Magmatic Diversity on Venus: Constraints from terrestrial analog experiments

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Terrestrial Diversity

- Magmatic diversity is common for terrestrial igneous rocks.
- It has been suggested to occur on Mars and Venus.

  (Mars: Whitaker et al. 2005; Christensen et al. 2005; McCubbin et al. 2008)
  (Venus: Hess and Head 1990; Grimm and Hess 1997; Hashimoto et al. 2009)
- Crystallization vs. Melting (Talk: Kiefer and Filiberto).
- Numerous experimental crystallization studies have been conducted to explain compositional diversity of terrestrial igneous suites (e.g. Nekvasil and collaborators).
- Since basalts on Venus and Earth have similar chemistry (Treiman and Kargel talks), these studies may be useful for Venus.

Experimental Constraints

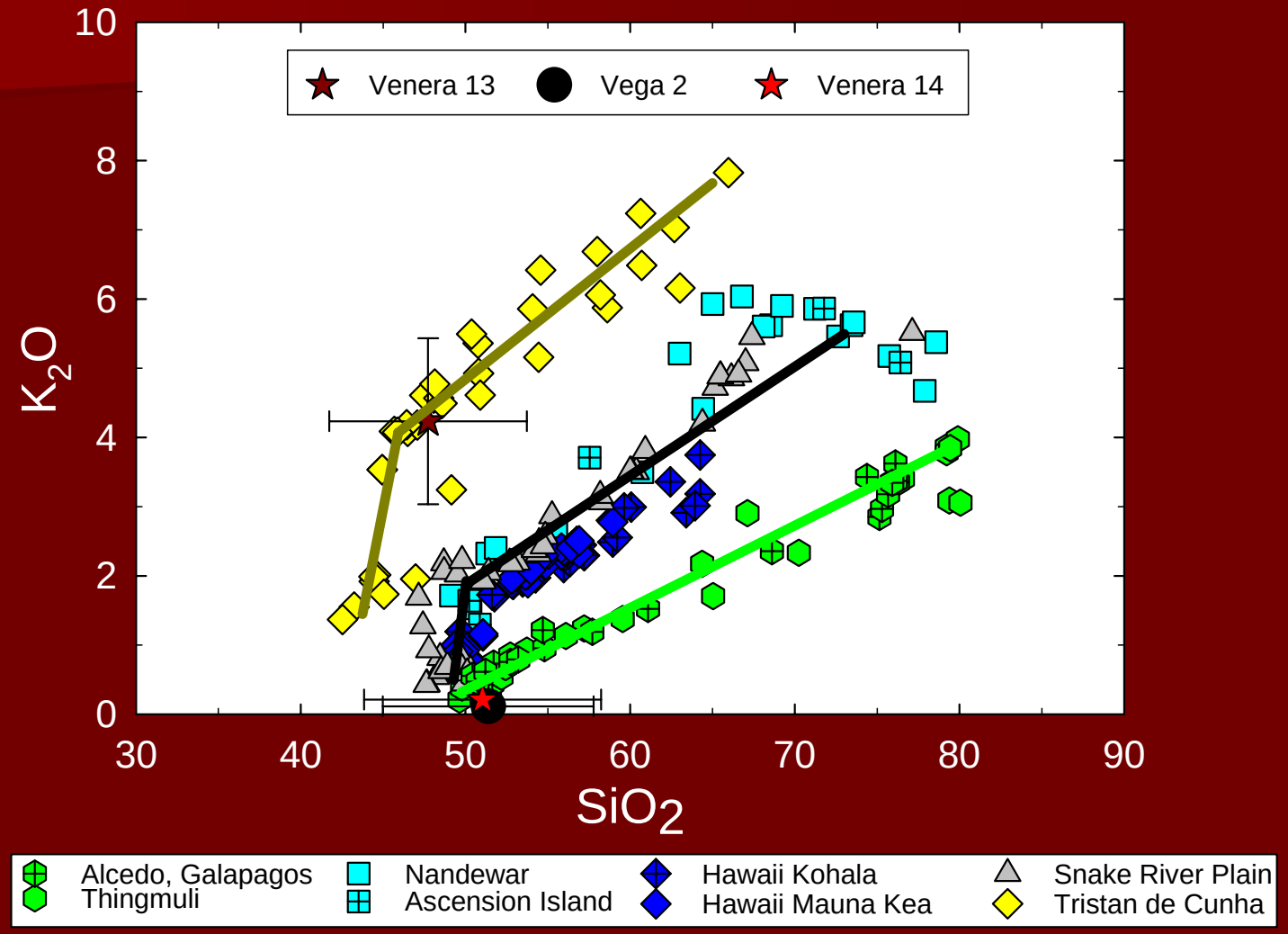
- Experiments on terrestrial rocks can provide information about:
  - The petrogenetic history of the Venera and Vega basalts (P, T, X_{H_2O} of formation).
  - What other types of basalts could be on the surface of Venus.
- These results can help constrain the type and quality of data we would need from future missions to determine the petrologic history of surface igneous rocks.

