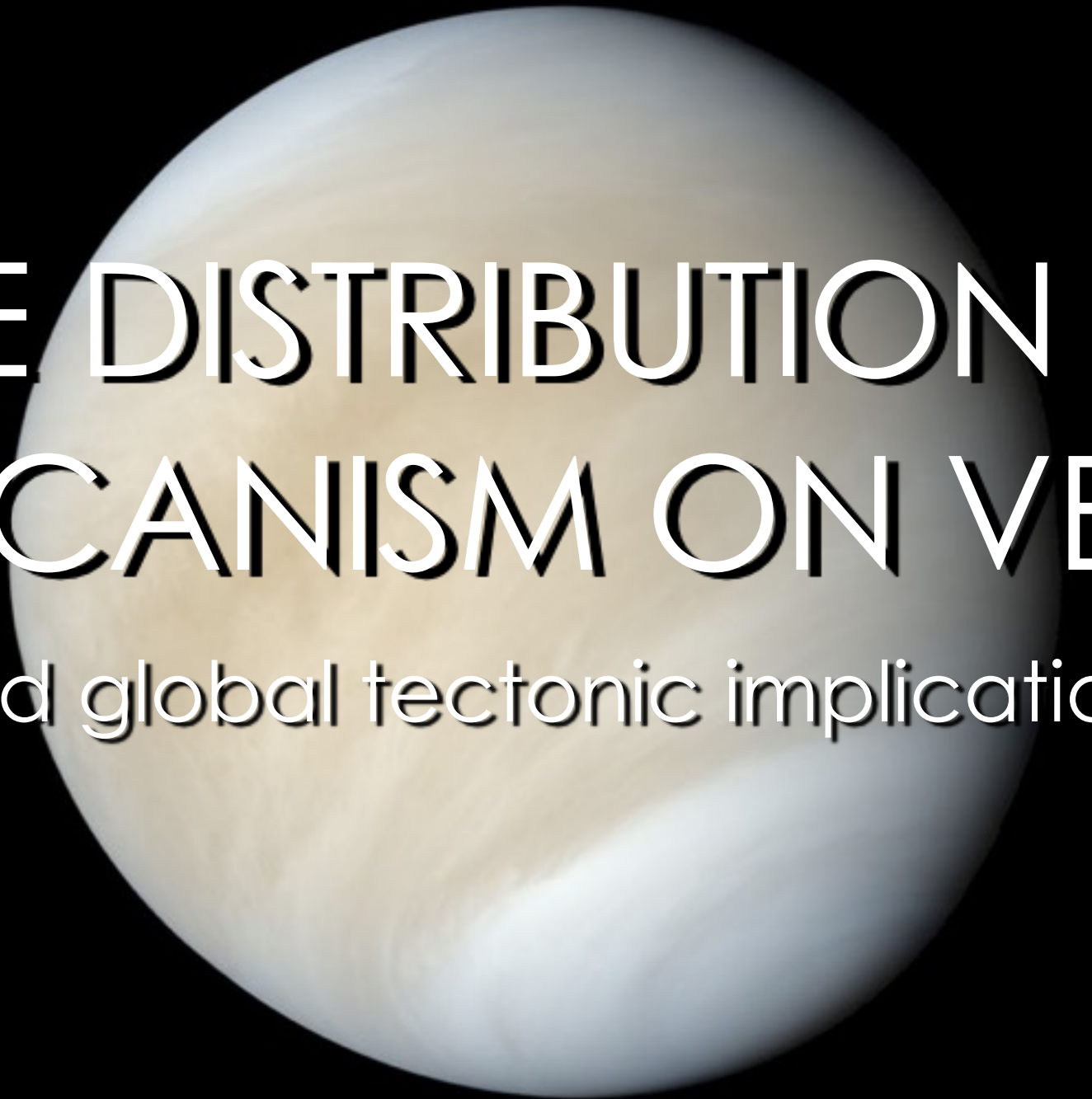


International Venus Conference, Oxford, UK
Monday 4th April 2016



THE DISTRIBUTION OF VOLCANISM ON VENUS

and global tectonic implications

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RESEARCH OBJECTIVES

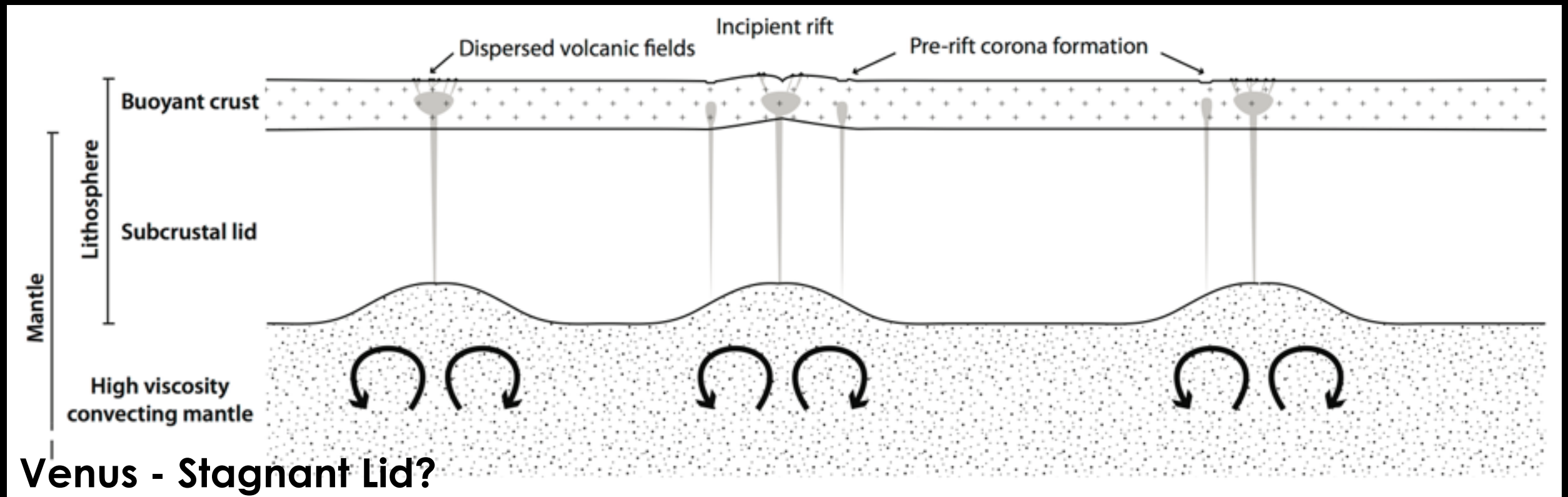
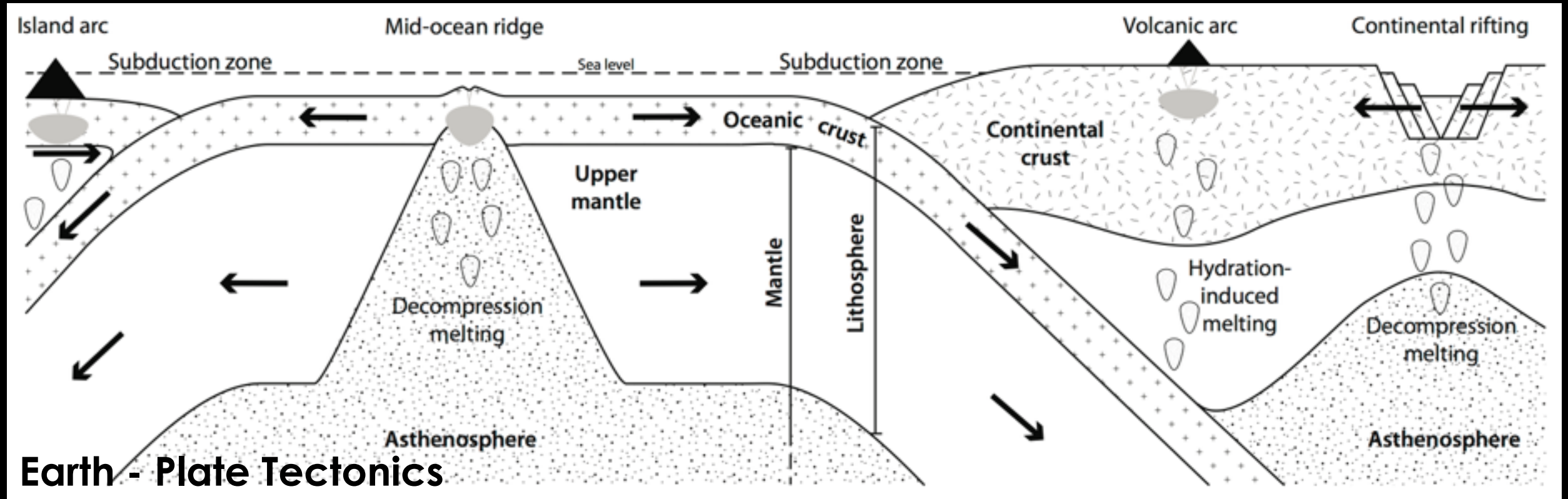
Identify:

