Update on Volcanism Investigations

Nuclear Waste Technical Review Board
Structural Geology and Geoengineering Panel

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San Francisco, CA

Presented by:

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Volcanism Studies

- **Characterization of Volcanic Features** (Frank Perry, PI)
  1. Geochronology studies
  2. Field Geologic studies
  3. Geochemistry studies
  4. Evolution of volcanic fields
  5. Volcanism drill holes

- **Probability of Magmatic Disruption of the Repository** (Bruce Crowe, PI)
  1. Location and timing of volcanic events
  2. Structural controls of basaltic volcanism
  3. Presence of magma bodies
  4. Probability calculations

- **Physical Processes and Effects of Magmatism** (Greg Valentine, PI)
  1. Eruptive effects
  2. Subsurface effects
  3. Dynamics of basaltic volcanism

Recent progress:

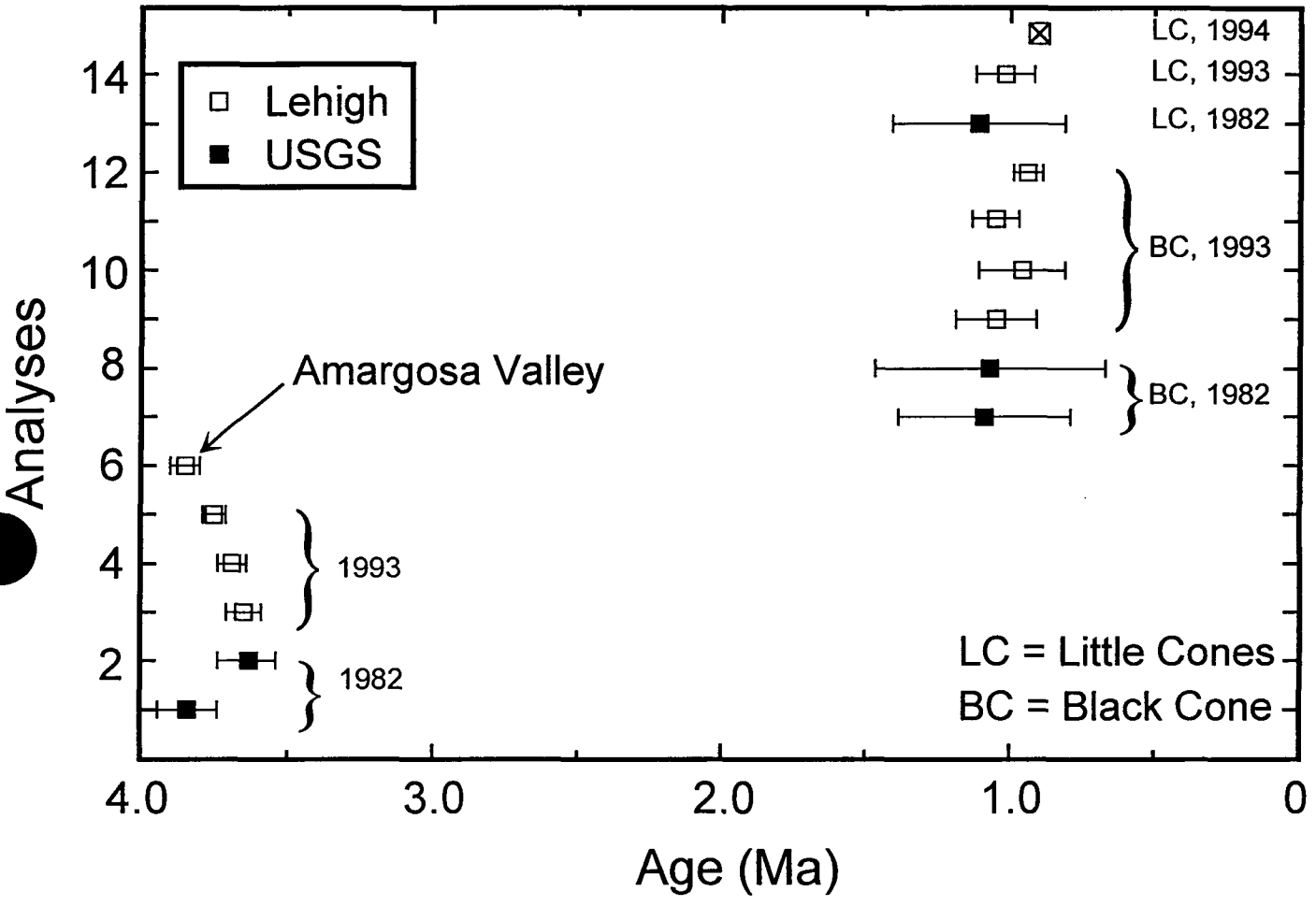
- **Regional geochronology well under way**
  1. Lehigh University and NM Bureau of Mines under contract for $^{40}Ar/^{39}Ar$
  2. 50% of post-Miocene centers and 1 aeromagnetic anomaly have been dated

- **Geochemical, geochronologic sampling continuing for rest of CFVZ, Buckboard Mesa**

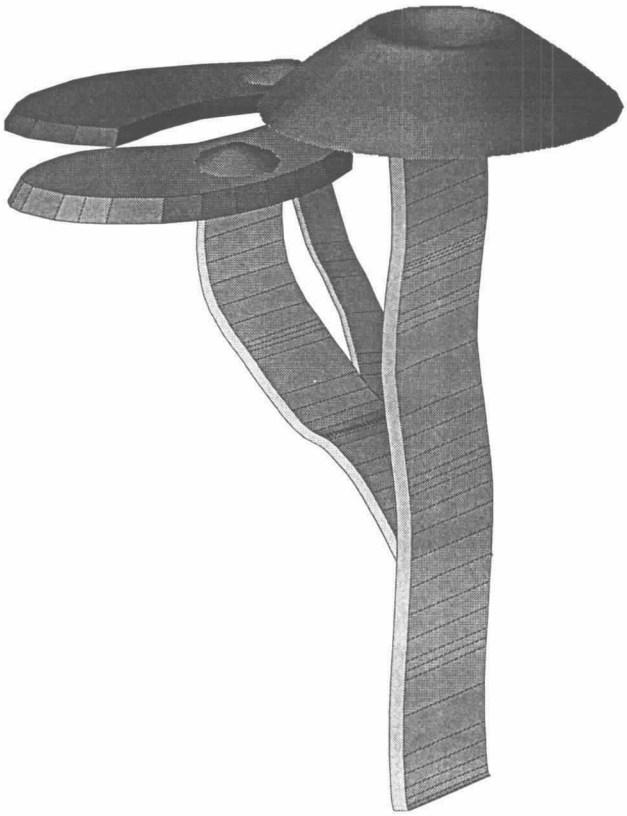
- **Work at Lathrop Wells in wrap-up phase**
  1. Four-episode polycyclic model established
  2. Minimum of 6-8 magma batches indicated by geochemistry
  3. Tuff sanidine separates being used to refine chronology

- **Magmatic effects studies underway**
  1. Field studies of analog centers at Paiute Ridge and Alkali Buttes complete
  2. Sensitivity studies begun for modeling liquid and vapor flow in the unsaturated zone in response to magmatic intrusion

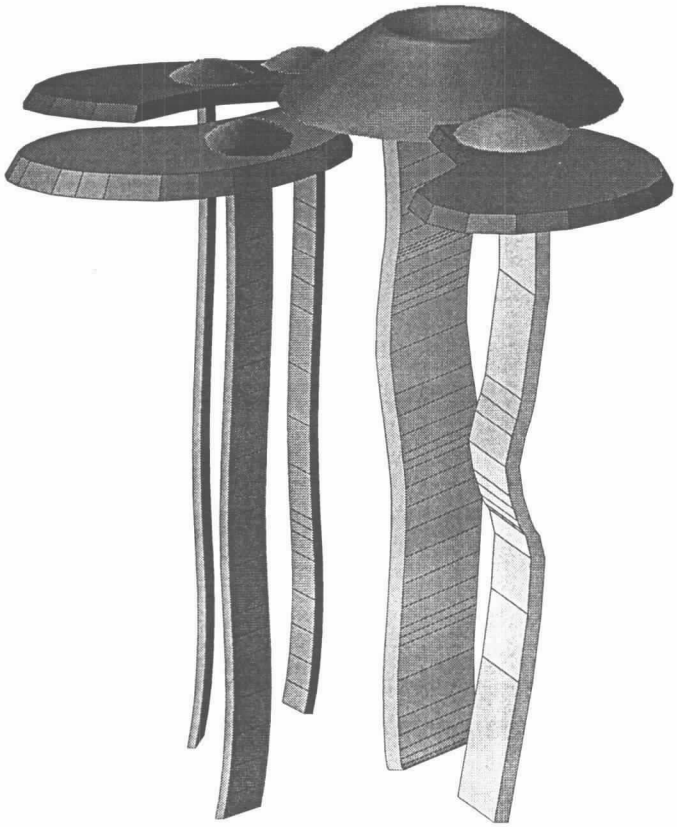
Crater Flat ages, comparison of Vaniman et al., 1982 dates (USGS), 1993 Lehigh dates, 1994 NMBM sanidine date



