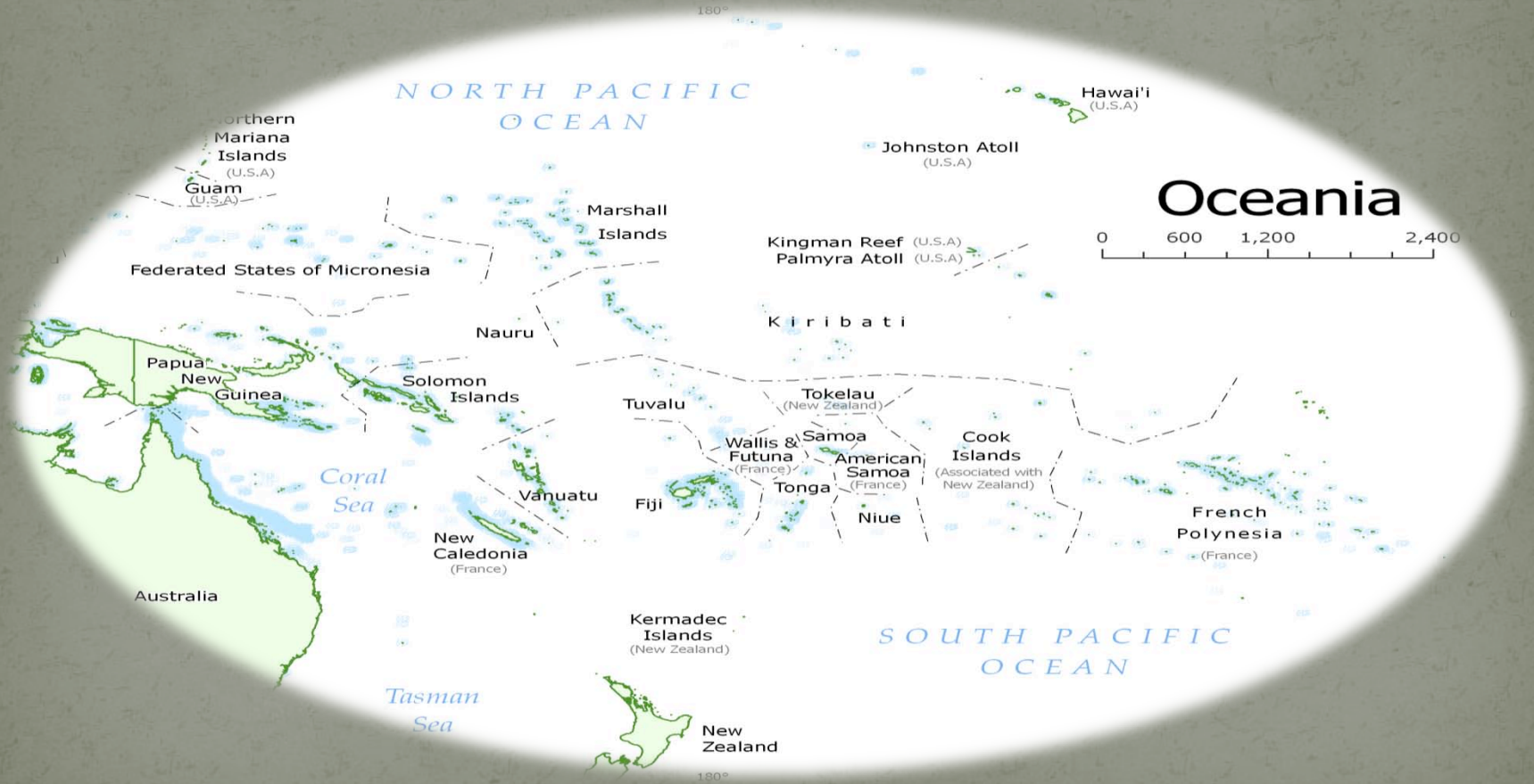
Stone Tools from Ofu Island

By Stephen Fried & Nick Sharp

Location

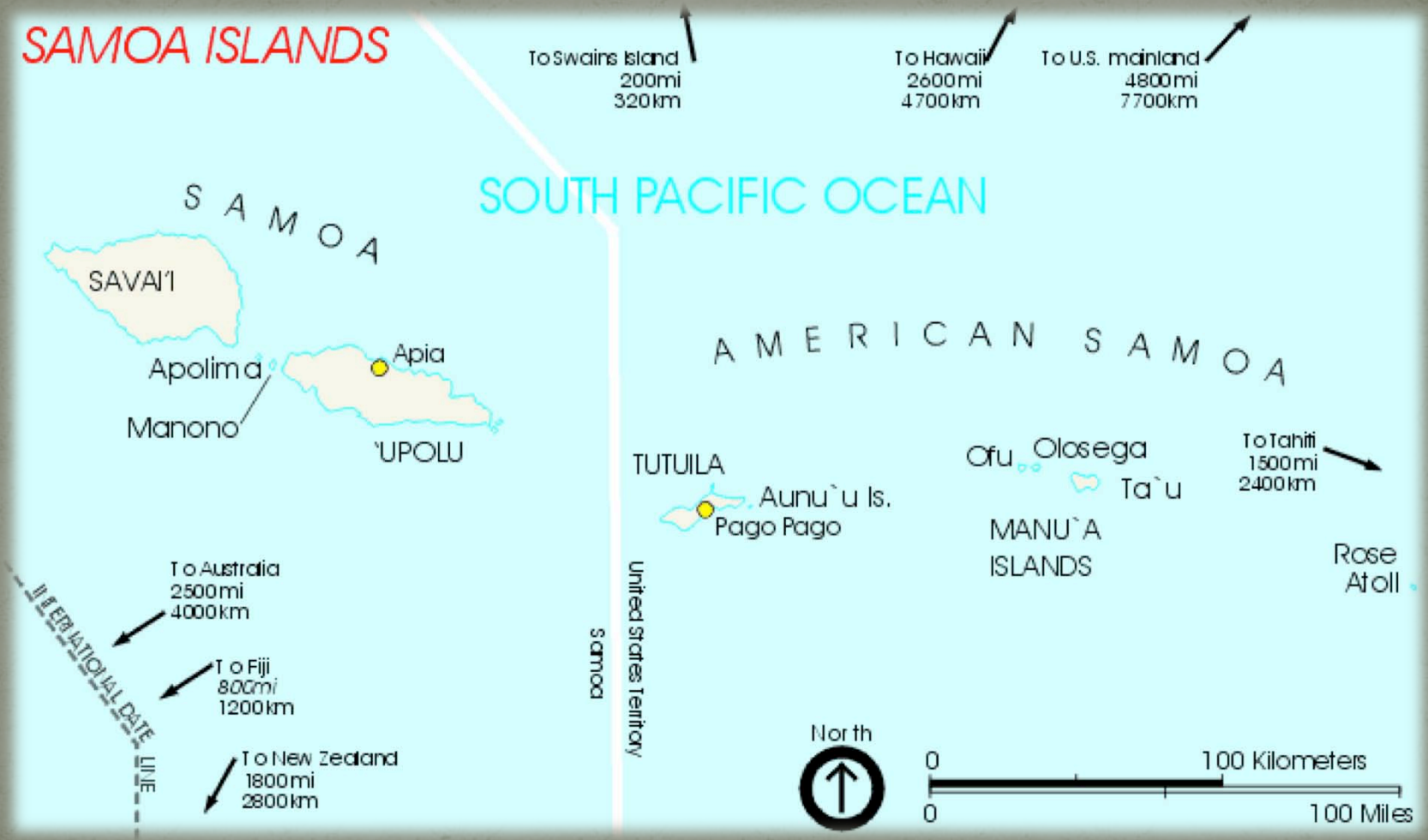


-East-West Center, 2003

Project Premise

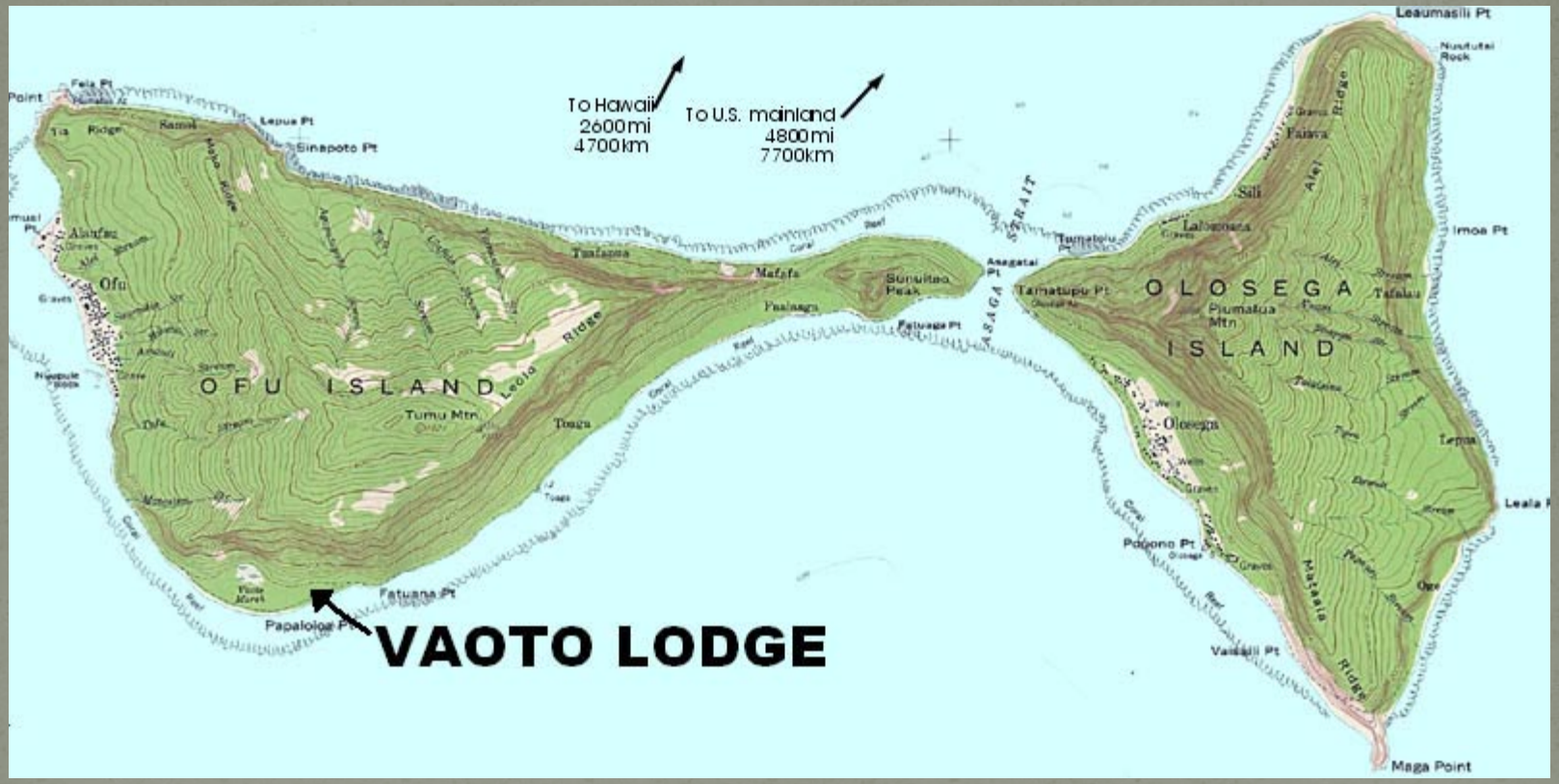
- Characterization of Stone Tools from American Samoa
- Tools recovered from Va'oto village, Ofu Island
- Our project is to determine the provenance of these stone tools
  - Did they come the island they were discovered on?