- Significant patterns/trends in volcanic features' **distribution**
- **Association** of volcanoes with **rifts**
- Significant **temporal/stratigraphical** relationships

Interpret:

- Internal driving **volcano-tectonic processes**
- Nature of **geological evolution** of Venus' surface

TECTONICS OF VENUS AND EARTH

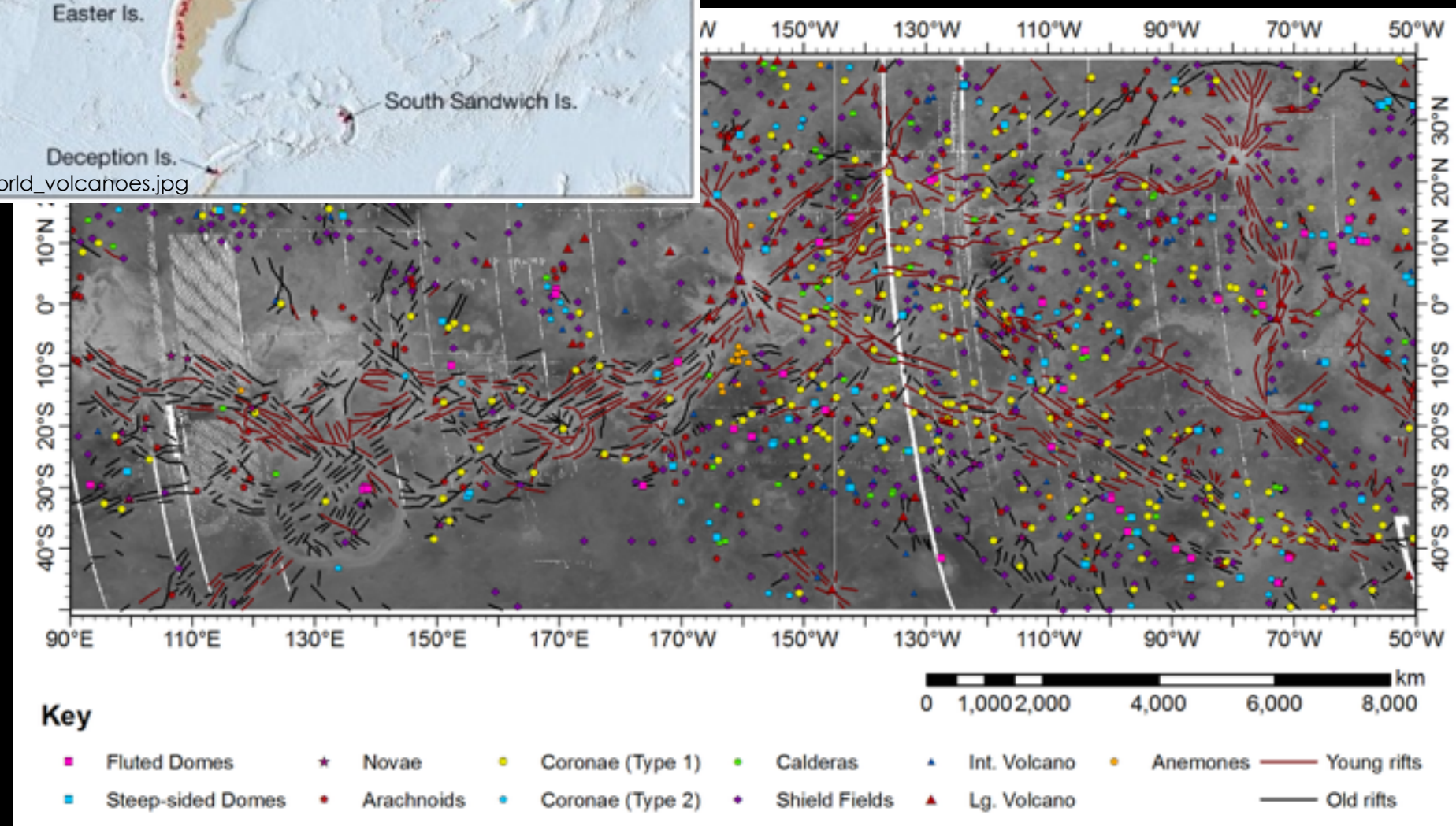


TECTONICS OF VENUS AND EARTH



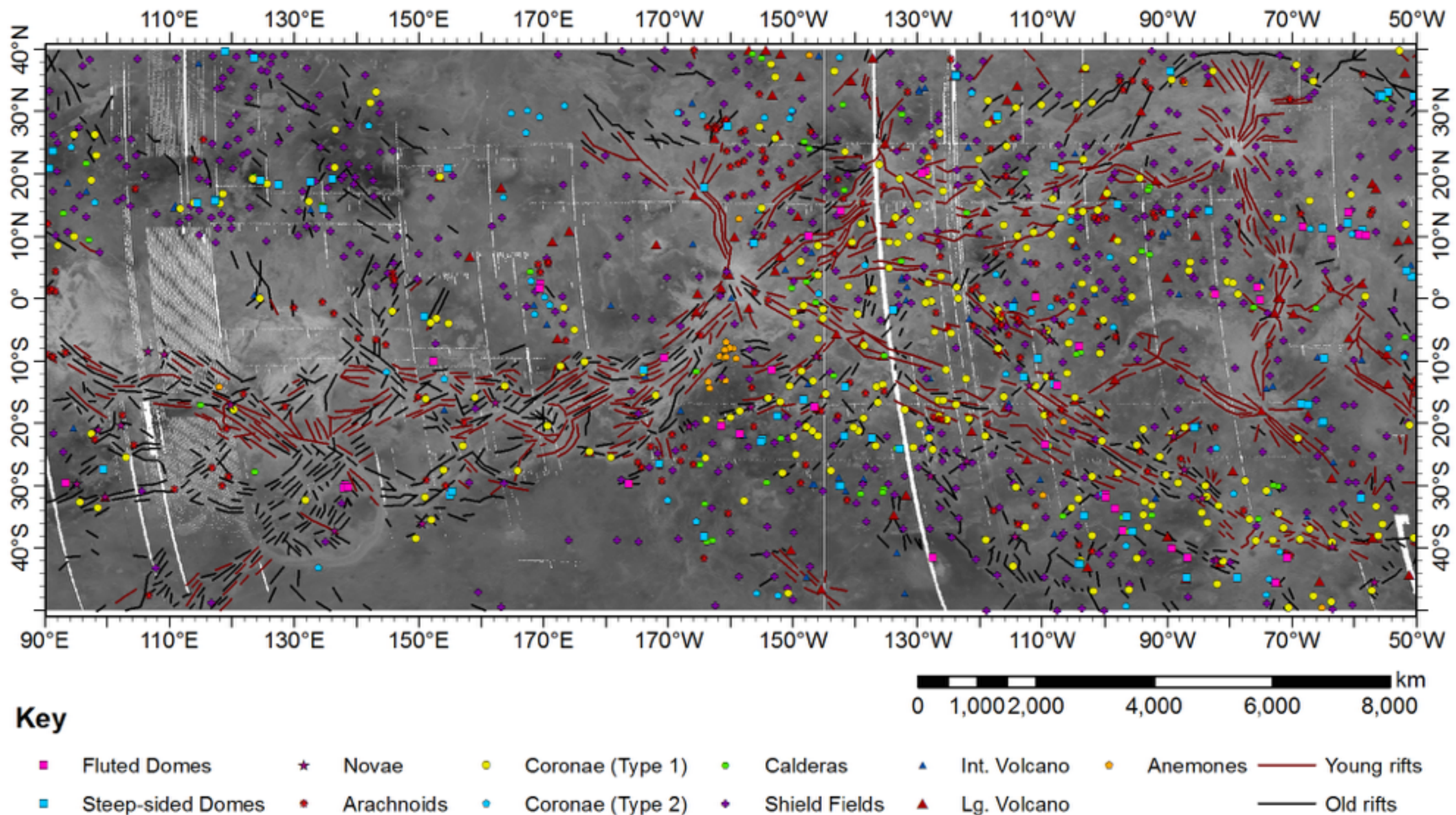
Earth - Volcanic features track plate boundaries