Monogenetic



Polycyclic

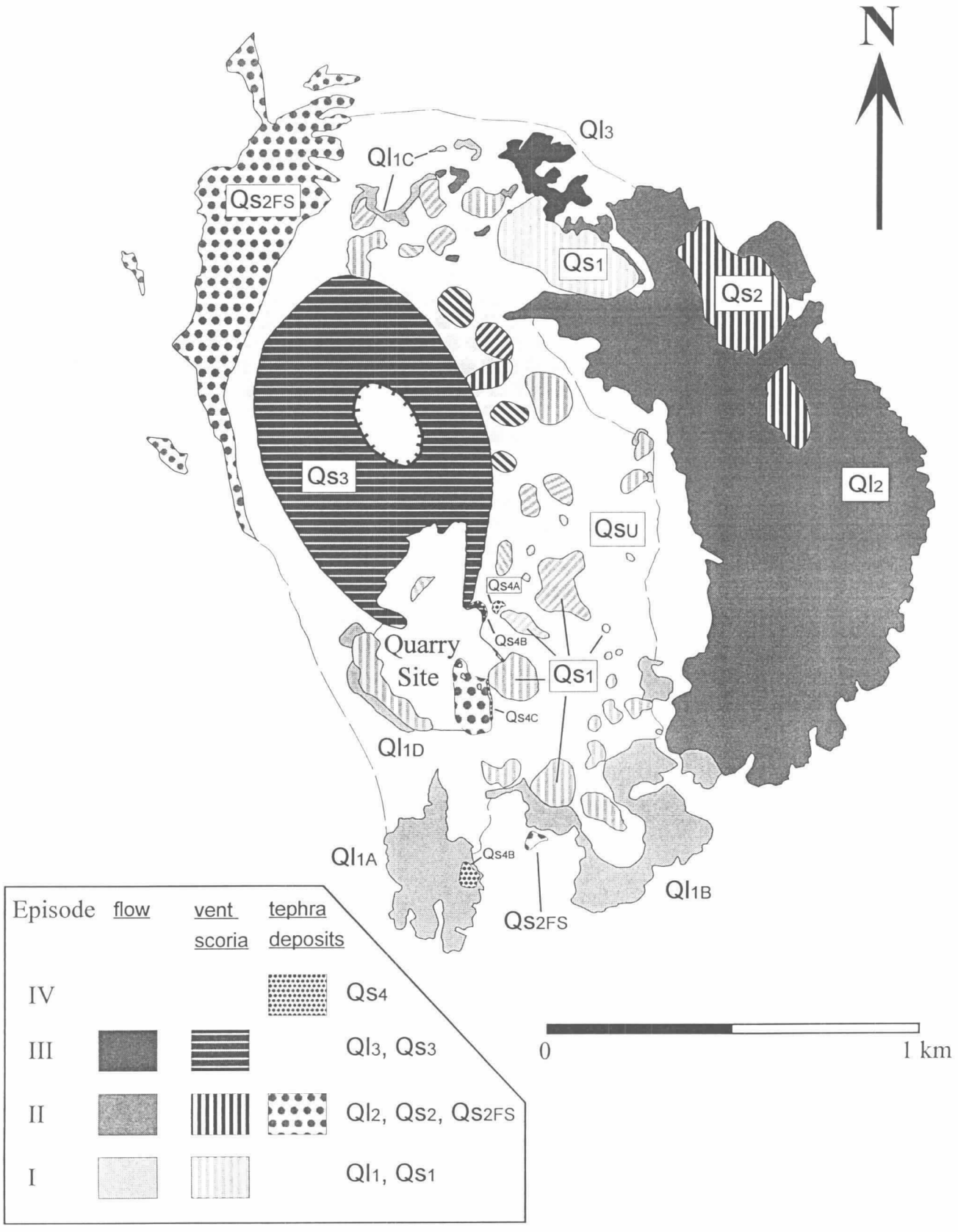


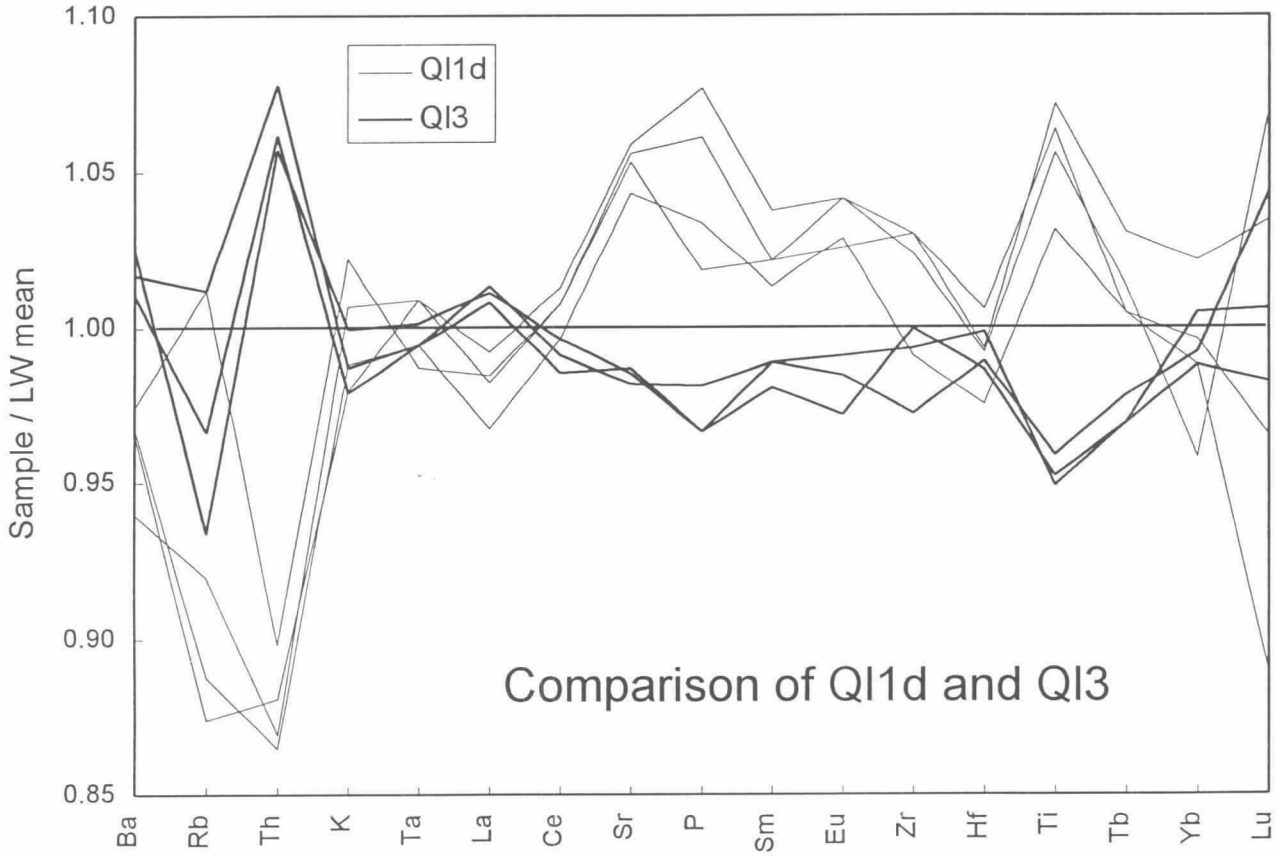
Polycyclic Volcanism at Lathrop Wells

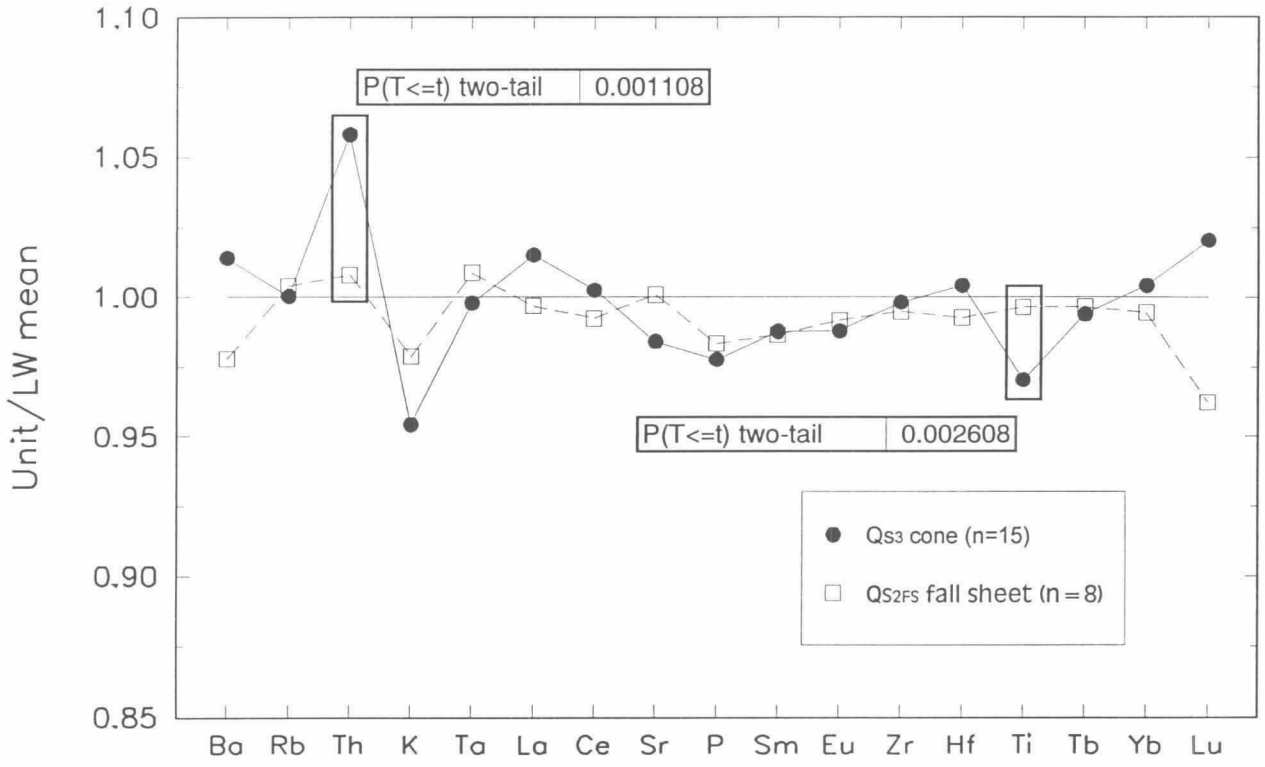
- Previously unrecognized class of volcano
- Field and geochronology studies indicate multiple, time-separate eruptive episodes
- Geochemistry indicates multiple, independent magma batches
- Holocene eruptions indicate center is probably still within a polycyclic period
- **Implications for volcanic risk assessment**

1. Effects studies must consider multiple intrusive episodes