  - Were the tools brought over from another nearby island through human interaction (i.e. trade)

Map of Samoan Islands



-University of Texas, 2002

Ofu Island



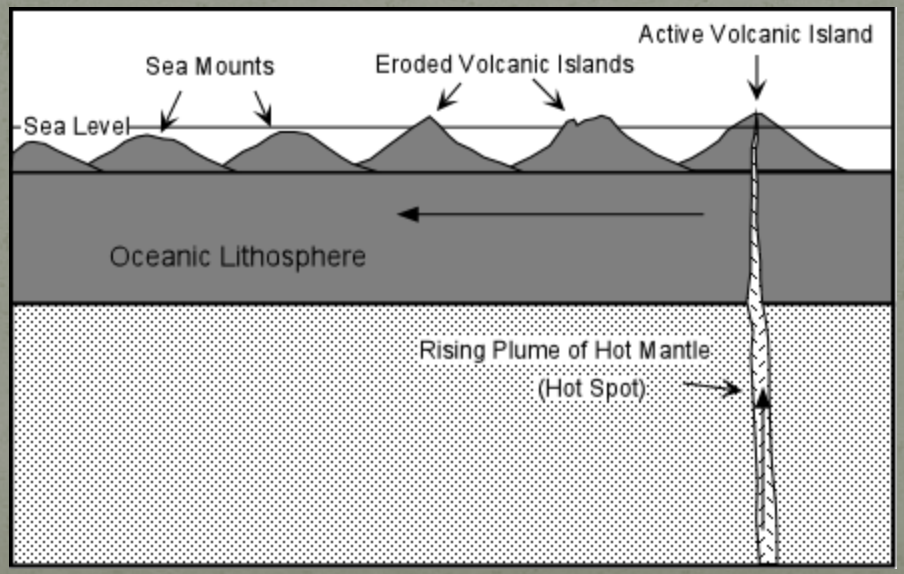
From vaotolodge .com/images/map1.jpg

Sample Characterization

- Four Basalt Stone Tools
- All tools came from Va'oto Village
  - Each tool was unearthed in a different cultural layer (strata people lived on at the time)
  - The soil in question is a sandy loam (duh, it's a beach!)