Venus - Widely distributed volcanism

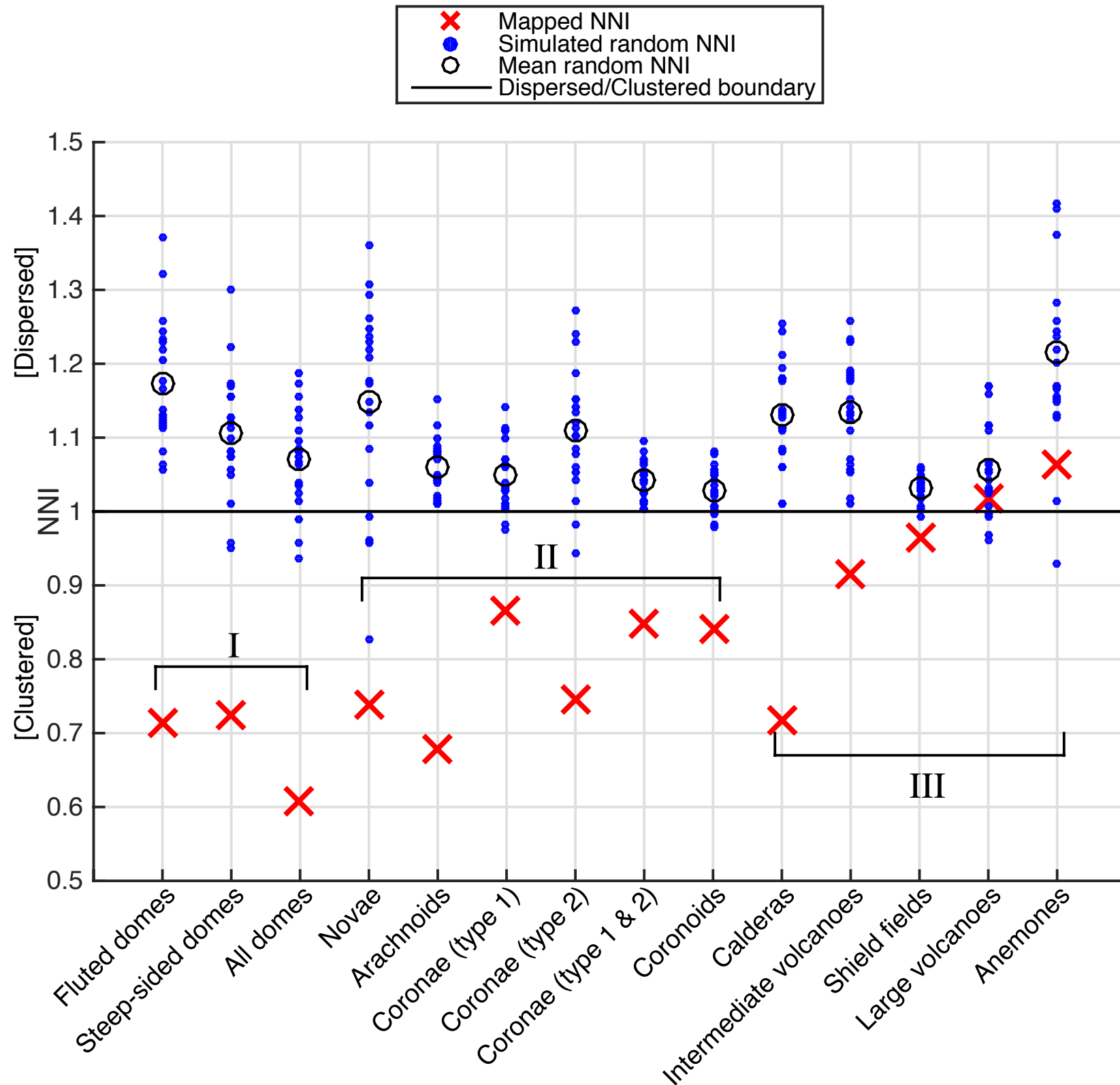


DATA AND MAPPING

Data sources: **Volcanoes & Coronae** (Head et al., 1992; Crumpler and Aubele, 2000), **Rifts** (Krassilnikov et al., 2012), **Coronae** (Stofan et al., 2001)