2. Provides constraint on location of future volcanism (monogenetic volcanism: future eruption forms new volcano at unconstrained location)
3. Disruption probability calculations that assume random distribution within event zones are conservative
4. ***The most likely volcanic event in the Yucca Mountain region during the next 10,000 years is another eruption at the Lathrop Wells center***

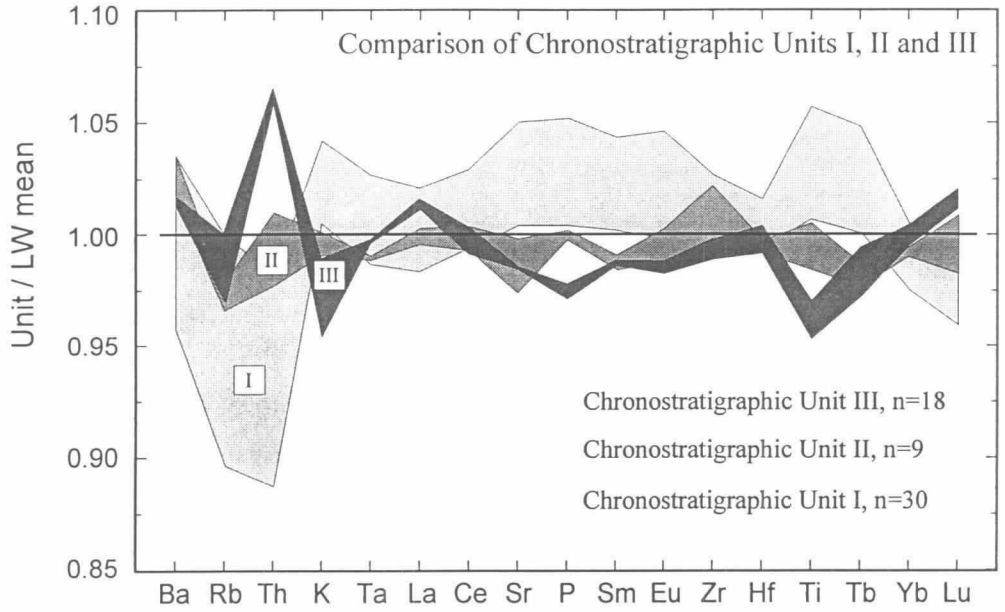
Lathrop Wells Volcanic Center

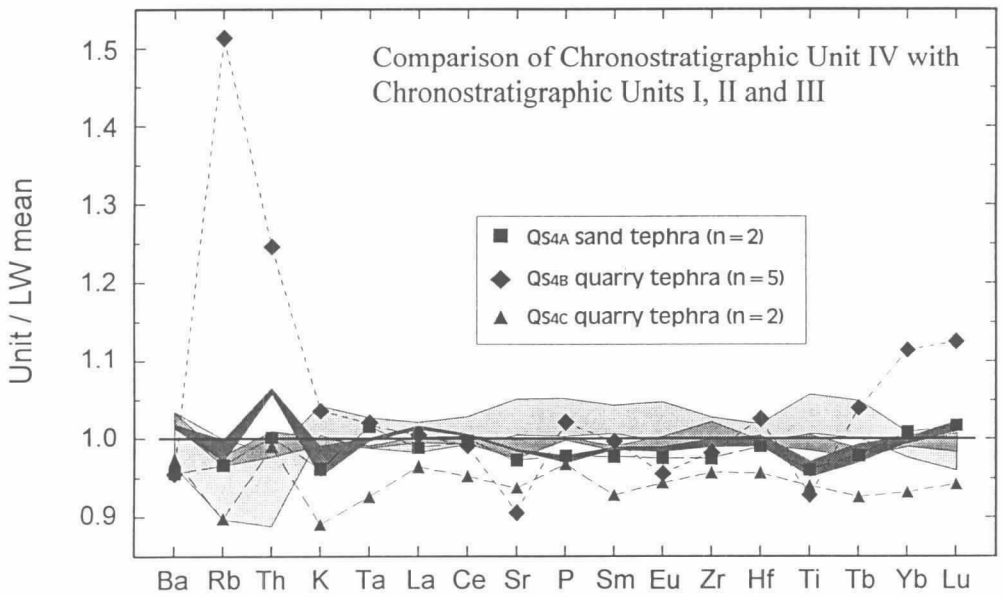



Ql1d
Ql3
Sample / LW mean
1.10
1.05
1.00
0.95
0.90
0.85
Ba
Rb
Th
K
Ta
La
Ce
Sr
P
Sm
Eu
Zr
Hf
Ti
Tb
Yb
Lu
Comparison of Ql1d and Ql3