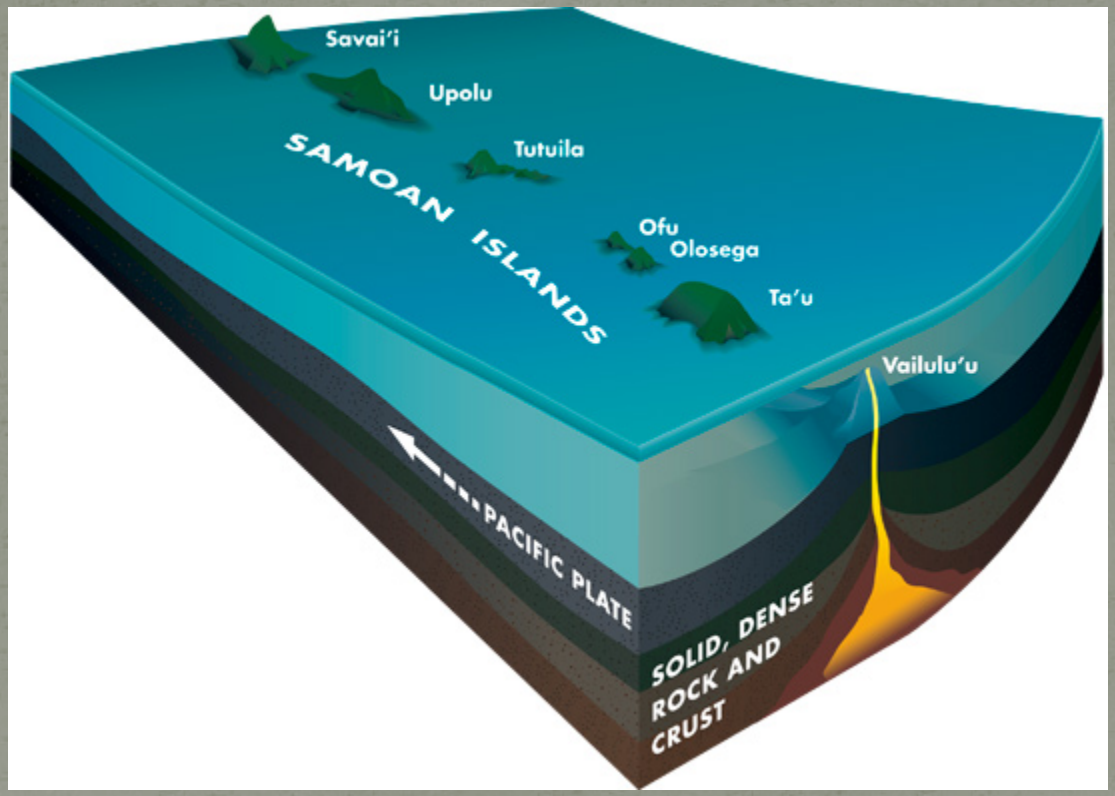
Geologic Setting: Hot Spots

- Occur where a portion of the mantle has punctured through the crust
- As plate tectonics moves the crust around, the previous surface location of the eruption moves with respect to the hotspot
- The hotspot re-punctures the crust in a new location on the surface



http://www.tulane.edu/~sanelson/geol204/volclandforms.htm

Movement of Pacific Plate over hot spot.



-Woods Hole Oceanographic Institution, 2007

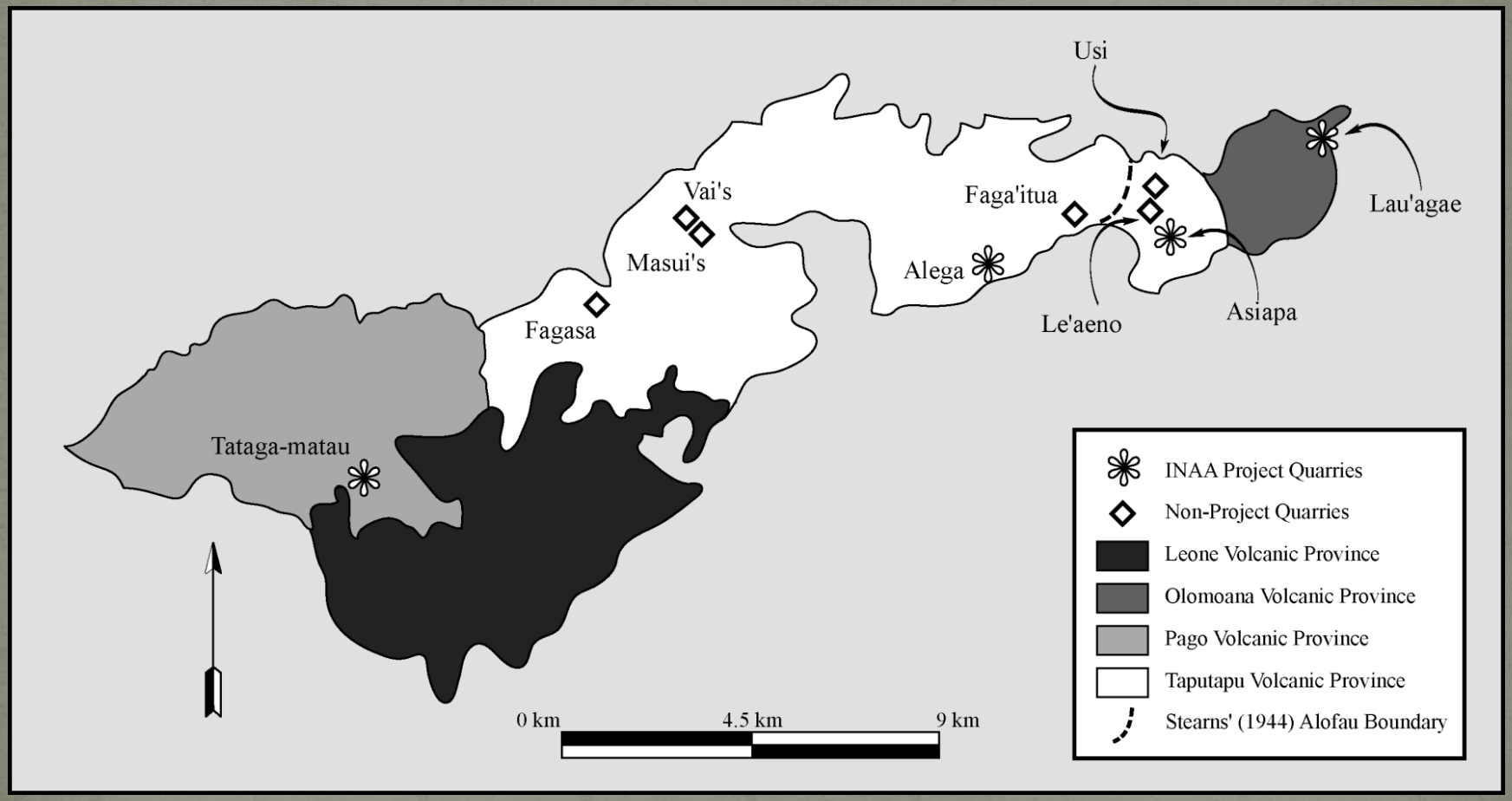
So Where Did the Tools Come From?

- There is no place for basalt to be excavated from on Ofu island
- The nearest place where known basalt quarries are located is Tutuila Island
- Possibly traded from another, farther island

The Island of Tutuila

- Tutuila is the largest of the American Samoans and is the third largest of the Samoan Island Chain
- Formed from multiple eruptions: Pliocene-Holocene.
- The island is composed of five* distinct volcanic provinces:
  - Pago
  - Alofau*
  - Olomoana
  - Taputapu
  - Leone

Volcanic Regions of Tutuila



Tutuilan volcanic provinces -Stearns (1944) and MacDougall (1985)

Polynesian Trade Systems

- Used between 3100 and 1700 yr BP based on artifacts.
- Three main centers of trade
  - Fiji – "ironwood" timber
  - Tonga – warriors (mercenaries)
  - Samoa – stone (basalt), *Pendanus* mats

Trade "Triangle"

http://www.geographicguide.com/oceania-map.htm

Phylogenetic Model

- Language principles paraphrased from (Pawley and Green 1973)
  - Principle 1. Under the conditions obtaining in the Pacific in pre-contact times, the foundation language of a remote island group could seldom be replaced by an intrusive language.
  - Principle 2. Once a language X has become established on two island groups, separated from each other by more than 450 km of open sea, linguistic splitting (gradual divergence into separate dialects Y and Z) is inevitable.
  - Principle 3. After 1,000 years Y and Z will have diverged to the point of being separate languages or will be very close to that point.