SPATIAL RELATIONSHIPS - NEAREST NEIGHBOUR INDEX



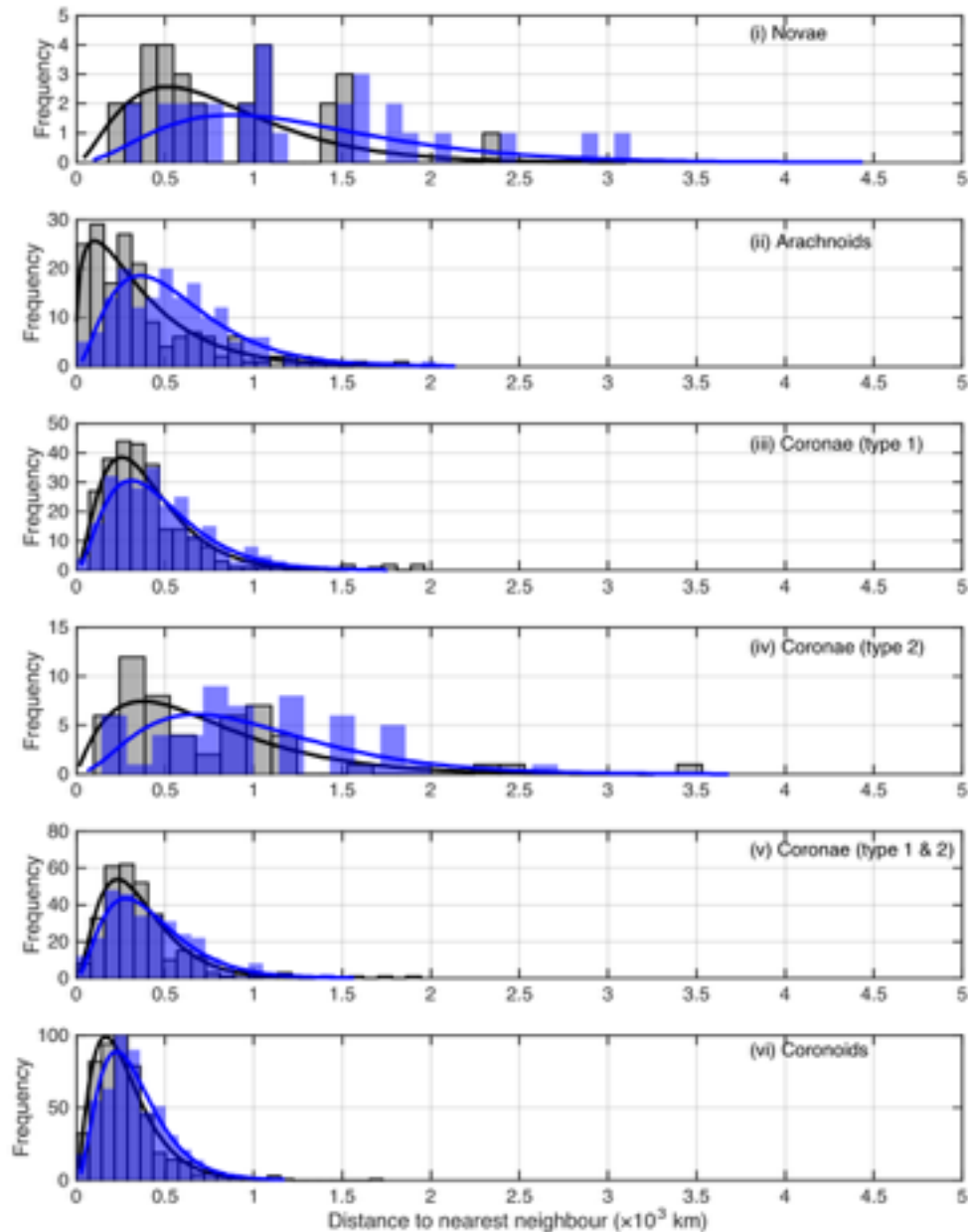
$$NNI = \frac{D_o}{D_E}$$

$$D_o = \frac{\sum_{i=1}^n d_i}{n}$$

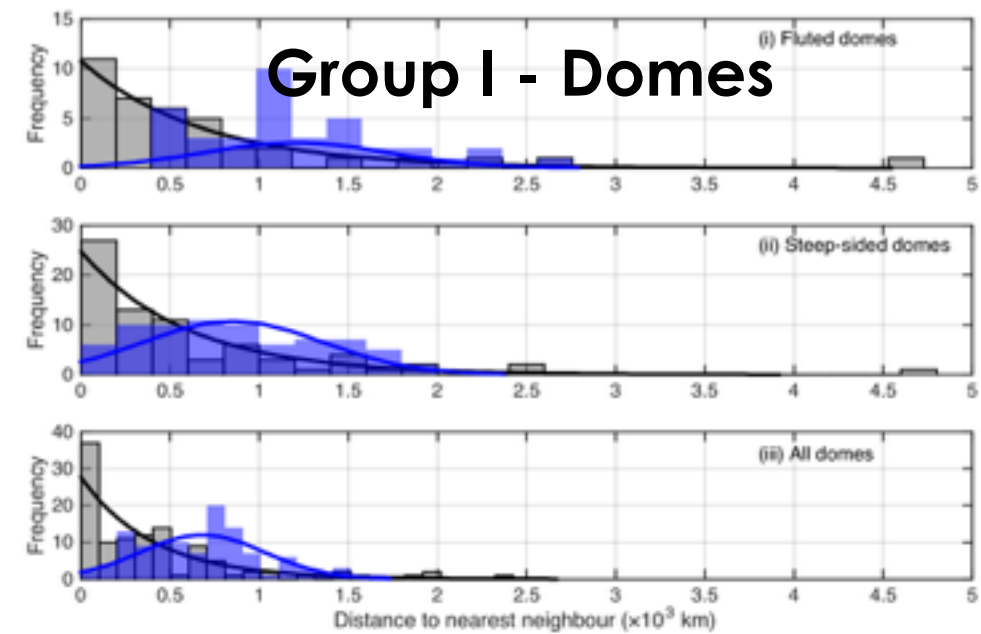
$$D_E = \frac{0.5}{\sqrt{\frac{n}{A}}}$$