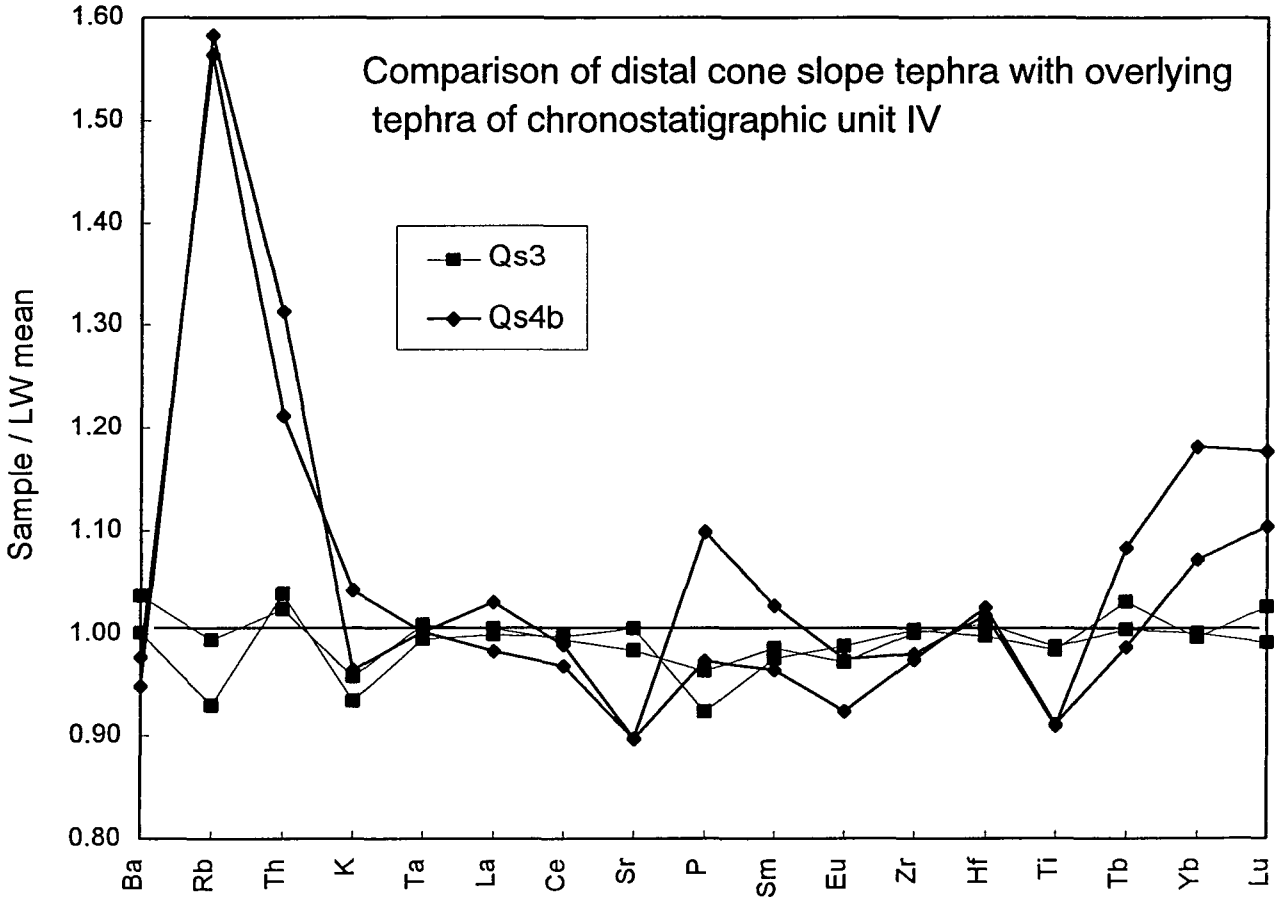

1.10
1.05
1.00
0.95
0.90
0.85
Unit/LW mean
P(T<=t) two-tail 0.001108
P(T<=t) two-tail 0.002608
Qs3 cone (n=15)
Qs2FS fall sheet (n=8)
Ba Rb Th K Ta La Ce Sr P Sm Eu Zr Hf Ti Tb Yb Lu

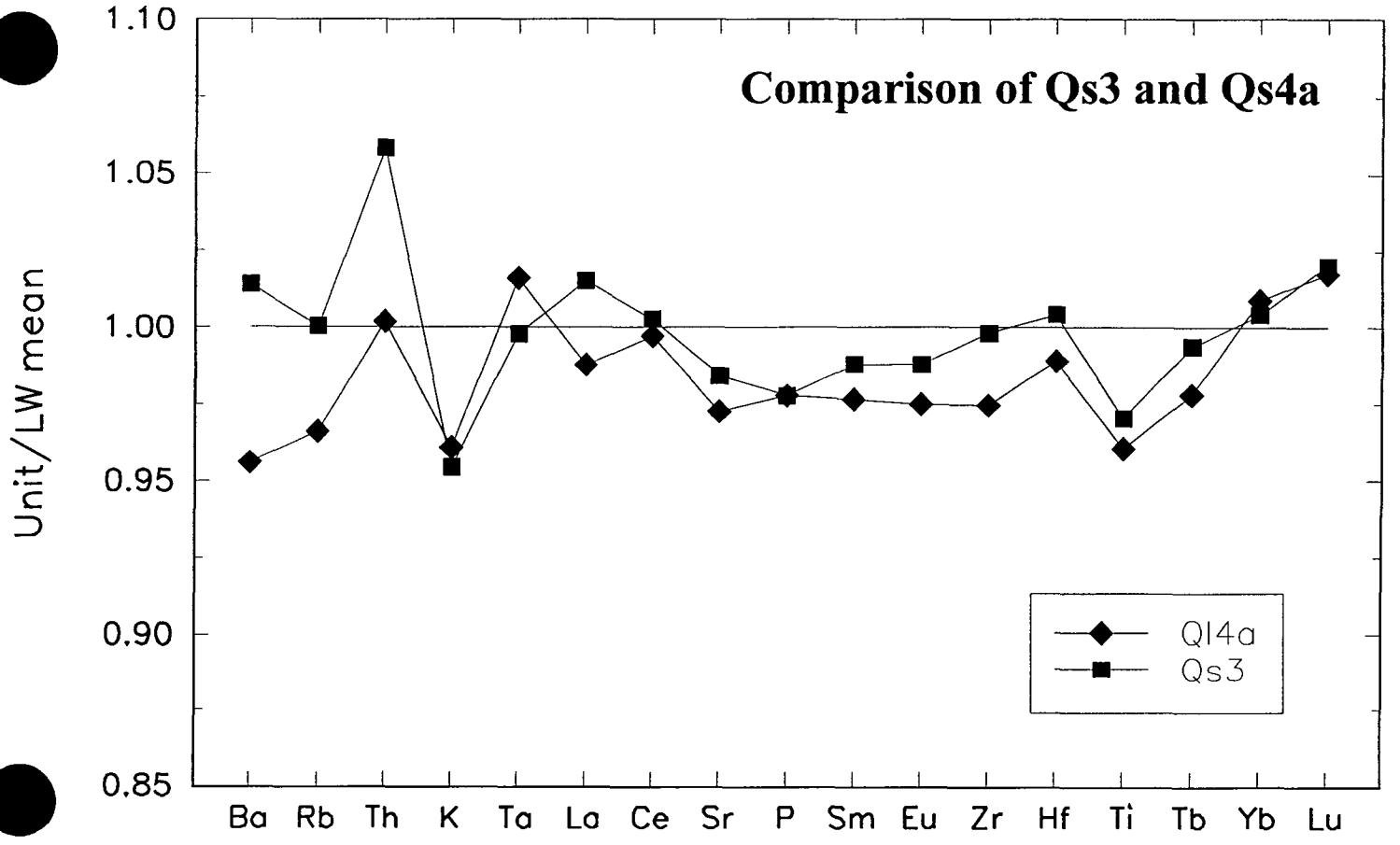
Geochemical Variations at the Lathrop Wells Volcanic Center