Terrestrial Analog Experiments

Fractionation Pressure		Volatile Content	Trend	Terrestrial Analog
Surface	0-2kb		Tholeiitic Trend	Galapagos Thingmuli
Upper mantle Base of the crust	5-11kb	<0.3wt% water	Potassic Alkalic Series	Snake River Plain
	9-11kb	>0.3wt% water	Sodic Alkalic Series	Nandewar Ascension Island
	12-16kb	>0.3wt% water	Si-Undersaturated	Hawaii
Mantle	18-27kb	~0.2 wt% water	Phonolitic Series	Tristan de Cunha

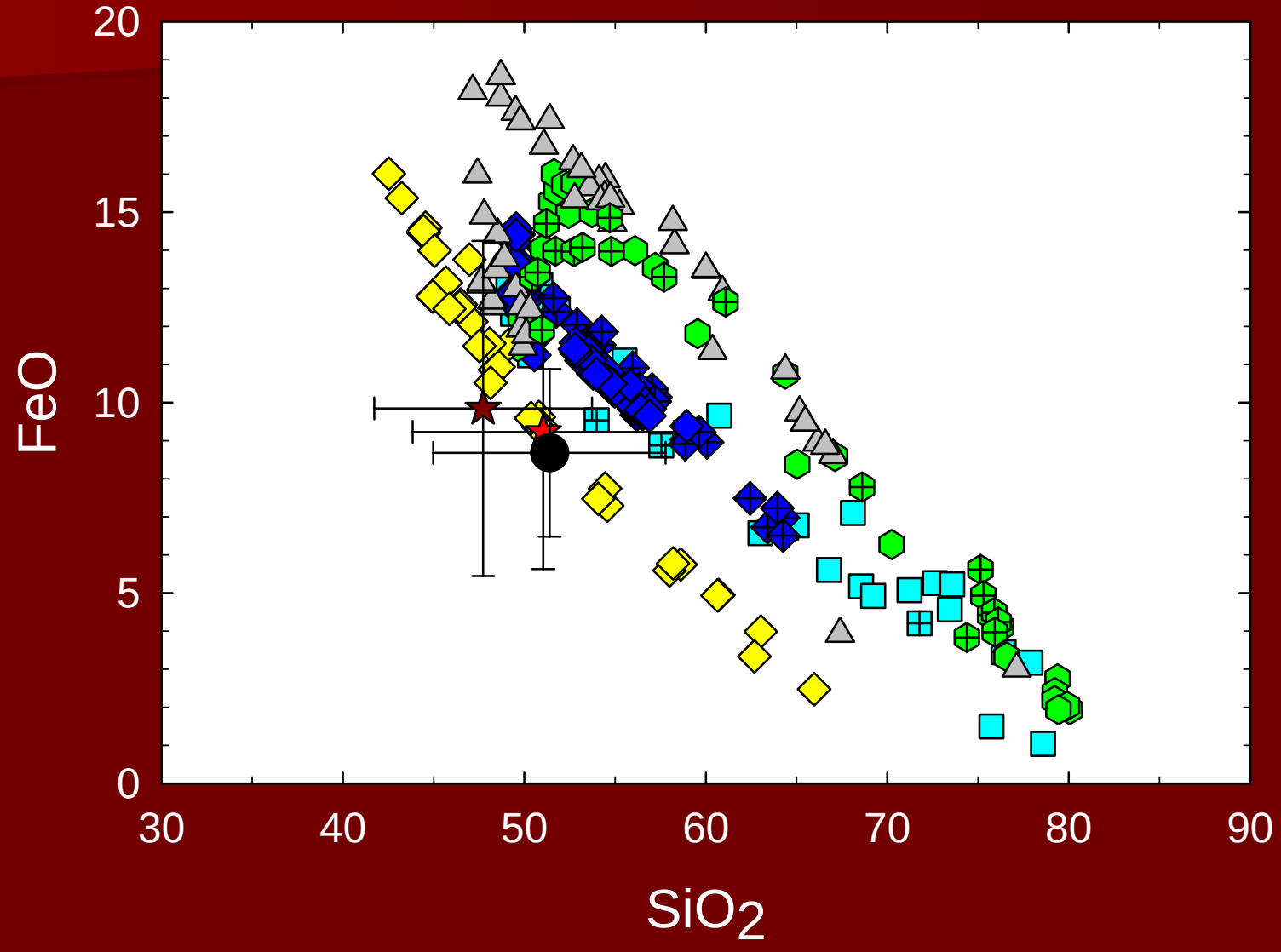
Experimental studies: Litvan 2005; Rossier 2006, Whitaker et al. 2007a, b, 2008
Spulber and Rutherford 1983; Horn 2004; Whitaker et al., 2007a;
Nekvasil et al. 2004; Filiberto et al. 2003; Filiberto 2006; Green 1970;