DISTANCE TO NEAREST NEIGHBOUR

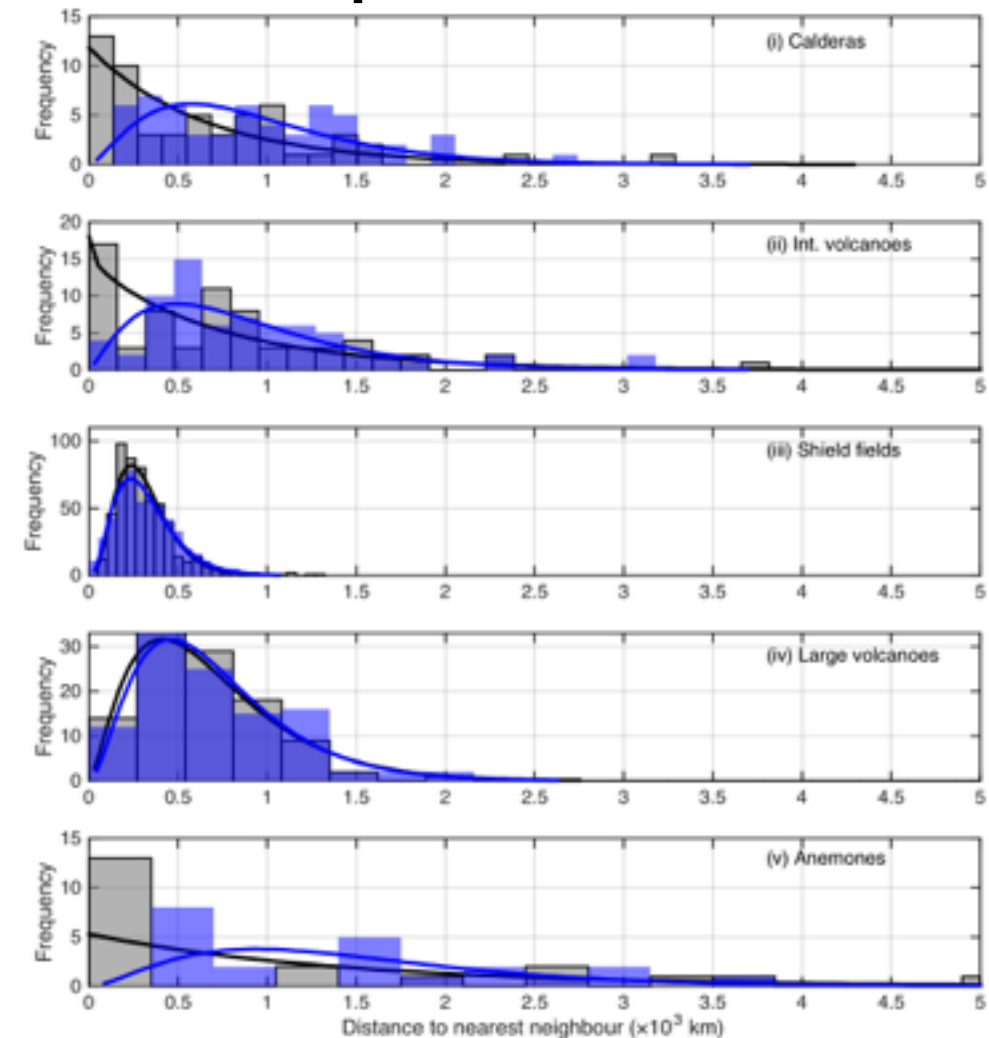
Group II - Coronoids



Group I - Domes

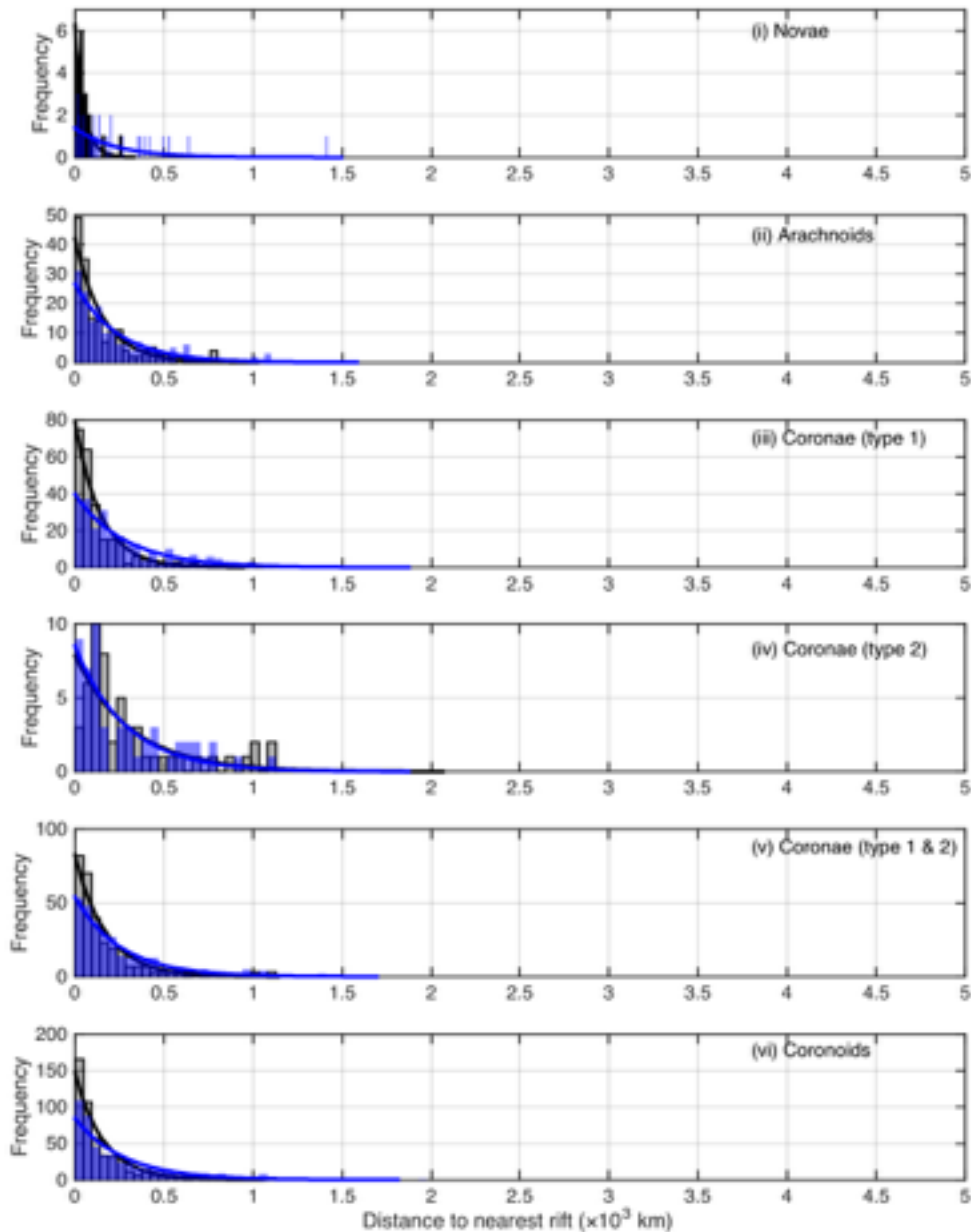