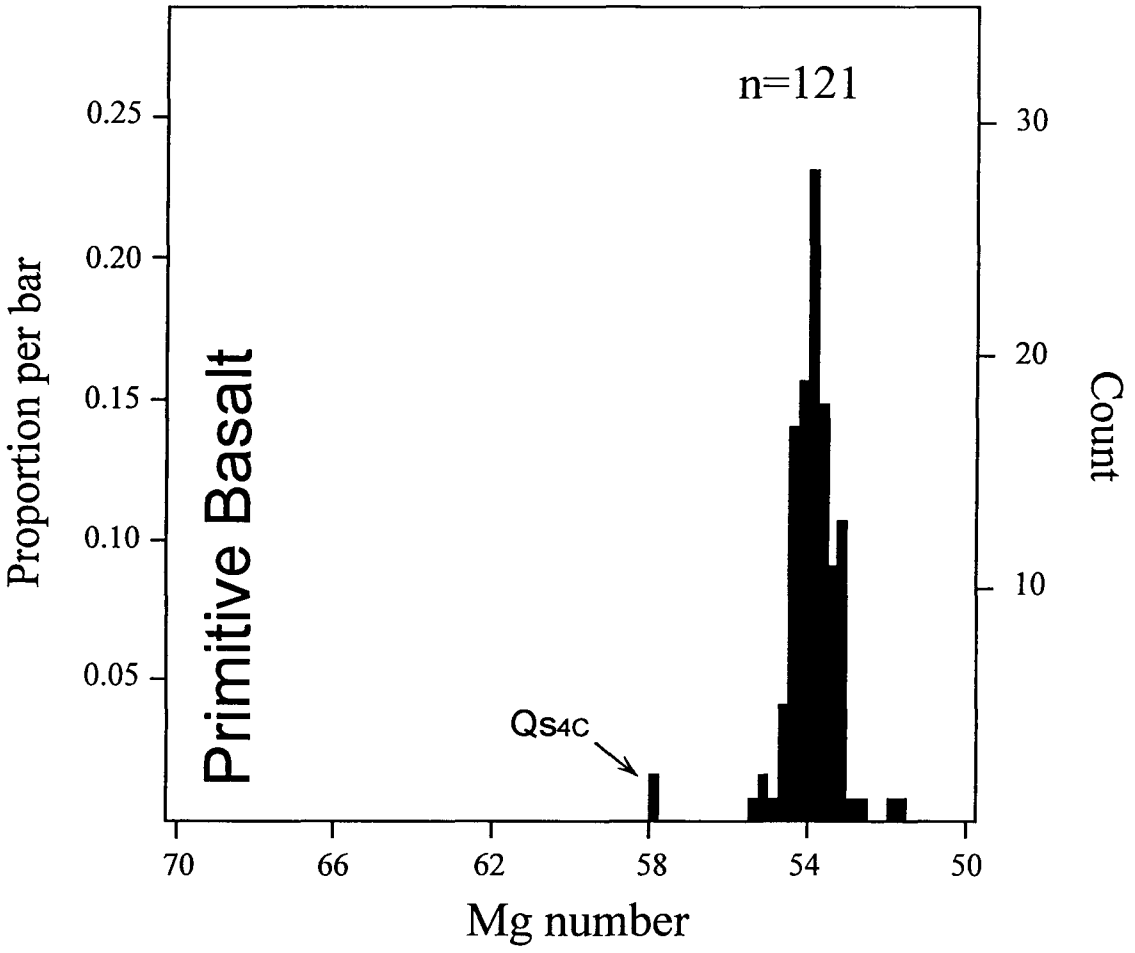


Four field photographs showing evidence of Holocene eruptions at the Lathrop Wells volcanic center.

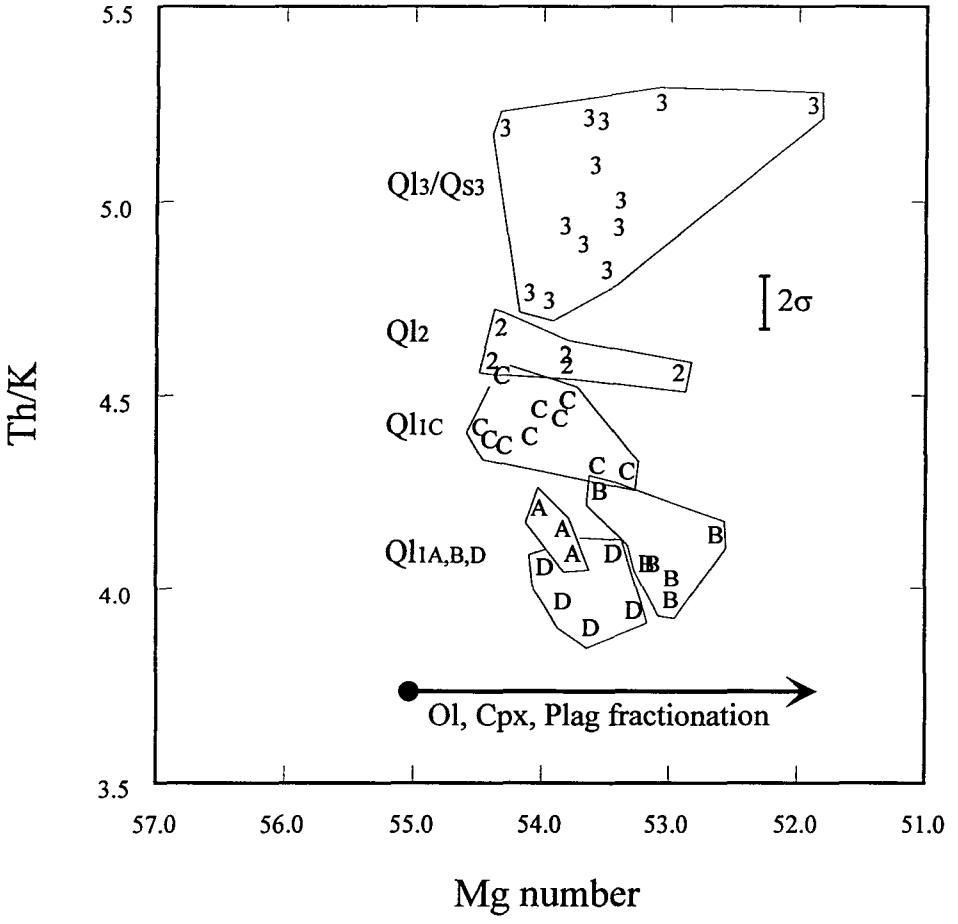

Comparison of distal cone slope tephra with overlying tephra of chronostatigraphic unit IV
Qs3
Qs4b
Sample / LW mean
1.60
1.50
1.40
1.30
1.20
1.10
1.00
0.90
0.80
Ba
Rb
Th
K
Ta
La
Ce
Sr
P
Sm
Eu
Zr
Hf
Ti
Tb
Yb
Lu


Comparison of Qs3 and Qs4a
Unit/LW mean
1.10
1.05
1.00
0.95
0.90
0.85
Ba Rb Th K Ta La Ce Sr P Sm Eu Zr Hf Ti Tb Yb Lu
Ql4a
Qs3