Interaction Spheres

- Maximum radial distance capable of being traveled by ancient seafarers

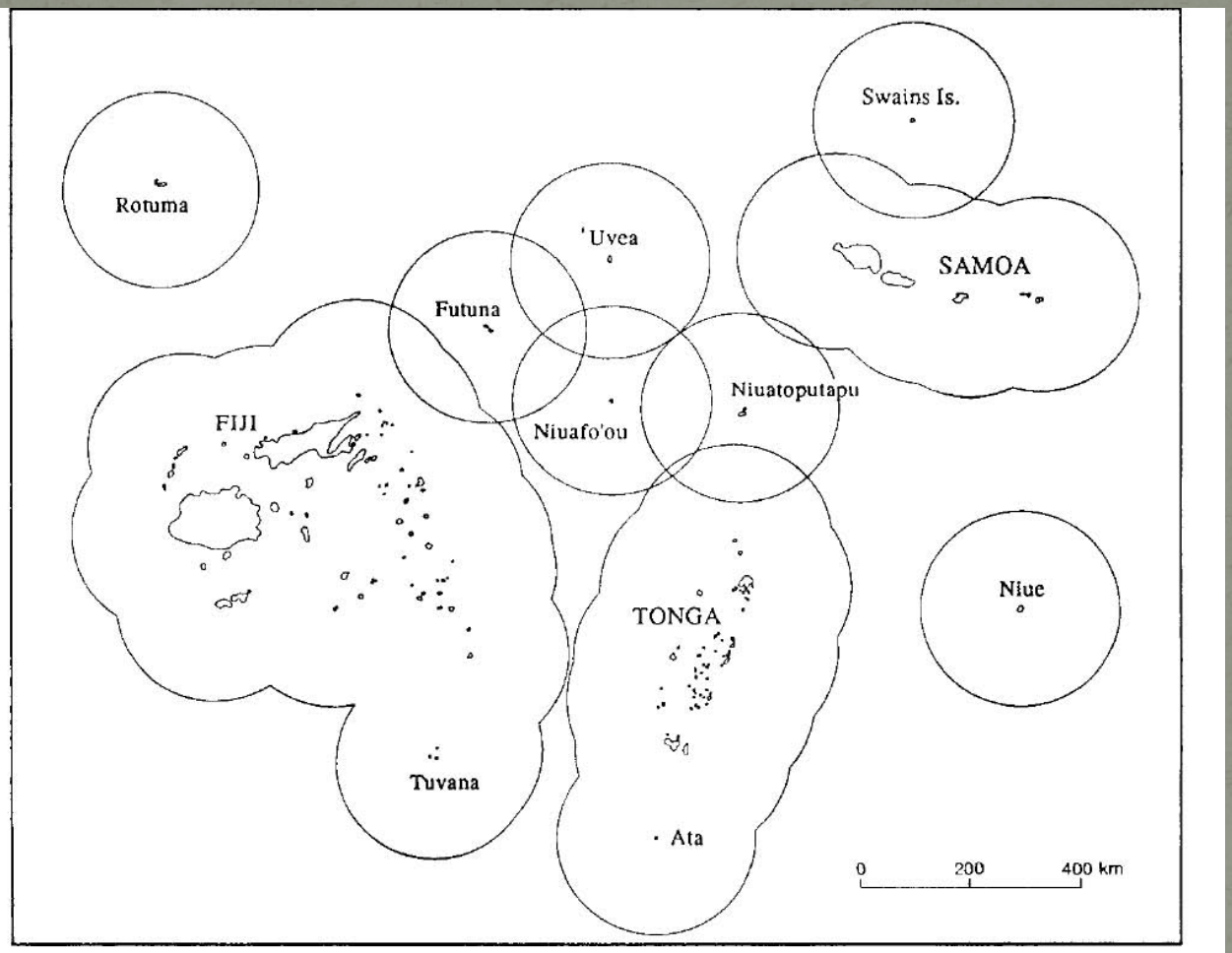


Fig. 3.6 Islands in the Fiji–Western Polynesian region linked by voyaging circles of 24 hours or less (after Marck 1999a).

As You May Already Know…

- Mineralogy of rocks from a single, continuous eruption will have little to no variances throughout
- Mineralogy of rocks from multiple eruptions will likely differ from sample to sample
- These facts, along with the islands' intermittent volcanic history, "provide a positive setting for recognizing geochemical differences among rock samples" (Natland 2004)

INAA & XRF

- XRF performed on 4 samples.
- INAA performed on quarry samples.
- Places each packaged sample into an irradiation vessel.
- Elements comprising each sample undergo neutron capture creating radioactive product nuclides.

INAA & XRF

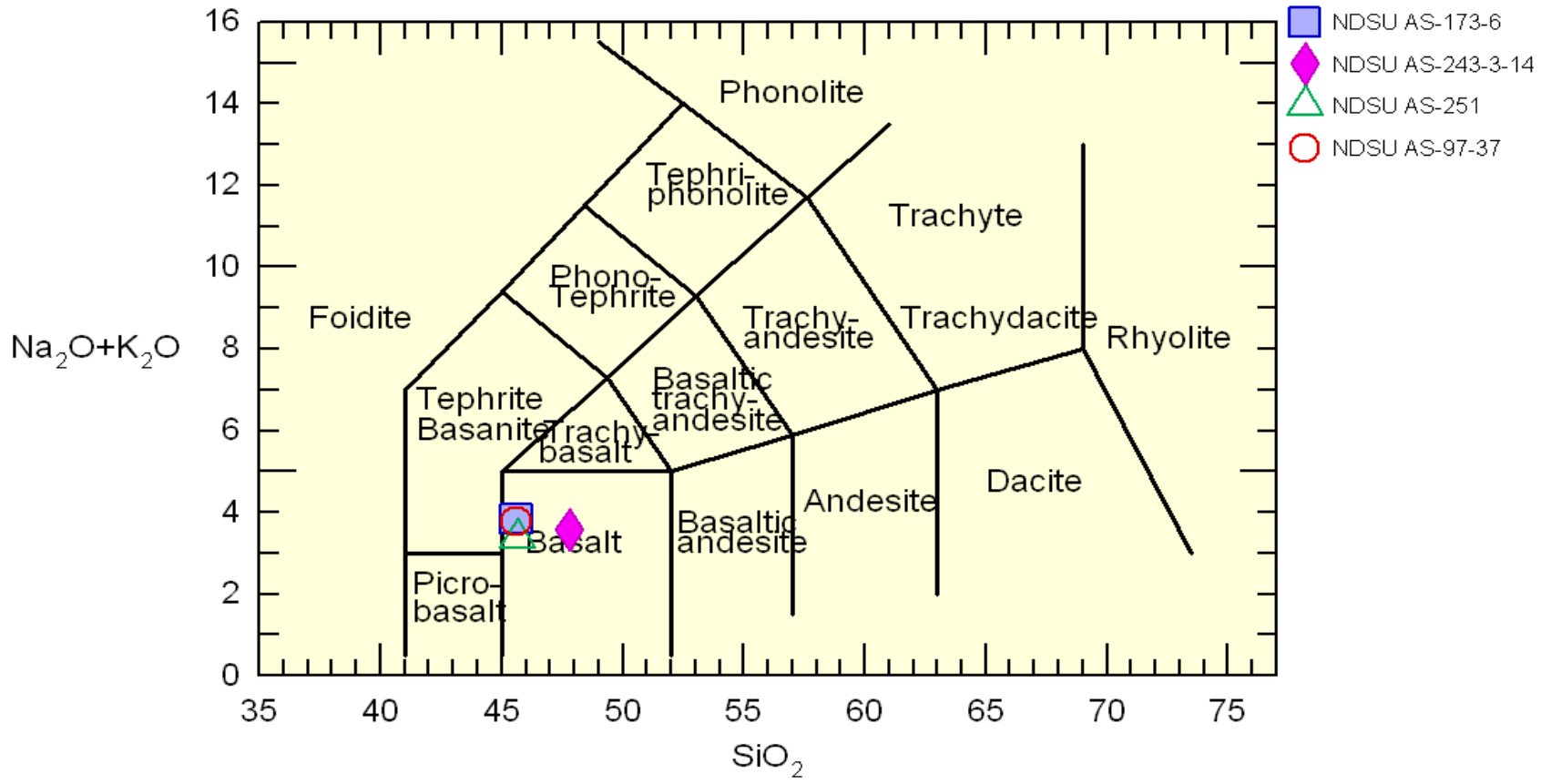
- Gamma rays emitted from each nuclide, measured, provides measurement.