Group III - Volcanoes

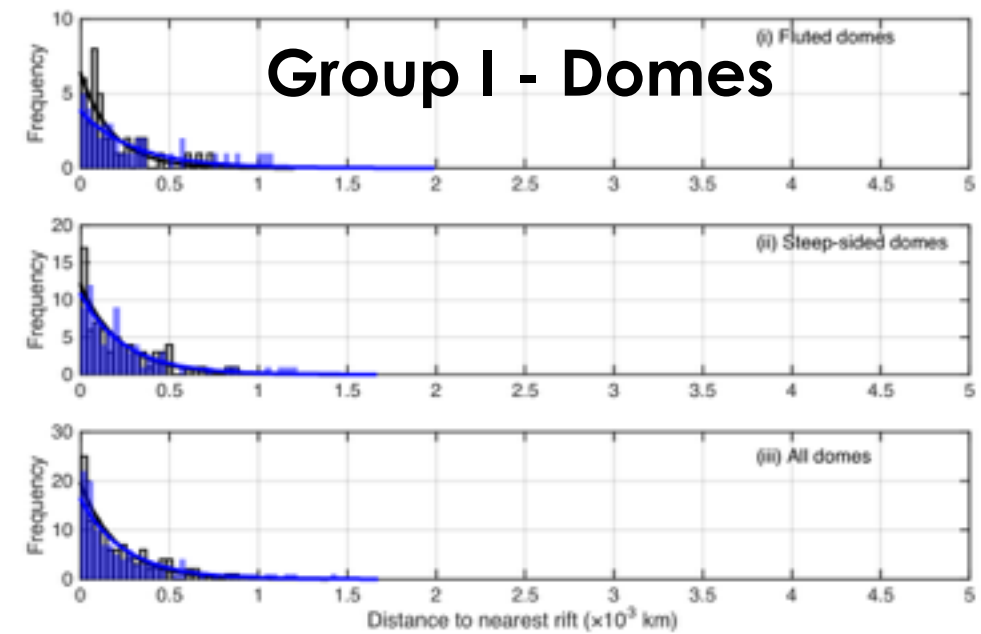


DISTANCE TO NEAREST RIFT

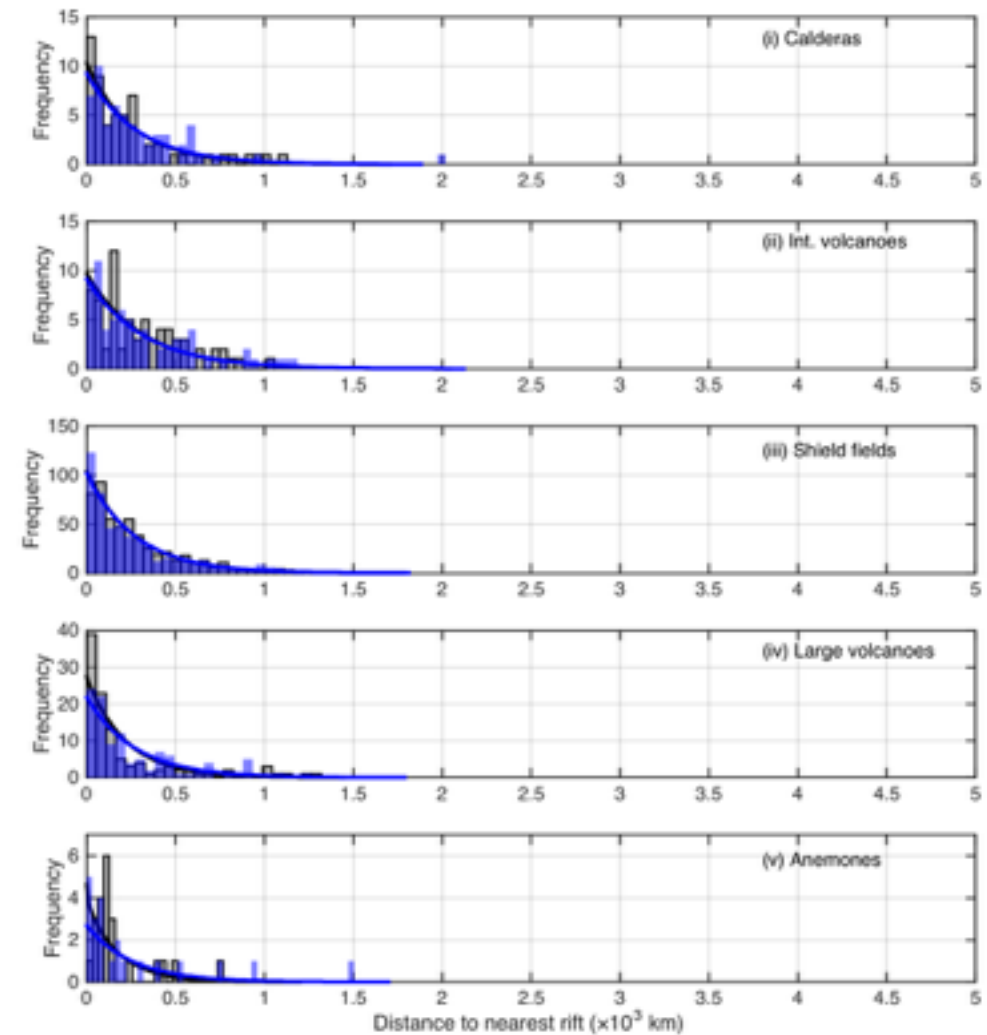