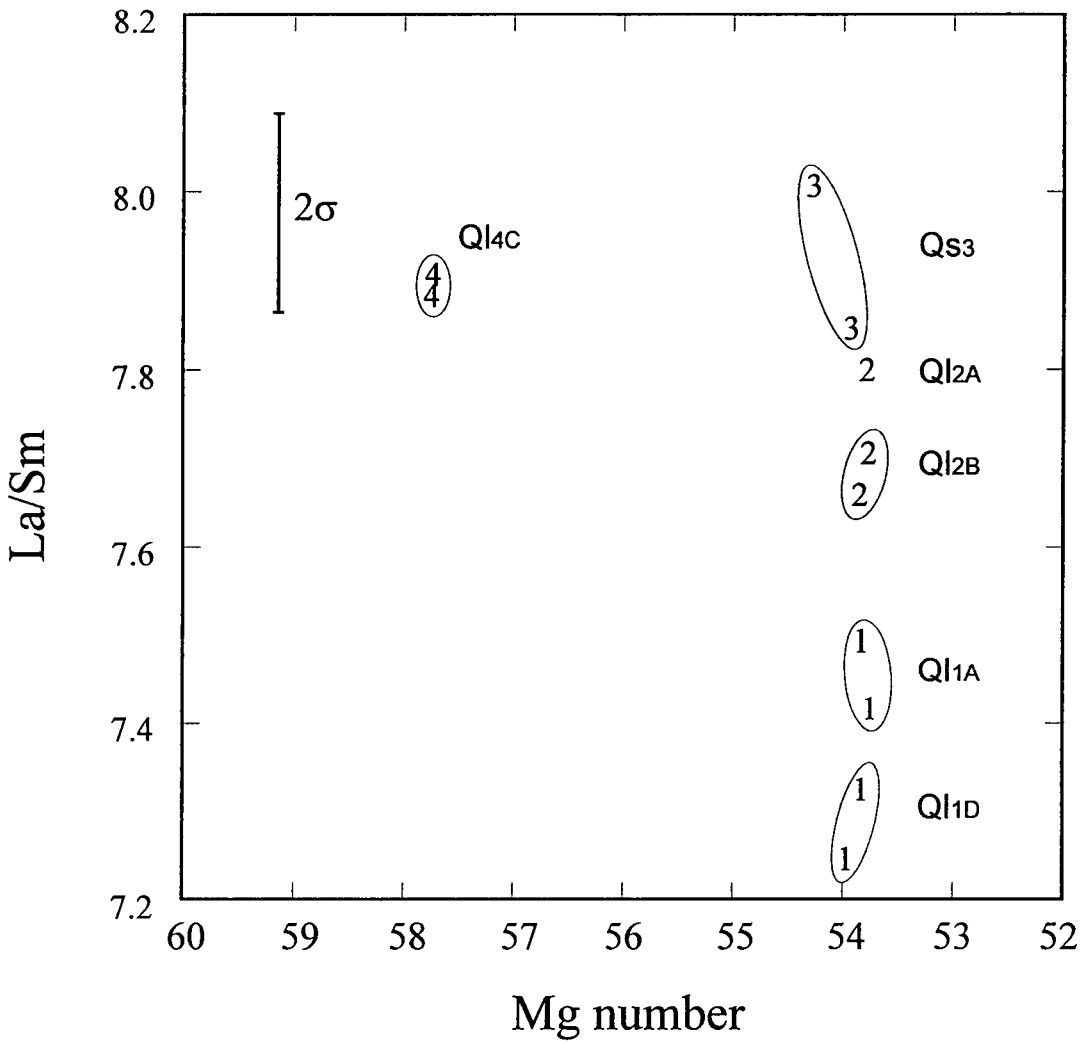
Lathrop Wells



Lathrop Wells



Lathrop Wells

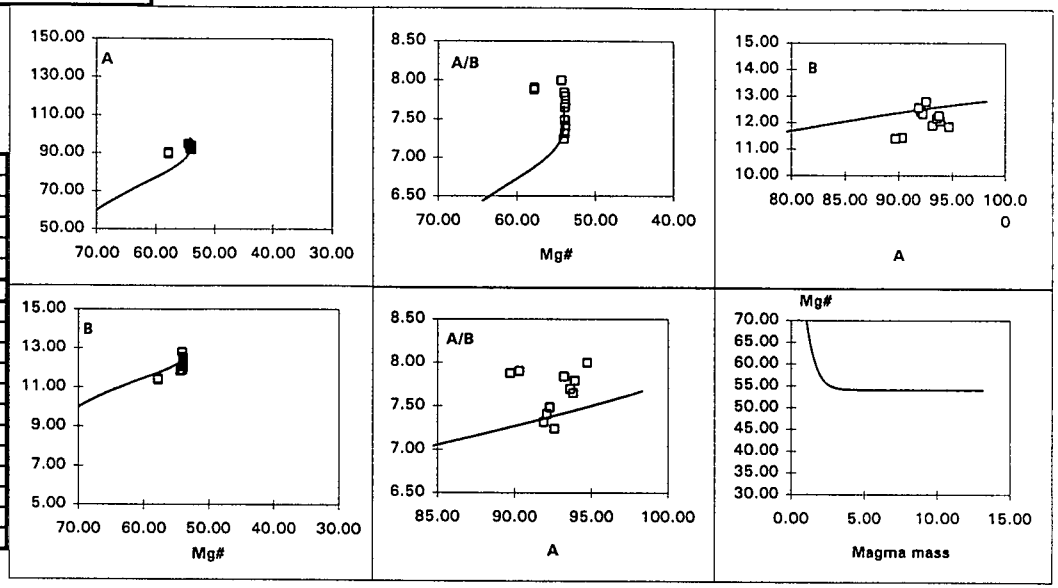


FEAR model to calculate Mg# and trace-element composition of a basaltic magma

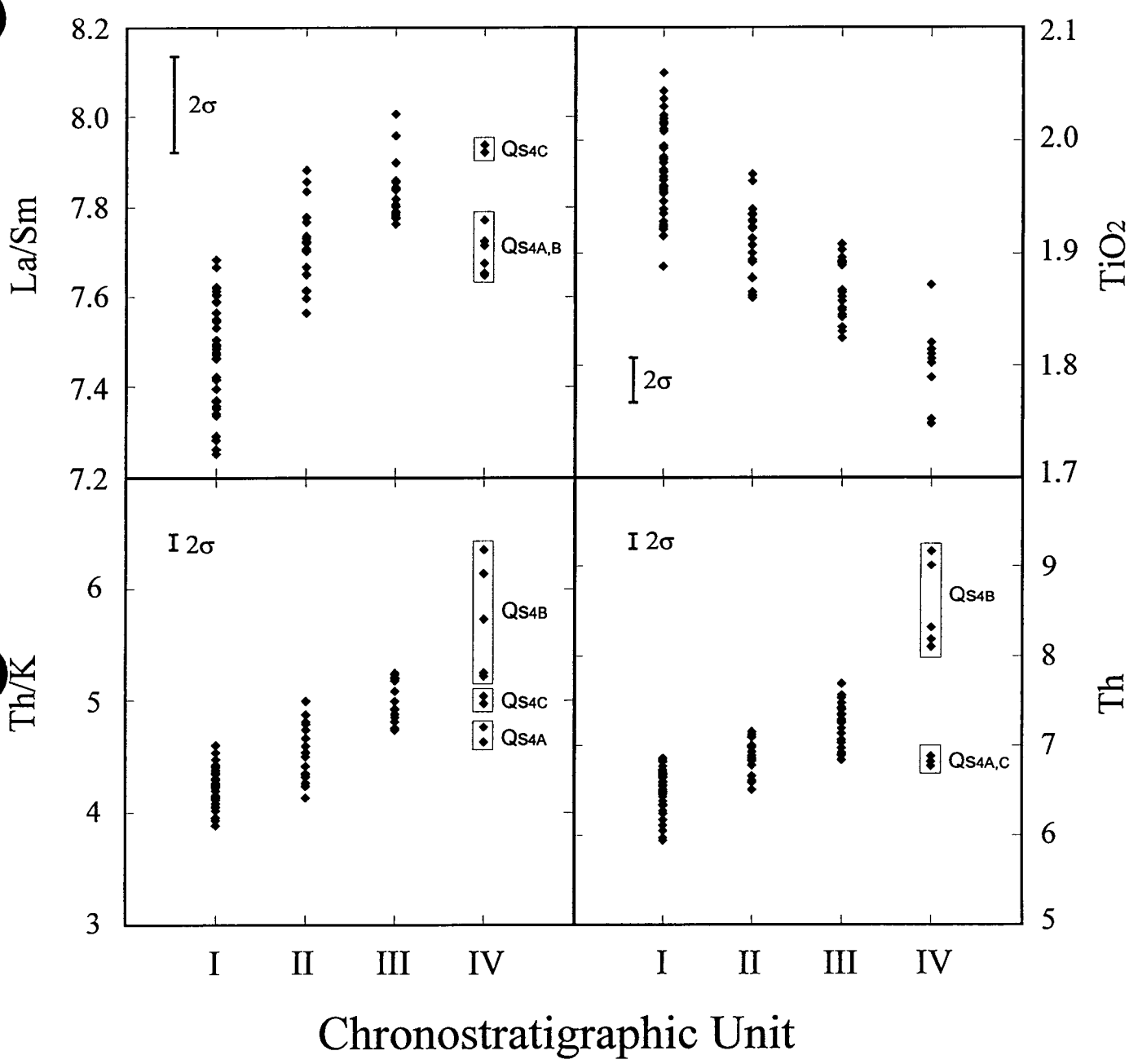
(Olivine and Clinopyroxene (Di-Hd) fractionation)