  -Eby, N., 2007

-serc.carleton.edu

-Eckert and Welch, 2009

TAS Diagram

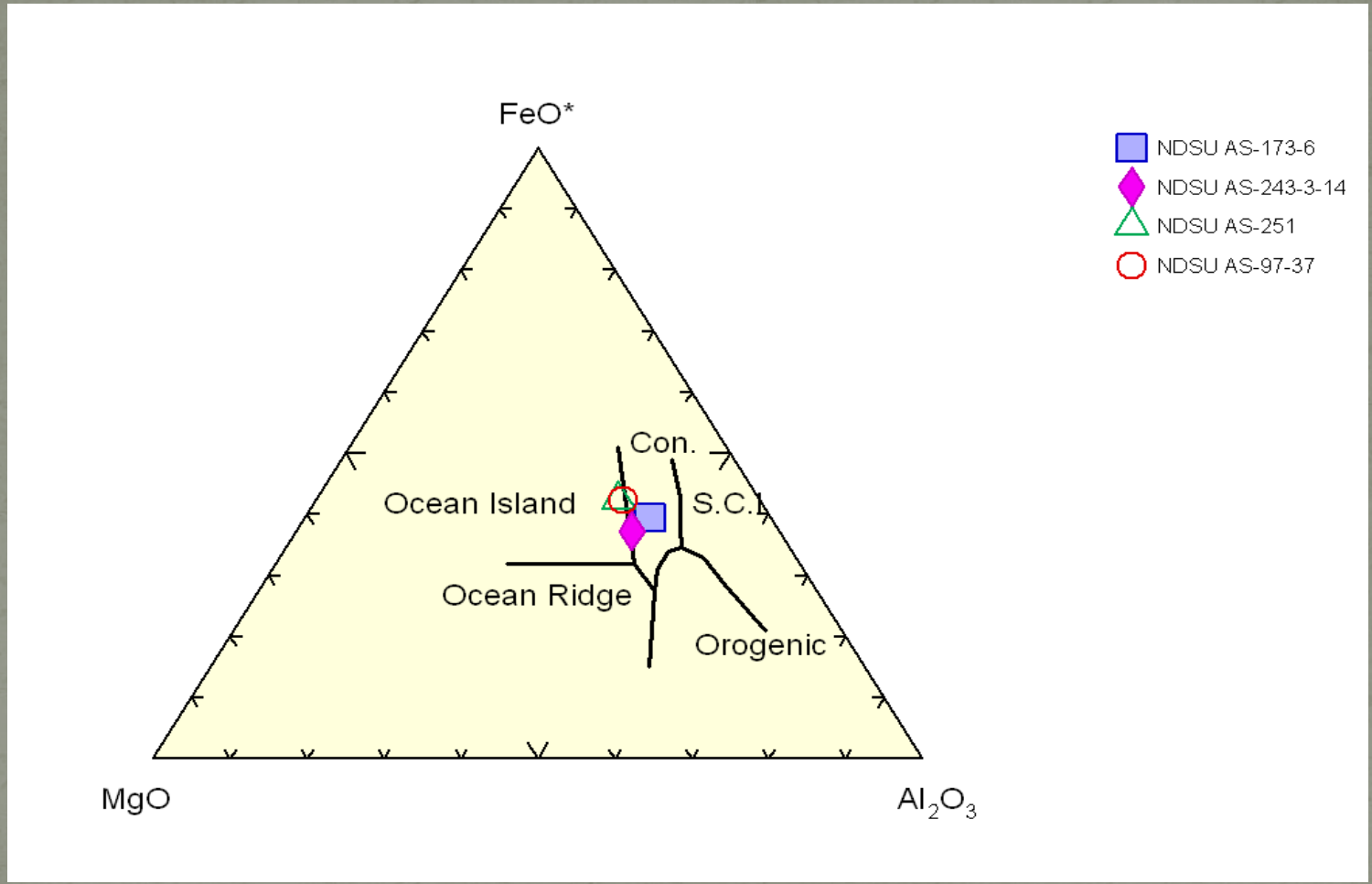

NDSU AS-173-6
NDSU AS-243-3-14
NDSU AS-251
NDSU AS-97-37
Phonolite
Tephri-phonolite
Trachyte
Phono-Tephrite
Foidite
Trachy-andesite
Trachydacite
Rhyolite
Basaltic trachy-andesite
Tephrite Basanite
Trachy-basalt
Andesite
Dacite
Basalt
Basaltic andesite
Picro-basalt
Na2O+K2O
SiO2
0
2
4
6
8
10
12
14
16
35
40
45
50
55
60
65
70
75

Discrimination Diagrams

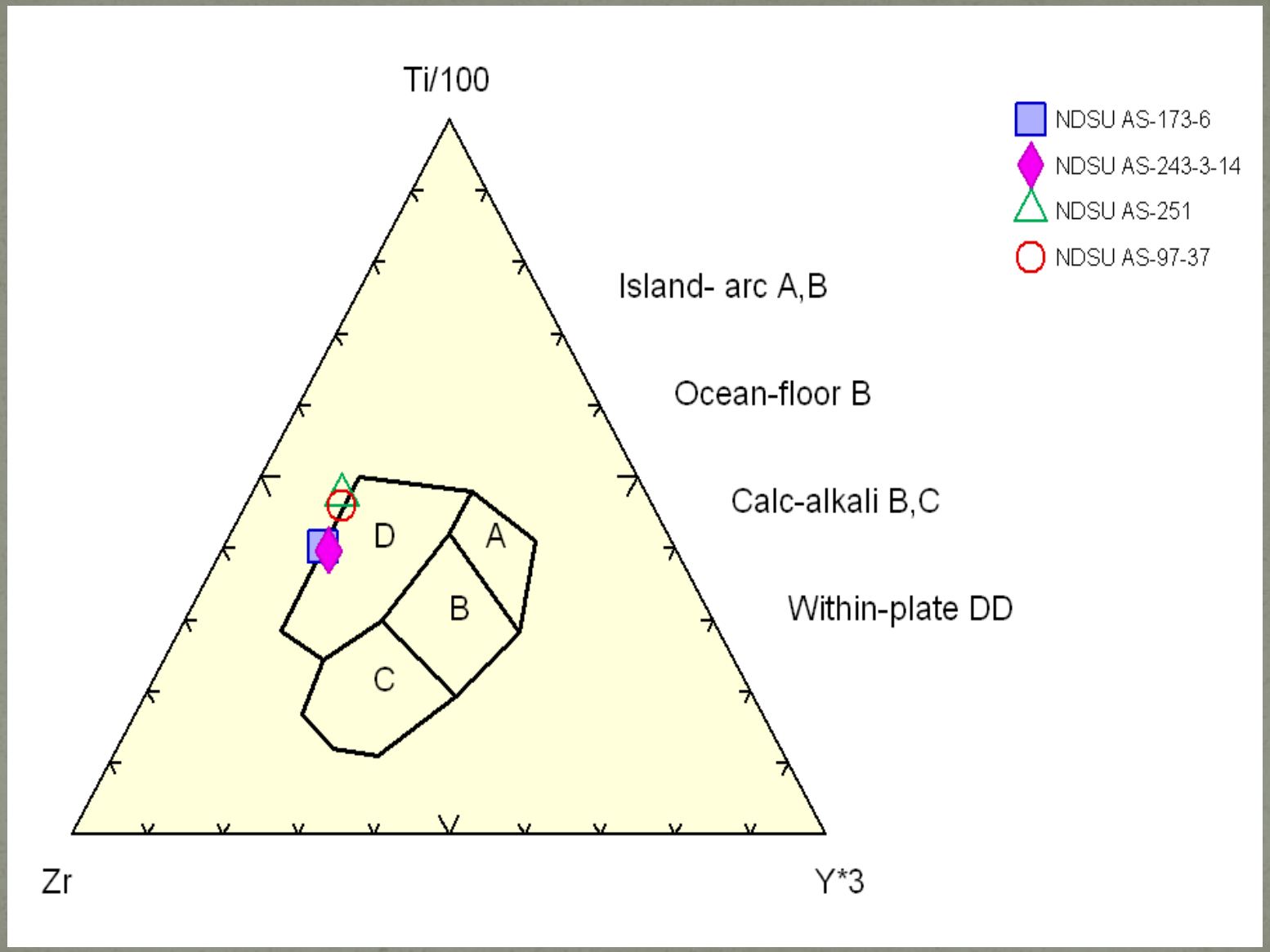
- Different tectonic environments may be distinguished through specific geochemical data.
- Trace elements considered immobile.
- Diagrams can be used to assign rocks to their original source.