Group II - Coronoids



Group I - Domes

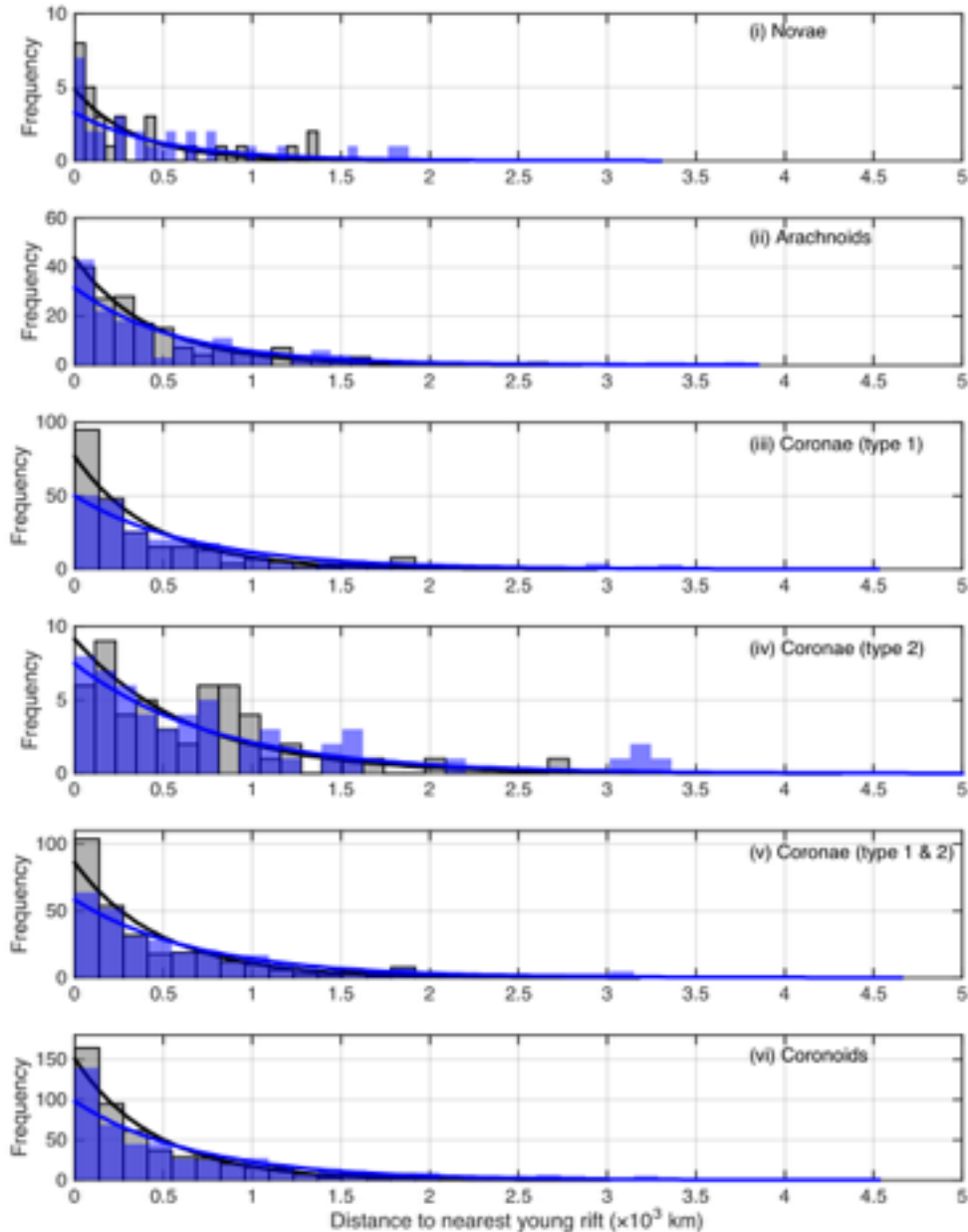


Group III - Volcanoes

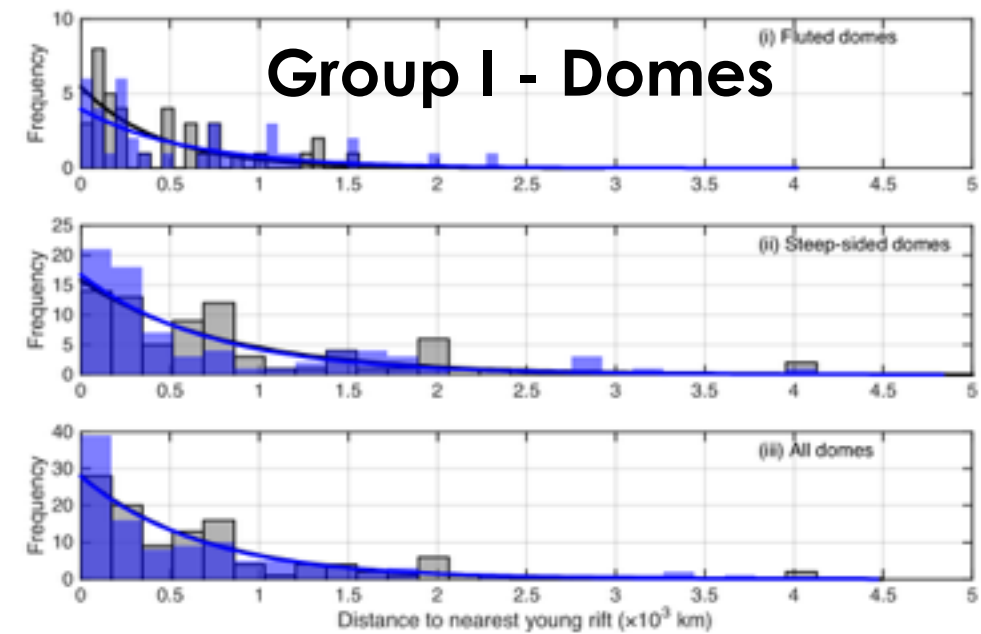