Venera and Vega

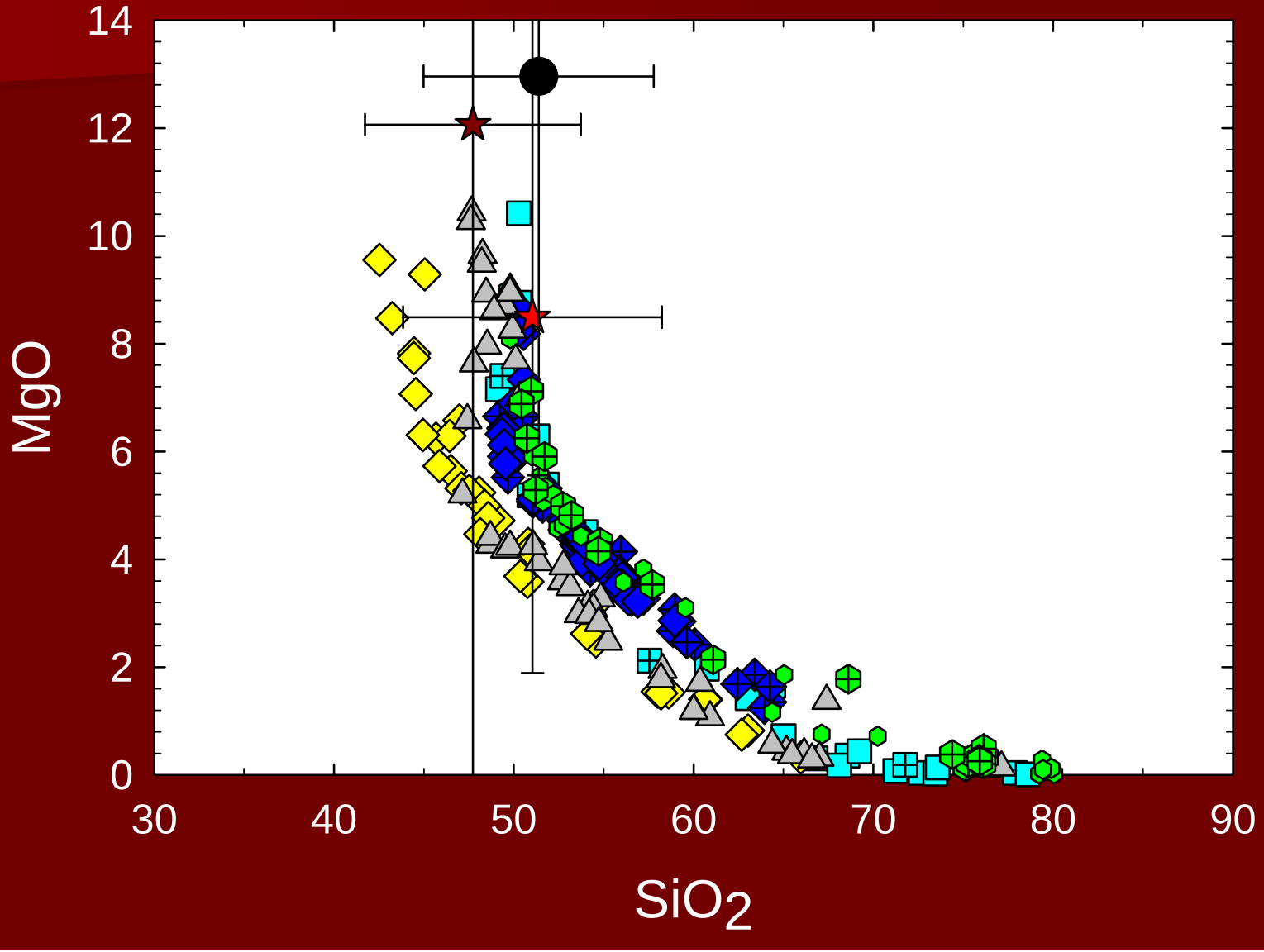


All terrestrial data have been renormalized P- and Na-free

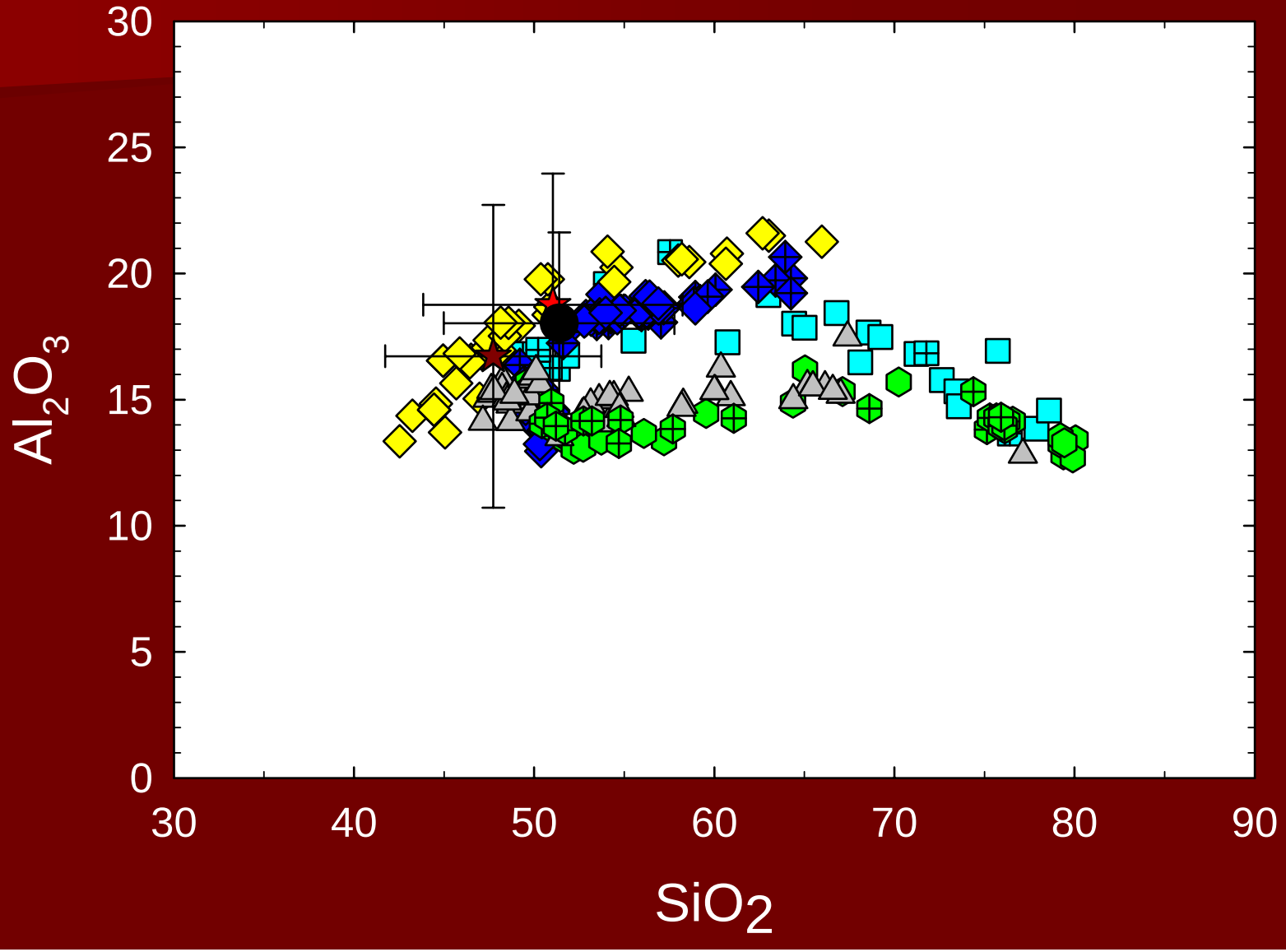
Venera and Vega



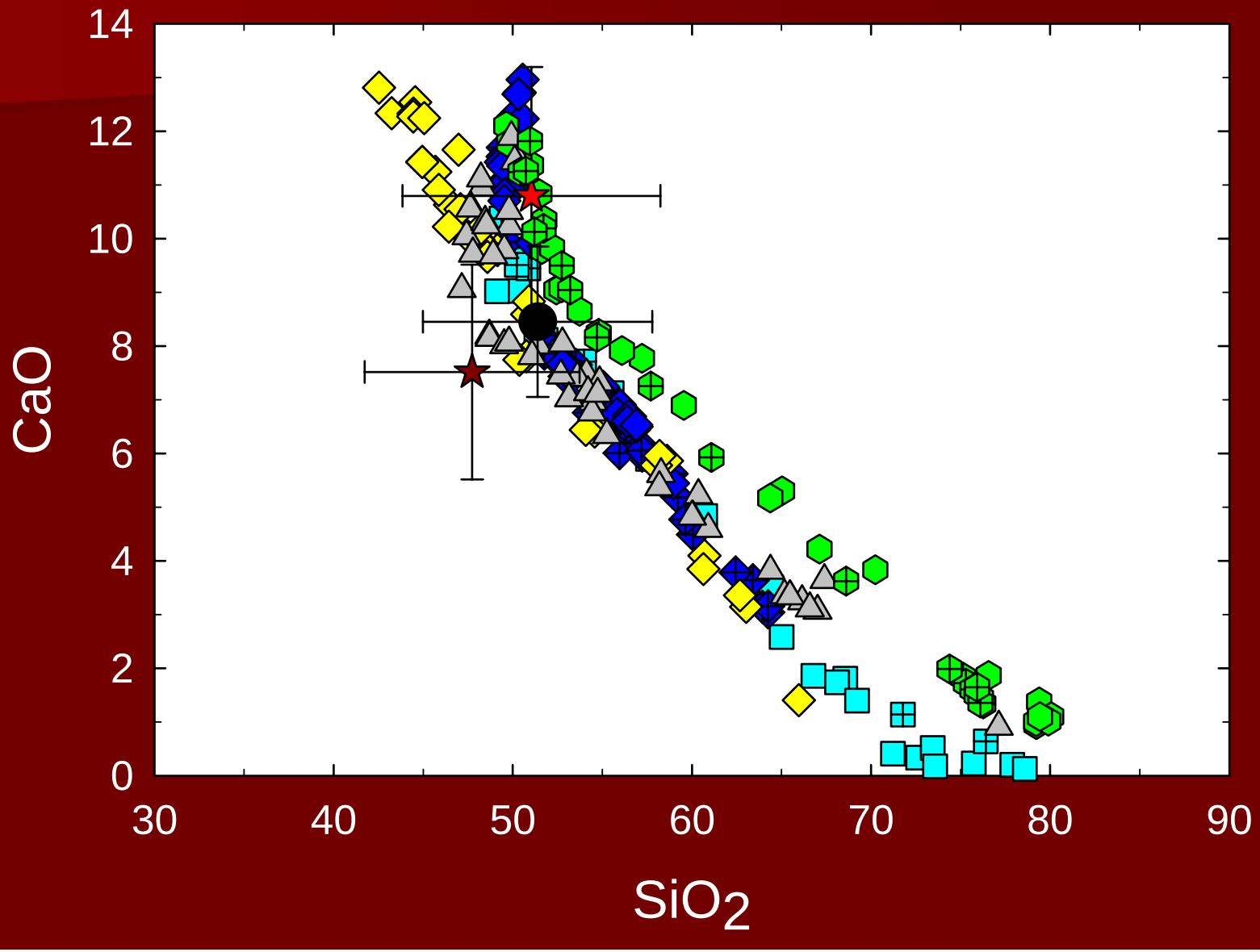
Venera and Vega



Venera and Vega