Element A is:	La	Element B is:	Sm

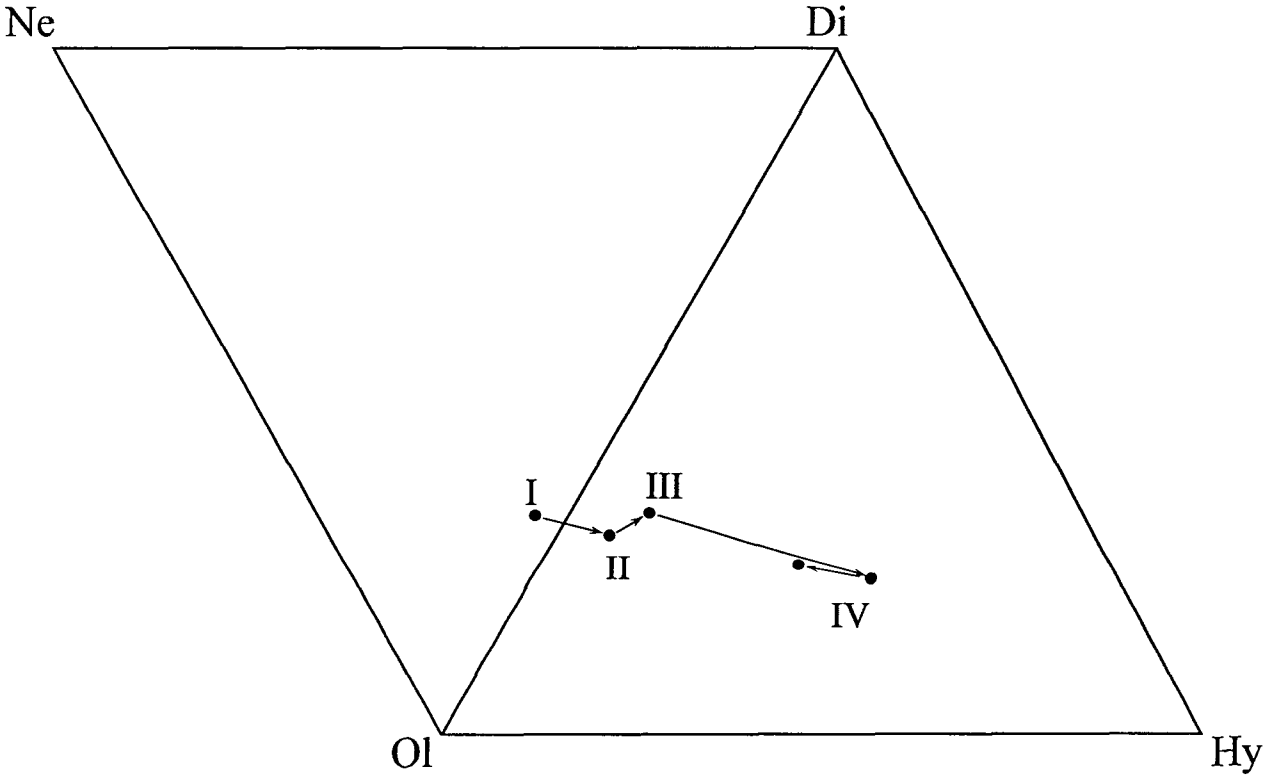
Assimilation rate	0.00				
Recharge rate	2.22				
Eruption rate	0.00				
Initial mass of magma	1.00				
crystallization increment	0.0050				
Mg# of magma	70.00		Magma	Recharge	Assim
MgO content of magma	14.00	FeO	10.70	10.70	2.00
Mg# of recharging magma	70.00	MgO	14.00	14.00	0.02
MgO content of recharging magma	14.00	Fe	0.1489	0.1489	0.0278
Mg# of assimilate	2.00	Mg	0.3474	0.3474	0.0006
FeO content of assimilate	2.00	Mg#	70.00	70.00	2.00
Conc. of element A in magma	60.00		Partition coefficients		
Conc. of element B in magma	10.00			Ol	Cpx
Conc. of element A in recharge	60.00		La	0.0001	0.1346
Conc. of element B in recharge	10.00		Nd	0.0002	0.4874
Conc. of element A in assimilate	60.00		Sm	0.0015	0.6693
Conc. of element B in assimilate	10.00		Pb	0.0010	0.0500
Prop. of Ol in xl assemblage	0.25		Rb	0.0006	0.0104
Prop. of Cpx in xl assemblage	0.75		Th	0.0009	0.0467
Fe-Mg Kd for Olivine	0.32		Sr	0.0010	0.1199
Fe-Mg Kd for Cpx	0.25		Ni	21.1200	4.1190
Fe-Mg Kd for bulk	0.27		Co	1.2542	1.7446
D (A) for Olivine	0.0001		Sc	0.2457	6.3553
D (B) for Olivine	0.0015		K	0.0006	0.0104
D (A) for Cpx	0.1346	Bulk D (A)	0.1010		
D (B) for Cpx	0.6693	Bulk D (B)	0.5024		