-Winter, 2010

Tectonic Diagrams



-Pearce et al., 1977

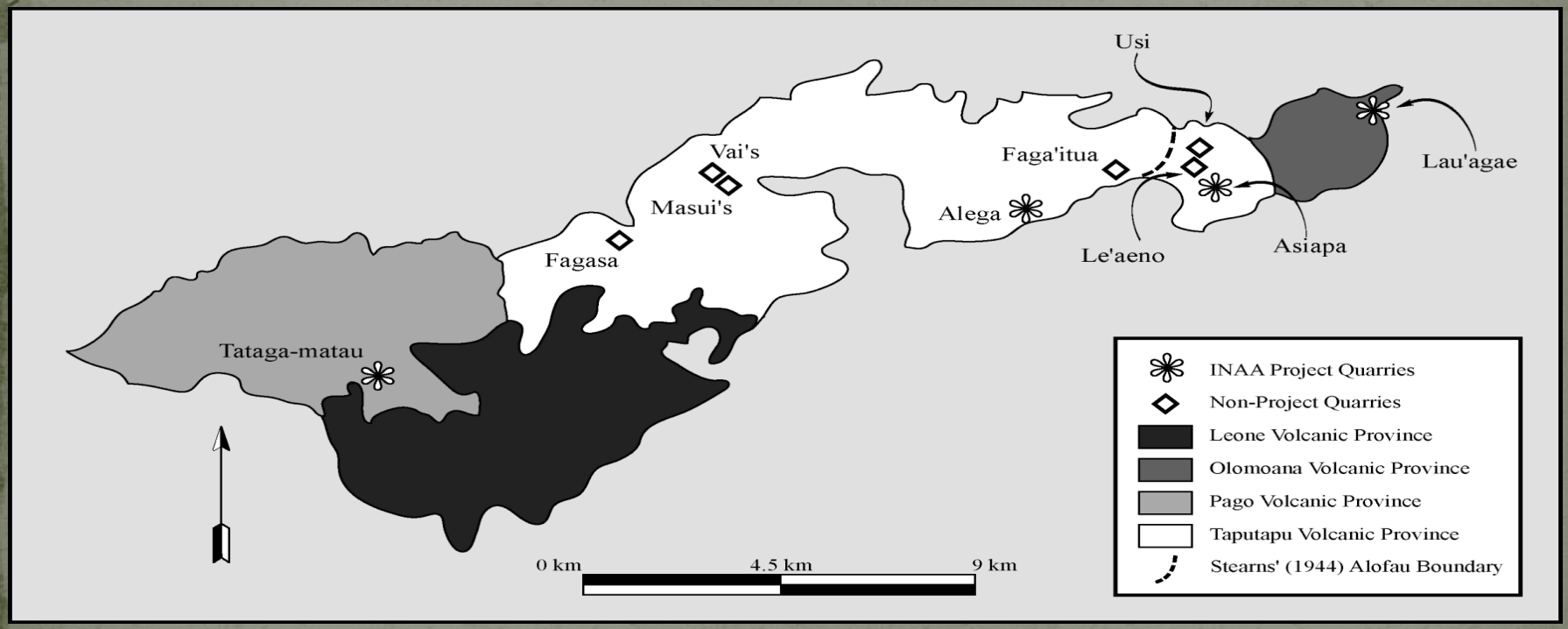

Ti/100
NDSU AS-173-6
NDSU AS-243-3-14
NDSU AS-251
NDSU AS-97-37
Island- arc A,B
Ocean-floor B
Calc-alkali B,C
Within-plate DD
D
A
B
C
Zr
Y*3

- Sample data mostly plotted along ocean island.
- Expected with intraplate volcanism.
- Suggests a deep mantle origin.
- Within-plate basalts: expected result in a diagram for OIB samples.