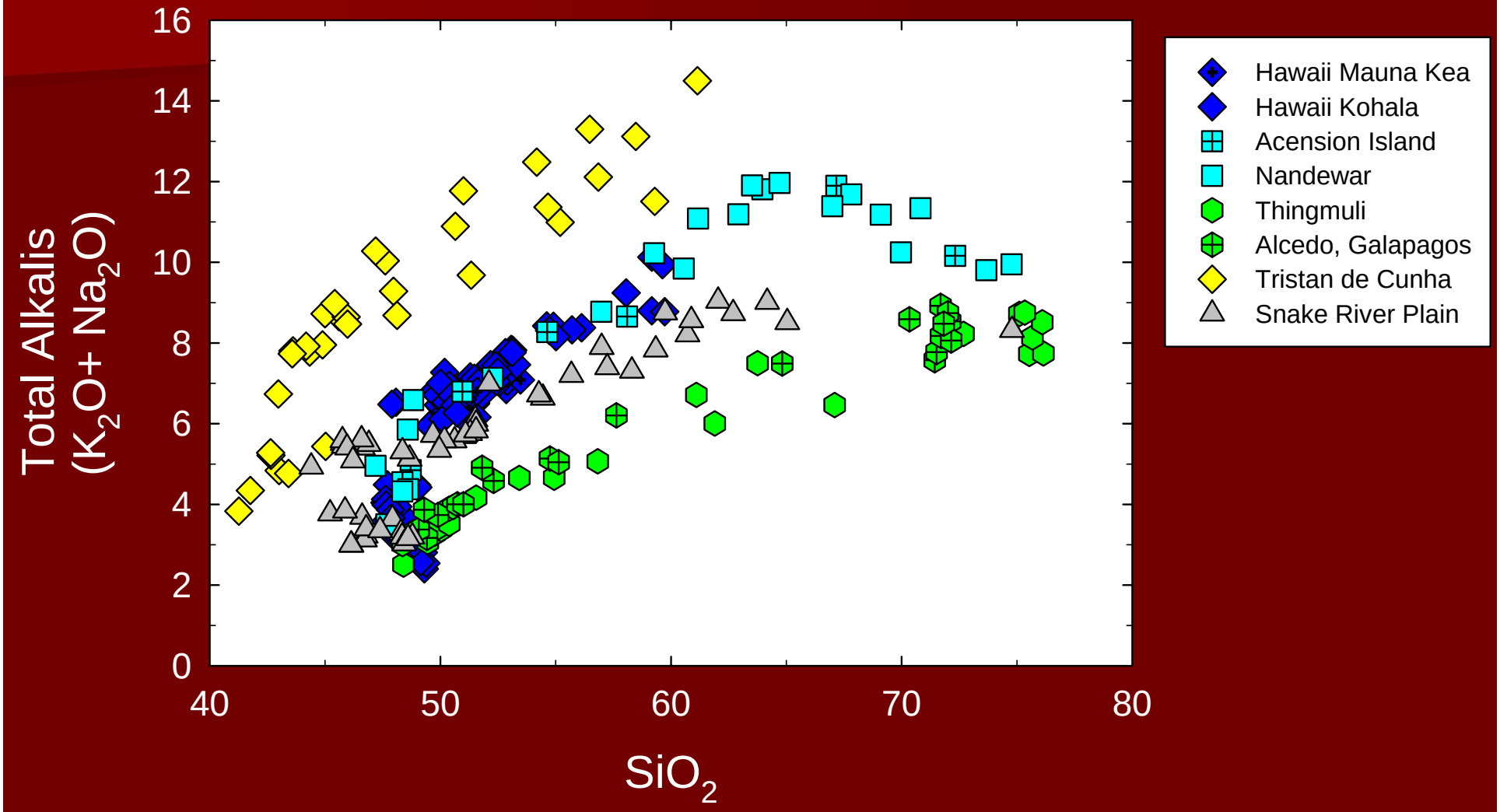
Venera and Vega



Terrestrial Analog Experiments

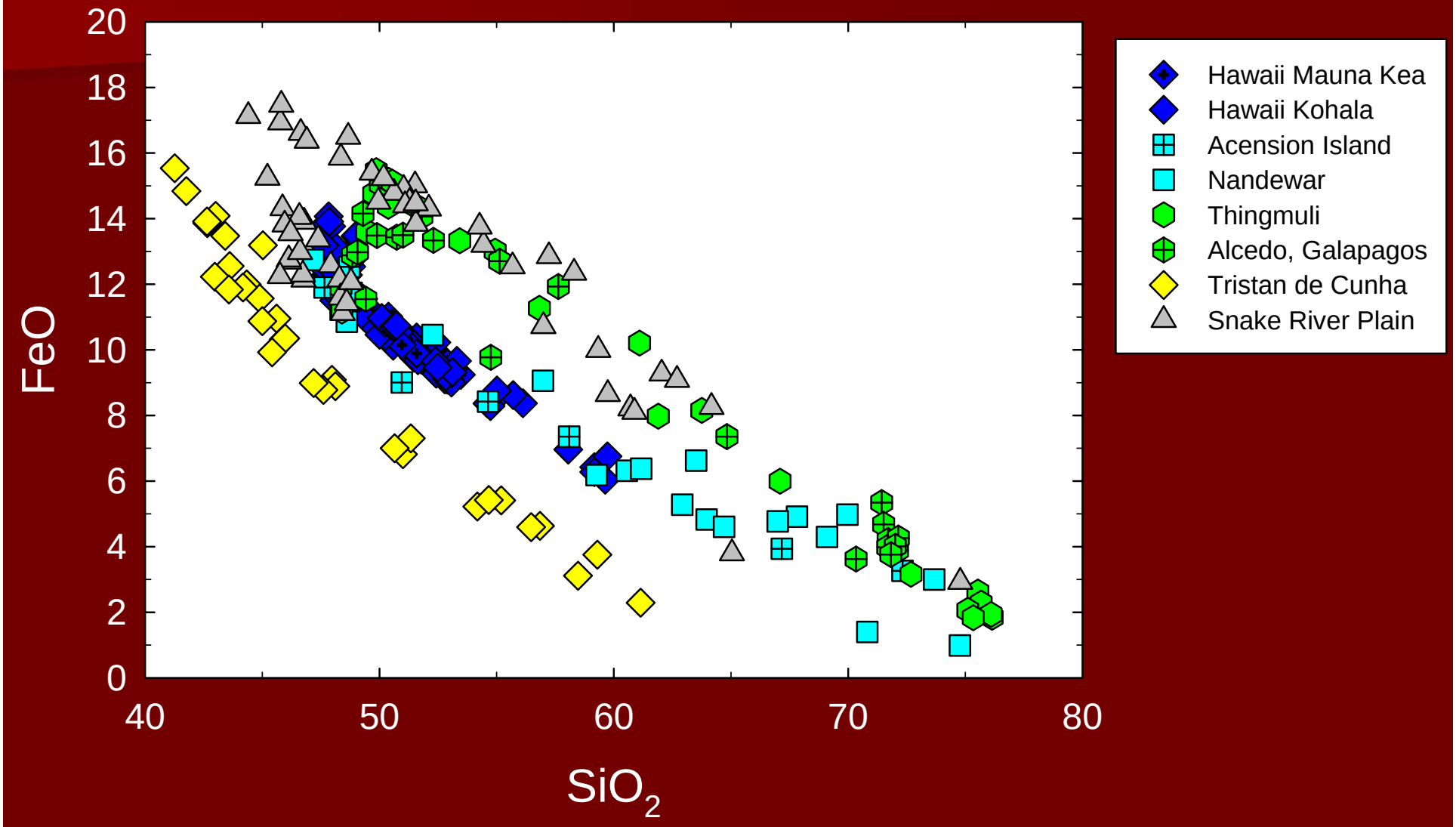
Fractionation Pressure		Volatile Content	Trend	Terrestrial Analog
Venera 14 Vega 2	0-2kb		Tholeiitic Trend	Galapagos Thingmuli
	5-11kb	<0.3wt% water	Potassic Alkalic Series	Snake River Plain
	9-11kb	>0.3wt% water	Sodic Alkalic Series	Nandewar Ascension Island
	12-16kb	>0.3wt% water	Si-Undersaturated	Hawaii
Venera 13	18-27kb	~0.2 wt% water	Phonolitic Series	Tristan de Cunha

Future Mission Data



All terrestrial data have been renormalized for all major elements

Future Mission Data



Summary

- Vega 2 and Venera 14 analyses
  - Consistent with a terrestrial olivine tholeiite
  - Unknown P, T, or XH_2O
  - Maybe primary mantle melts
- Venera 13 analysis
  - Consistent with silica-undersaturated rocks
  - Deep/high P origin
  - Low water content
  - Origin similar to rocks from Tristan de Cunha
- Analysis of Na, K, Si, Fe, and Mg are the most important to distinguish rocks from each suite and place constraints on P, T, H_2O content of formation.