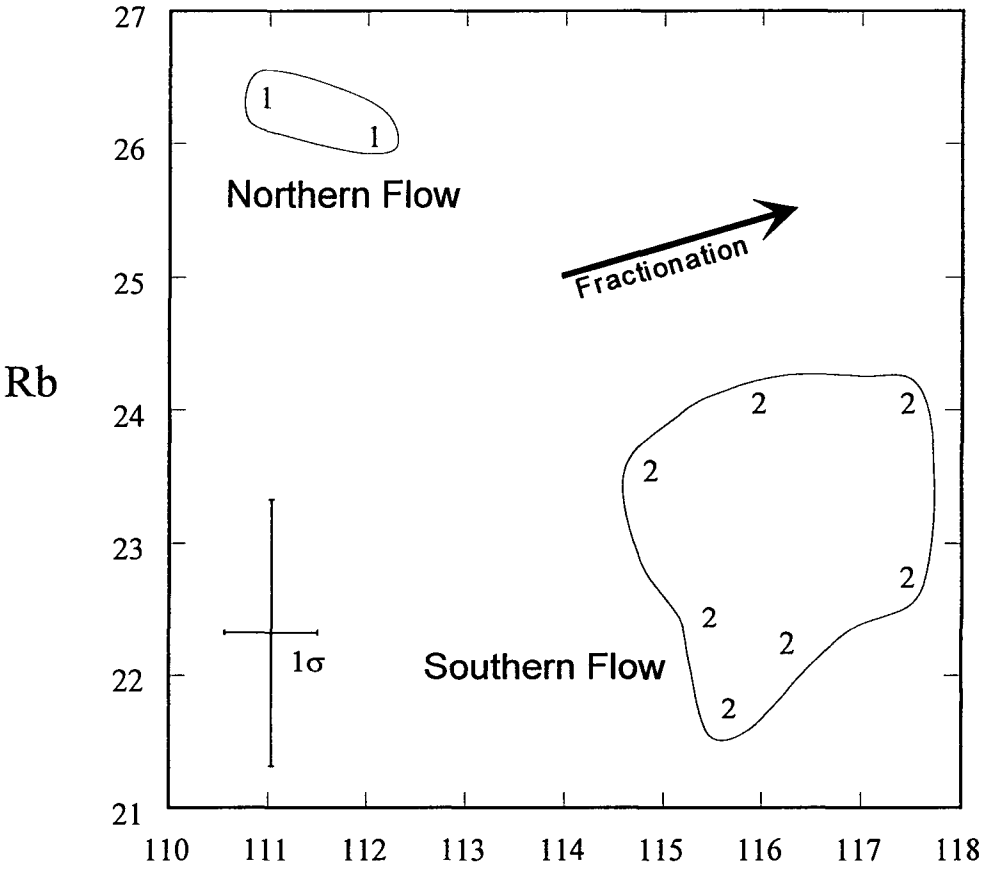
Lathrop Wells



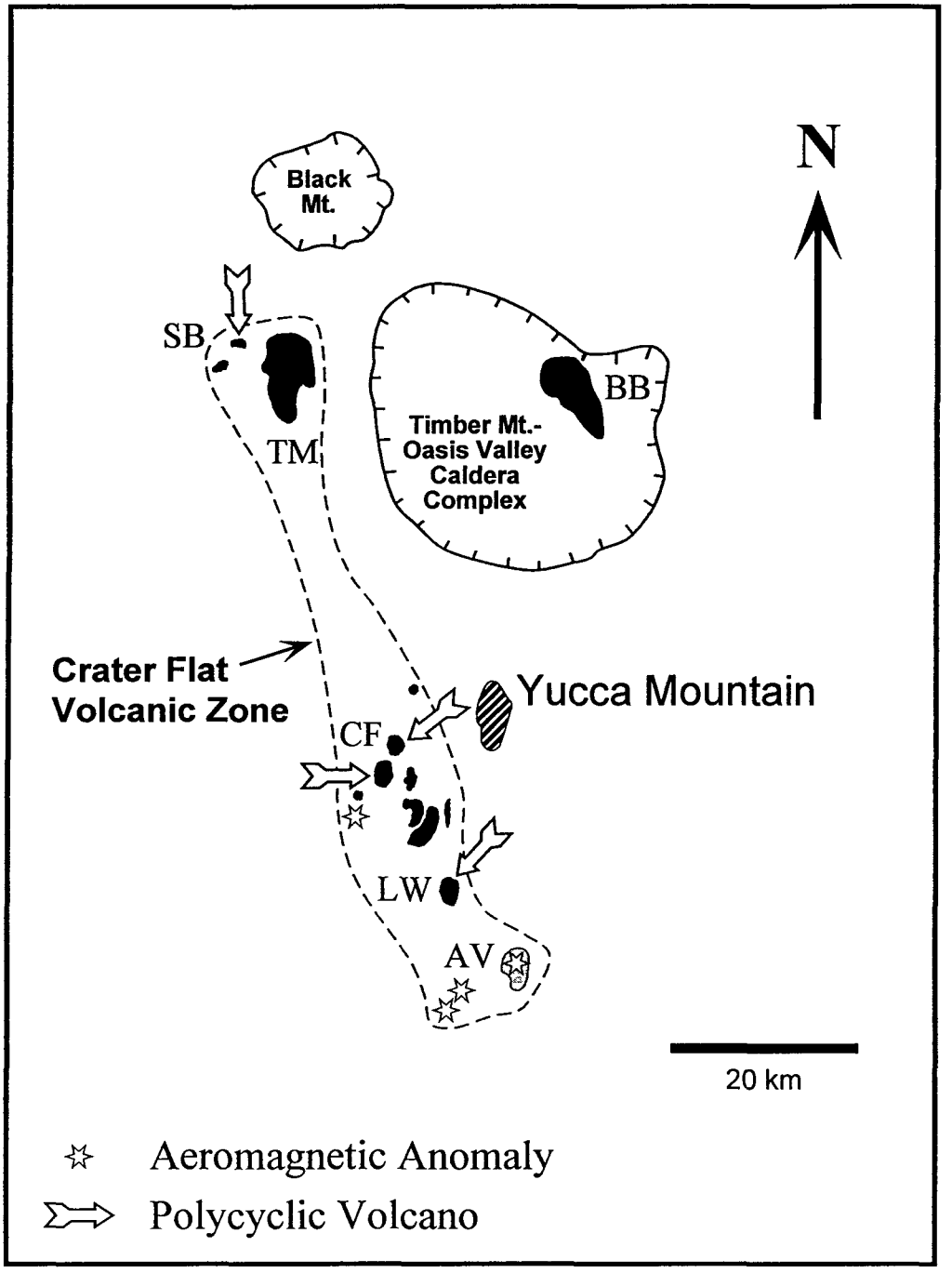
Lathrop Wells normative compositions



Black Cone


27
26
25
24
23
22
21
110
111
112
113
114
115
116
117
118
Rb
La
1
1
Northern Flow
Fractionation
2
2
2
2
2
2
2
Southern Flow
1σ

Post-Miocene Volcanic Centers of the Yucca Mountain Region



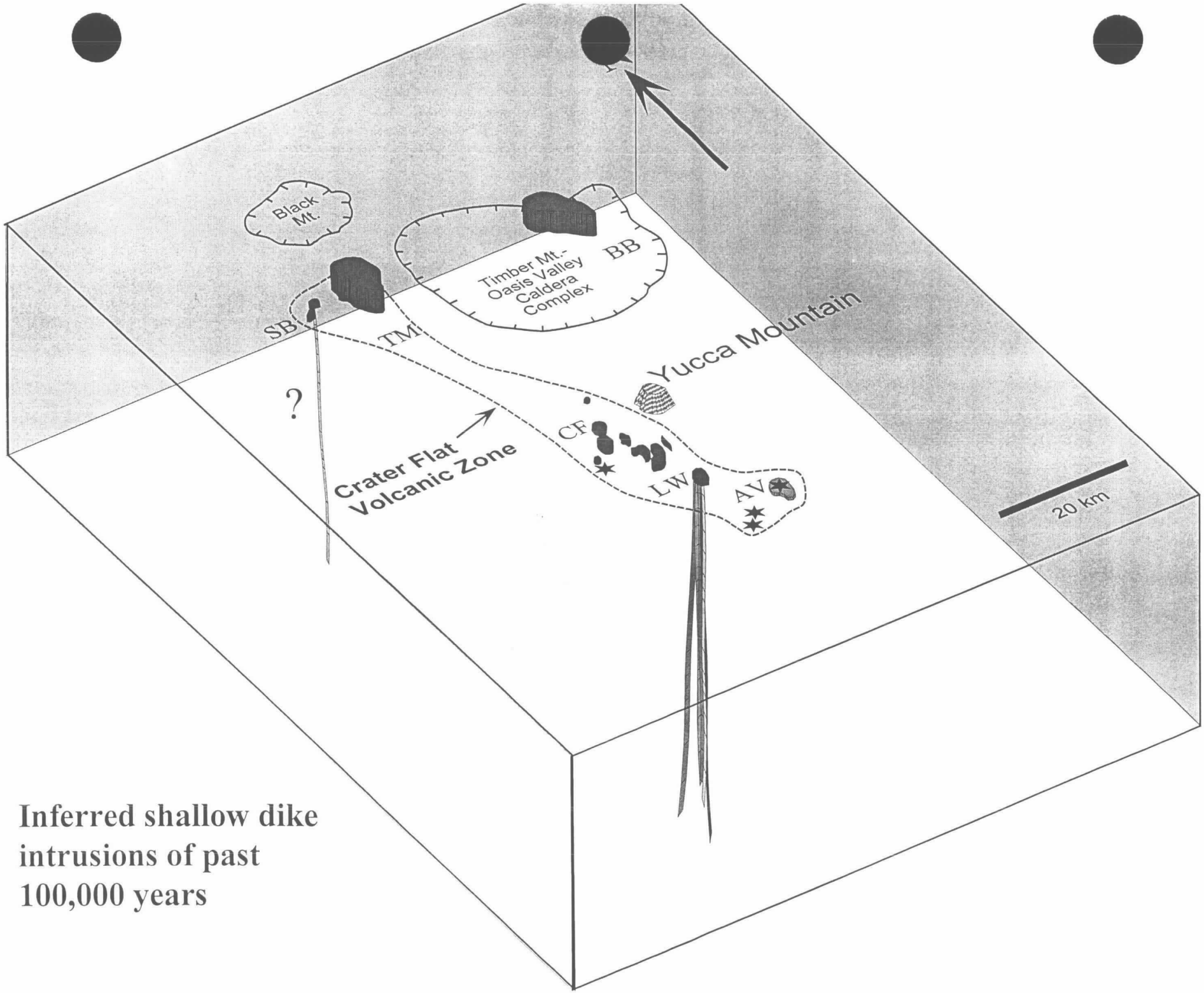
Summary of Quaternary polycyclic activity

- 1 Ma Crater Flat Centers
  - distributed polycyclic center?
  - $\geq$ 7 magma batches

- 0.3 Ma Sleeping Butte Centers
  - distributed polycyclic center?
  - chronology?
  - $\geq$ 2 magma batches

- $\leq$ 0.1 Ma Lathrop Wells Center
  - localized polycyclic center
  - $\geq$ 6 magma batches

The ~100,000 year pattern of repeated volcanism at Lathrop Wells, which has been maintained into the Holocene, indicates that the next eruption in the region will probably again be at Lathrop Wells.



Inferred shallow dike intrusions of past 100,000 years

Necessary future work:

- **Evolution of Crater Flat volcanic zone**
  1. Geologic/geochemical model of magma production patterns through time
     -is magmatism waxing or waning?
  2. Changes in volatile content, fractionation depth
     -ascent mechanics, eruption styles
  3. Provides physical framework for probability models and effects studies

- **Magmatic effects studies**

- **Refine mechanism/duration of polycyclic volcanism**

- **Wrap up geochronology**

- **Correlate ashes in fault trenches to dated eruptive episodes at Lathrop Wells**

- **Volcanism drill holes**
  1. determine age and nature (intrusion/extrusion) of aeromagnetic anomalies

- **Revised probability studies**
  1. Probability of polycyclic volcanism