS trace element data for Weiser or Powder River calc-alkaline for a similar study

- Weiser Volcanic Field
  - Includes tholeiitic basalts, and mildly calc-alkaline andesites, and rhyolites
  - Rhyolites
    U/Pb age of 16.396 ± 0.008 Ma
    (Dennis Feeney IGS)
  - Andesites
    Ar/Ar plateau age of 15.1 ± 0.16
    (Dennis Feeney IGS)
  - Basalts
    U/Pb of Ash confines an age of 14.901 ± 0.014 Ma
    (Dennis Feeney IGS)



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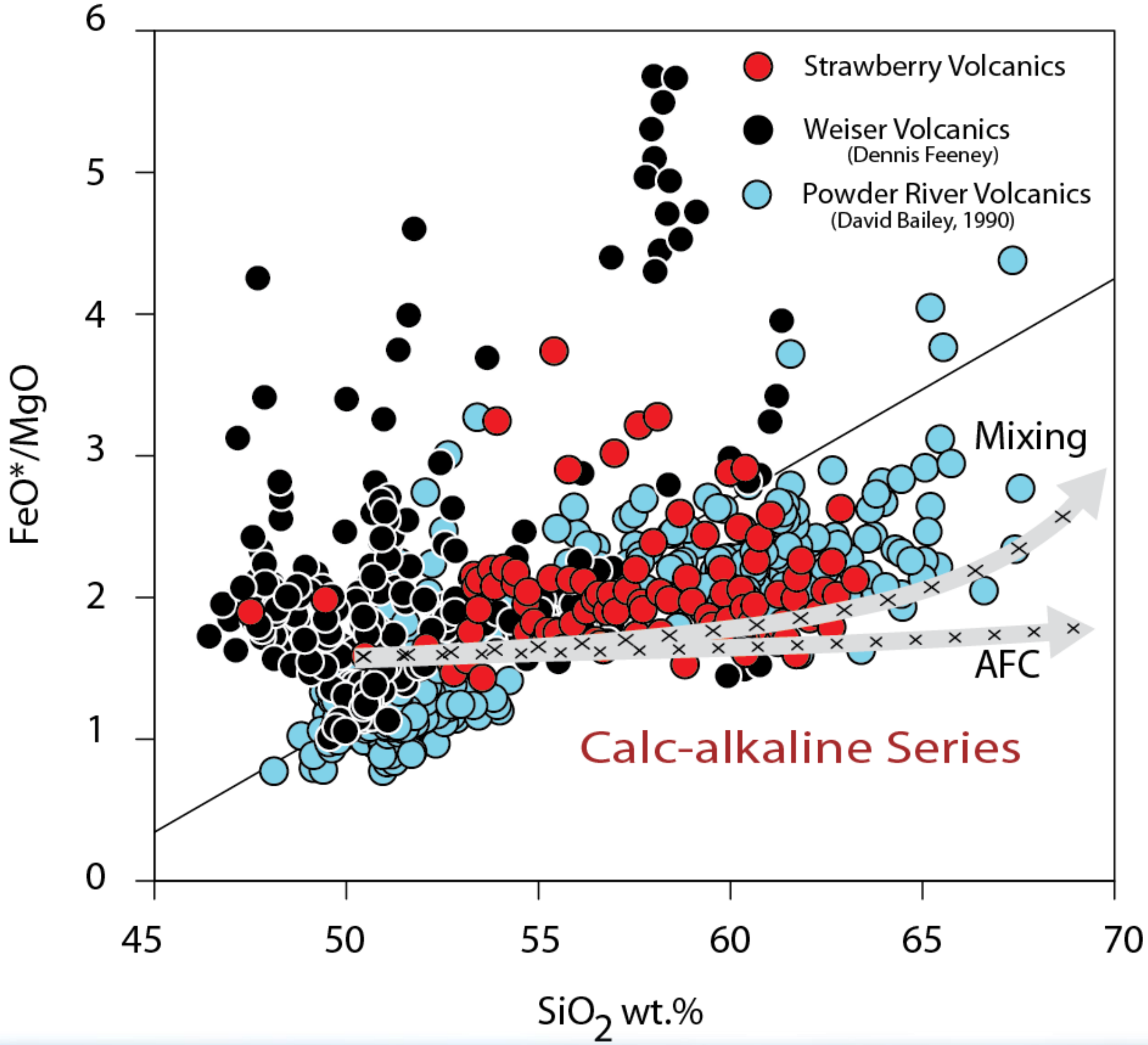
The Other Calc-Alkaline Volcanism.



Conclusions

- Tholeiitic and calc-alkaline lavas have similar geochemistry and a common parent basalt.
- Calc-alkaline lavas must be derived from open system processes while tholeiitic lavas can be generated by FC.
- Major and trace element geochemistry overlaps with the CRBG.
- Trace element and isotopic ratios suggest a similar melting source to the CRBG.
  - Specifically Steens and Imnaha
- Mineral chemistry of the calc-alkaline lavas indicate they may have been more primitive lava prior to interacting with rhyolite or crust
- Thermobarometry of cpx indicate variable crystallization depths and may suggest a crystal mush than discrete magmatic chambers.
  - This may provide an exchange in mush product and generate variable but common magma types
- No crystallization of cpx between 0 -~6 km
  - Rhyolite may be stored in this zone and preventing mafic and intermediate magmas to the surface
  - After the rhyolites erupt, the mafic and intermediates are able to ascend through the crust and may interact with leftover liquids or crystal residue.