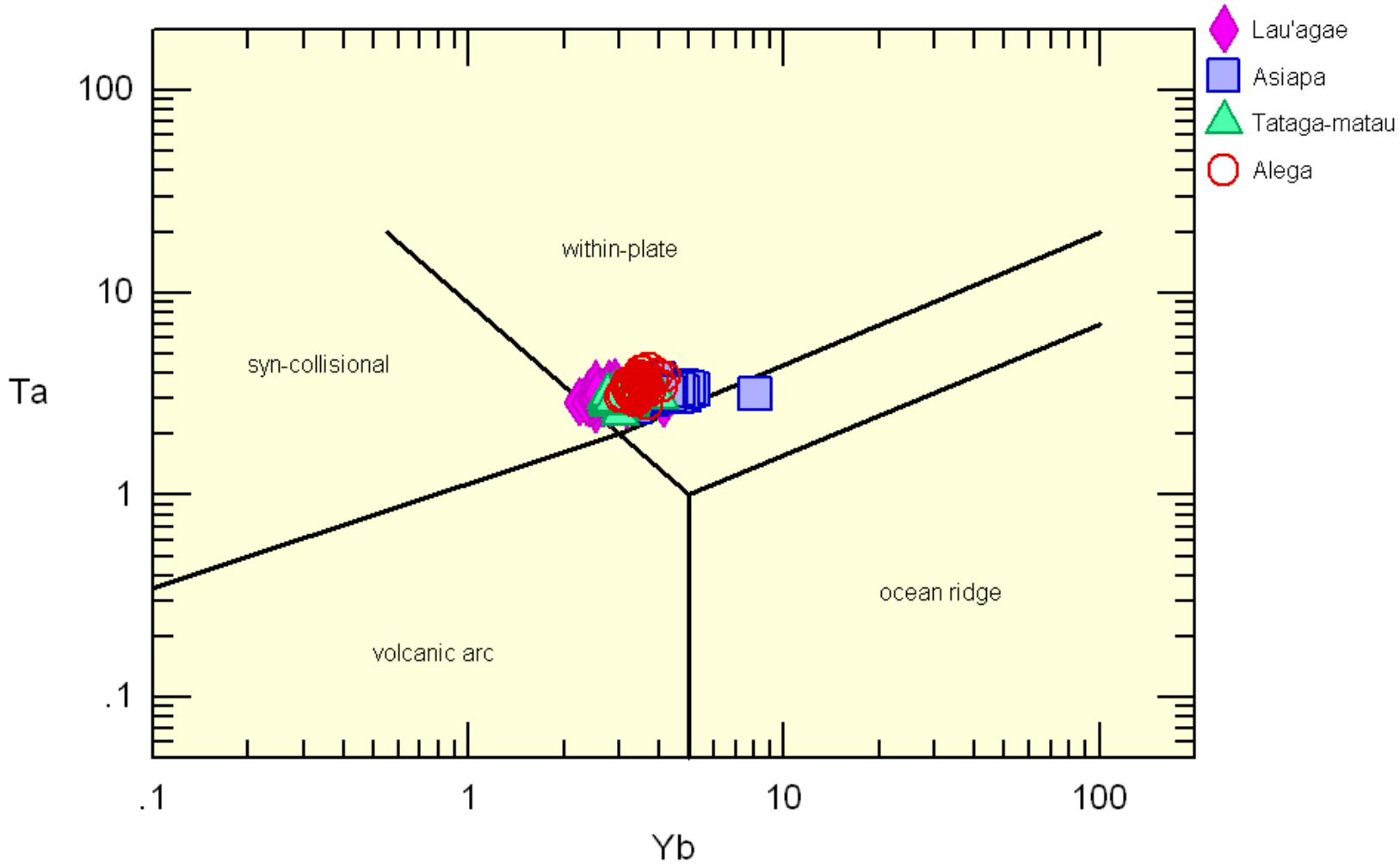
-Winter, 2010

Quarry Samples

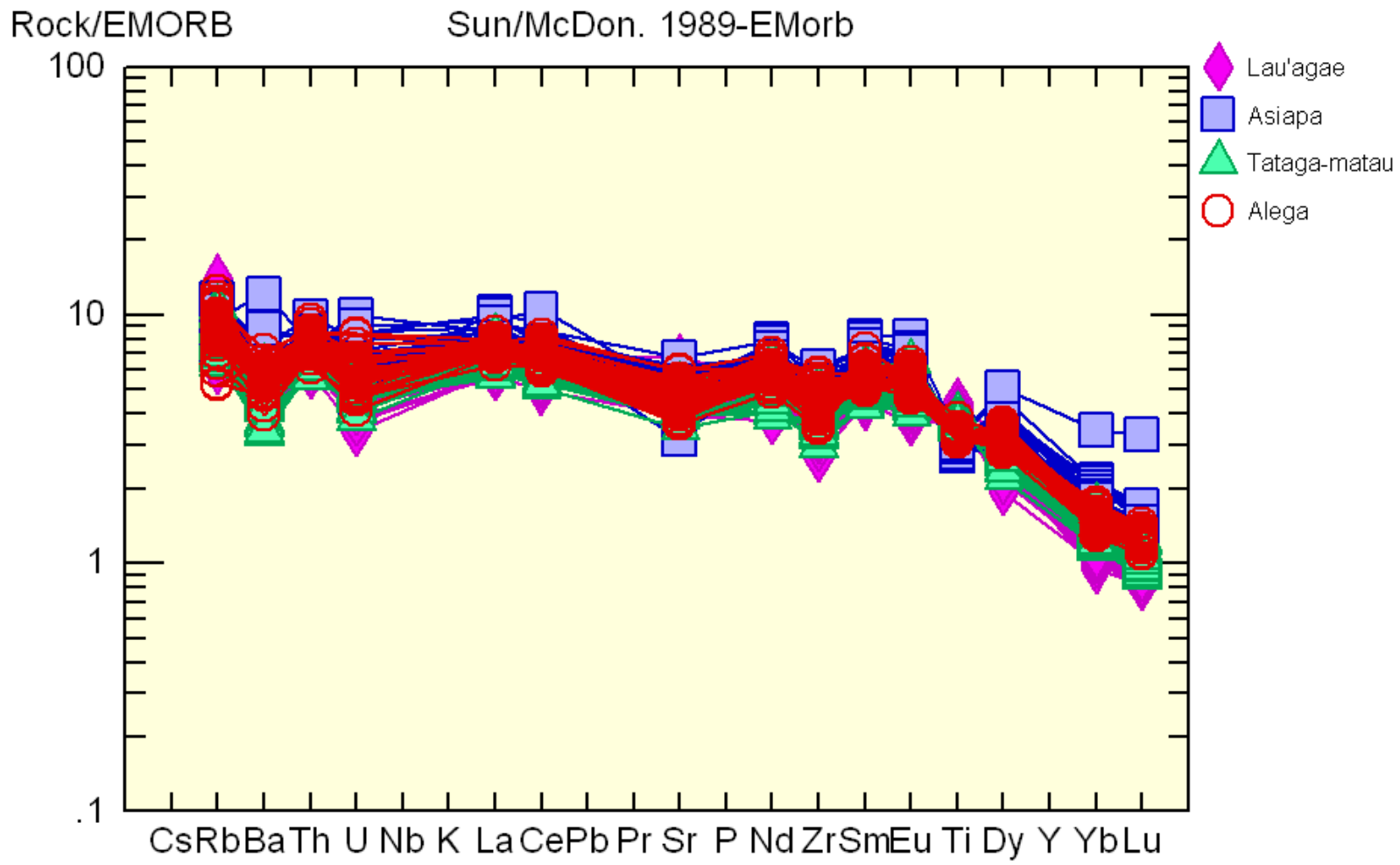
- 138 samples with Instrumental Neutron Activation Analysis (INAA) data used.

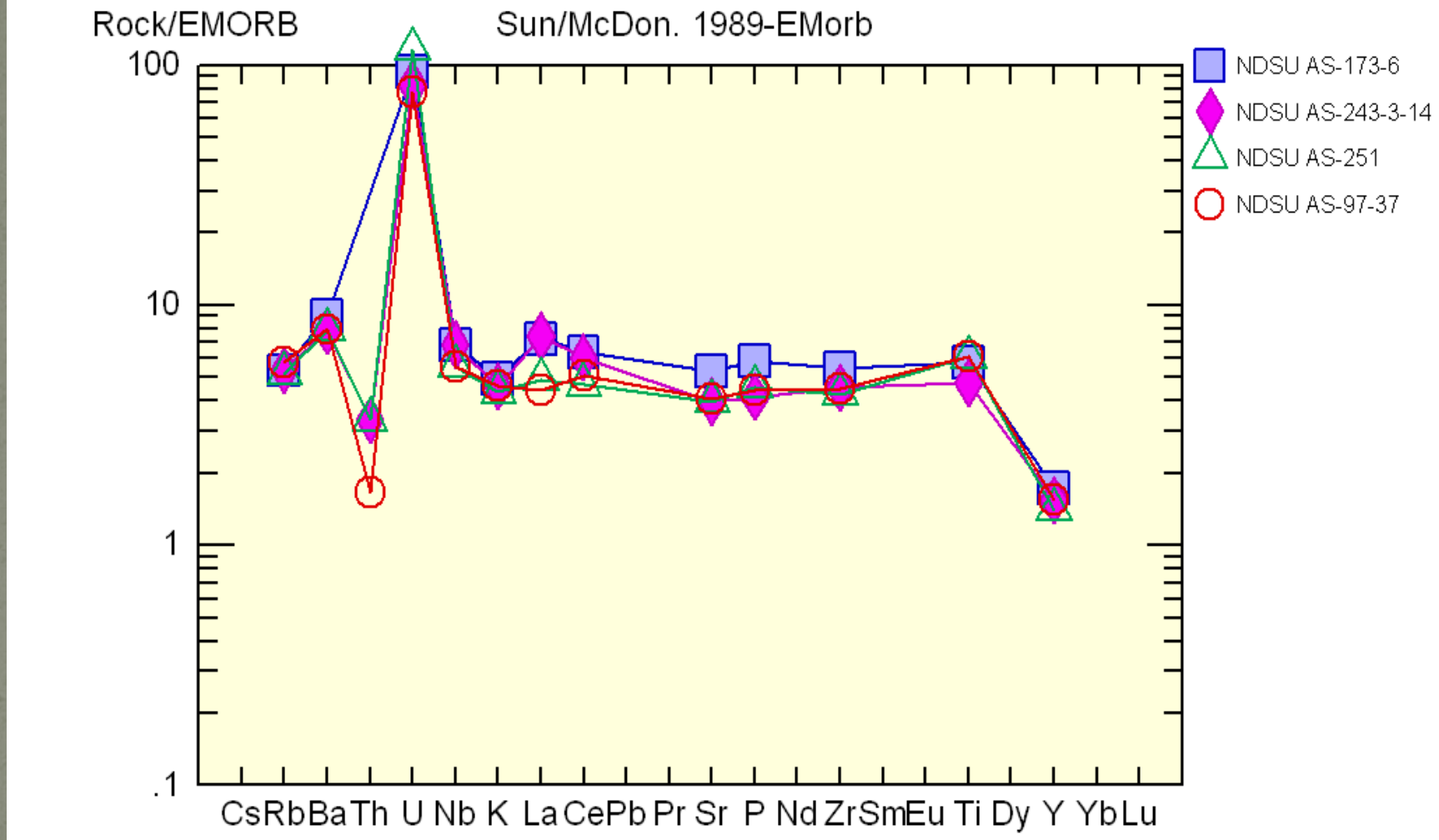


Tutuilan volcanic provinces -Stearns (1944) and MacDougall (1985)


Lau'agae
Asiapa
Tataga-matau
Alega
within-plate
syn-collisional
volcanic arc
ocean ridge
100
10
1
.1
Ta
.1
1
10
100
Yb

- Unable to share majority of diagrams due to different elements available from XRF and INAA resources.
- Different diagrams, similar output.
- Suggests that samples and quarries share a tectonic source.


Rock/EMORB
Sun/McDon. 1989-EMorb
100
10
1
.1
Lau'agae
Asiapa
Tataga-matau
Alega
CsRbBaTh U Nb K La CePb Pr Sr P Nd ZrSmEu Ti Dy Y YbLu


Rock/EMORB
Sun/McDon. 1989-EMorb
100
10
1
.1
Cs Rb Ba Th U Nb K La Ce Pb Pr Sr P Nd Zr Sm Eu Ti Dy Y Yb Lu
NDSU AS-173-6
NDSU AS-243-3-14
NDSU AS-251
NDSU AS-97-37

- Shallow mantle sources (N-MORBs) depleted of lithophile elements.
- Positive slope due to this.
- Ocean island basalts have a deeper origin.
- Lower mantle source of both OIB and E-MORB.
- Negative slope similar to E-MORB.

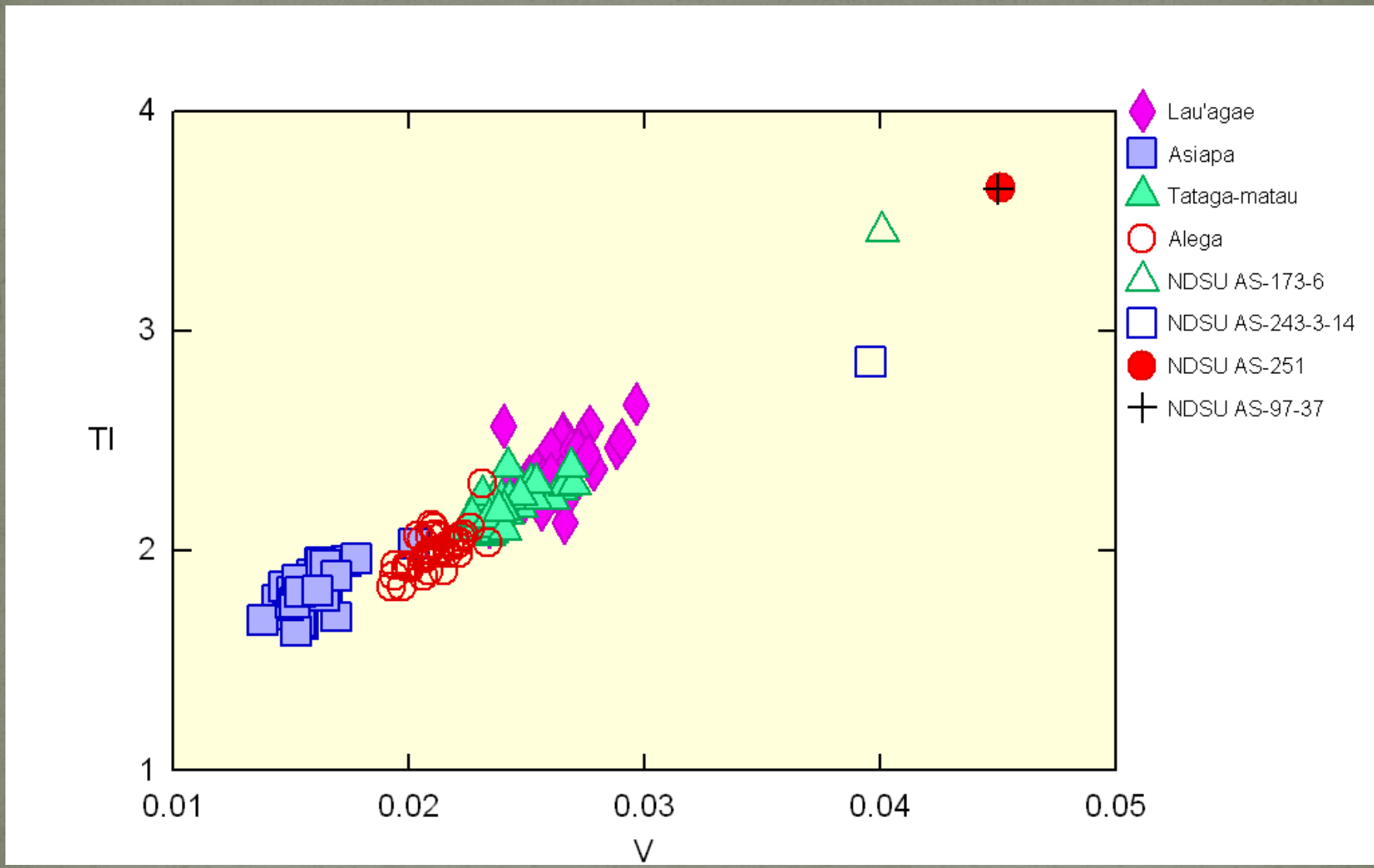
-Winter, 2010

- Plumes attributed to heating at two mantle boundaries. (660-km, 1700-km)
- Correlation between normal magnetic polarity and activity noted by Moberly and Campbell in 1984.
- Suggests plumes are related to core.
- Localized fluid concentrations possibly decrease density of mantle. Hotter material rises.
- Origin not certain.

-Winter, 2010

Testing samples against quarry data

- Most trace elements tested not shared by the data sets.
- Mg/Fe = Ti inconclusive.
- Ti = V clustered samples best.
- Samples did not match with quarry data.


4
3
2
1
TI
0.01
0.02
0.03
0.04
0.05
V
Lau'agae
Asiapa
Tataga-matau
Alega
NDSU AS-173-6
NDSU AS-243-3-14
NDSU AS-251
NDSU AS-97-37

Conclusions

- Samples only taken from four of five volcanic event areas.
- Data sources our samples and quarry samples to same tectonic setting.
- XRF vs INAA
- Trade.


Thanks, Chris!

References

- Winterhoff, E.Q., Wozniak, J.A., Ayres, W.S., Lash, E., 2007, Intra-island source variability on Tutuila, American Samoa and prehistoric basalt adze exchange in Western Polynesia-Island Melanesia: Archaeol. Oceania v. 42, p. 65-71.
- Natland, J.H., 2004, accessed April 26th, 2010. The Samoan Chain: A shallow Lithospheric Fracture System: http://www.mantleplumes.org
- Winter, J.D., 2010, Principles of Igneous and Metamorphic Petrology 2nd ed. Ch. 9, 14
- Eby, N., 2007, accessed April 26th, 2010. Instrumental Neutron Activation Analysis (INAA): University of Massachusetts Lowell: http://serc.carleton.edu/research_education/geochemsheets/techniques/INAA.html
- Johnson, P.R., 2005, Instrumental Neutron Activation Analysis (INAA) characterization of pre-contact basalt quarries on the American Samoan Island of Tutuila: thesis