DISTANCE TO NEAREST YOUNG RIFT

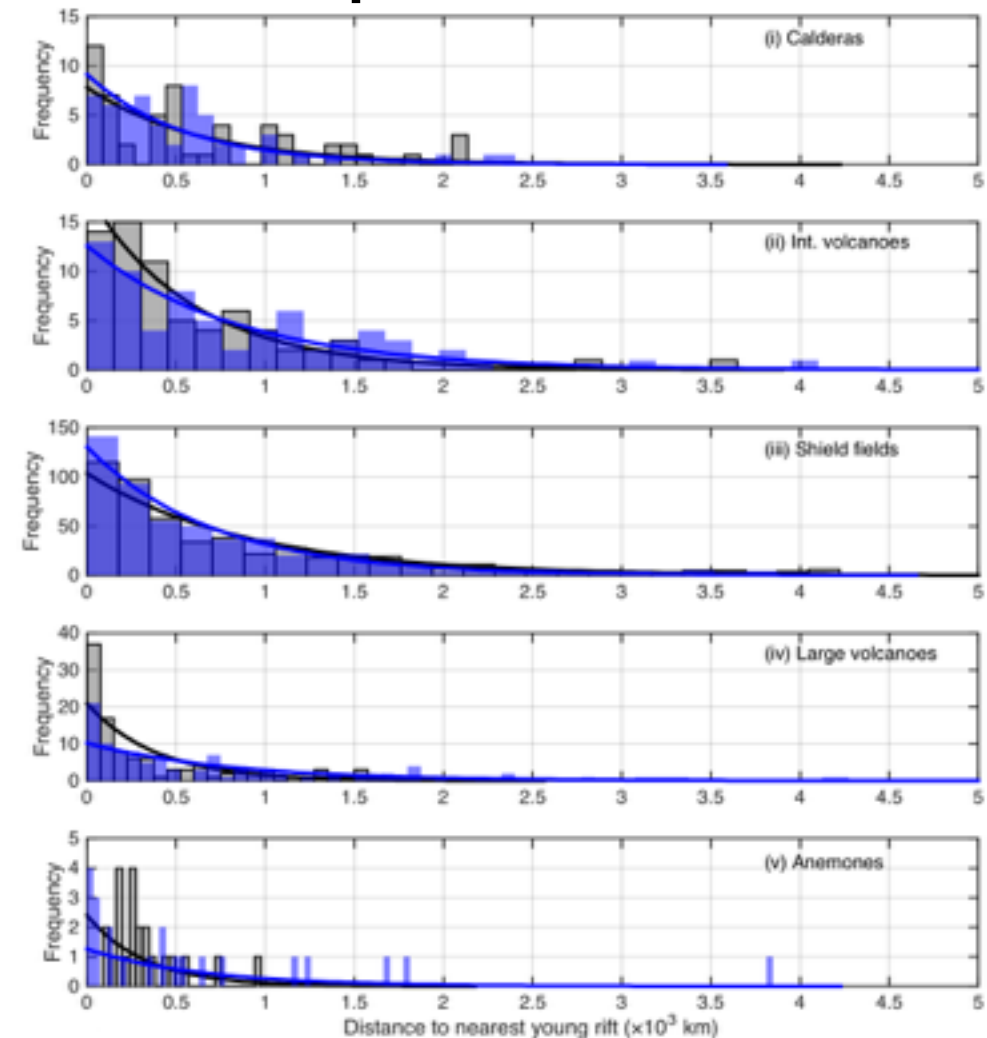
Group II - Coronoids



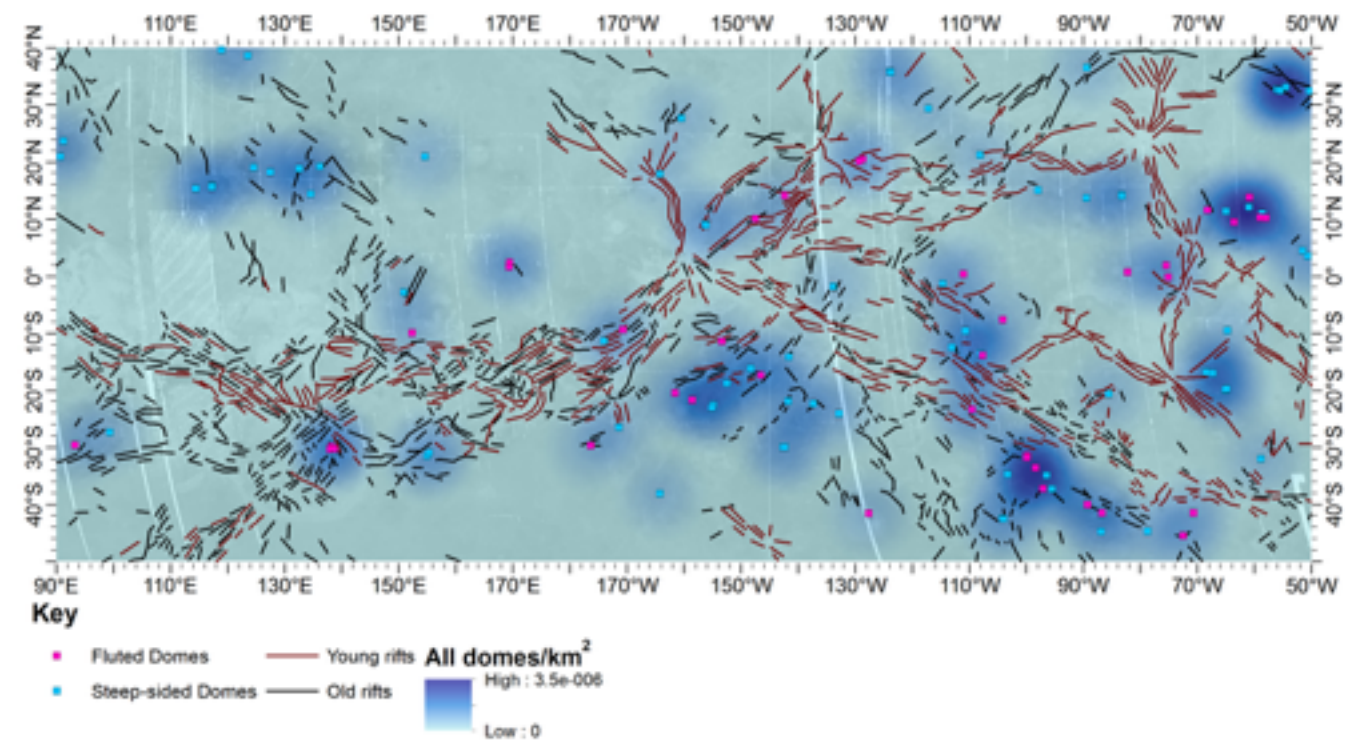
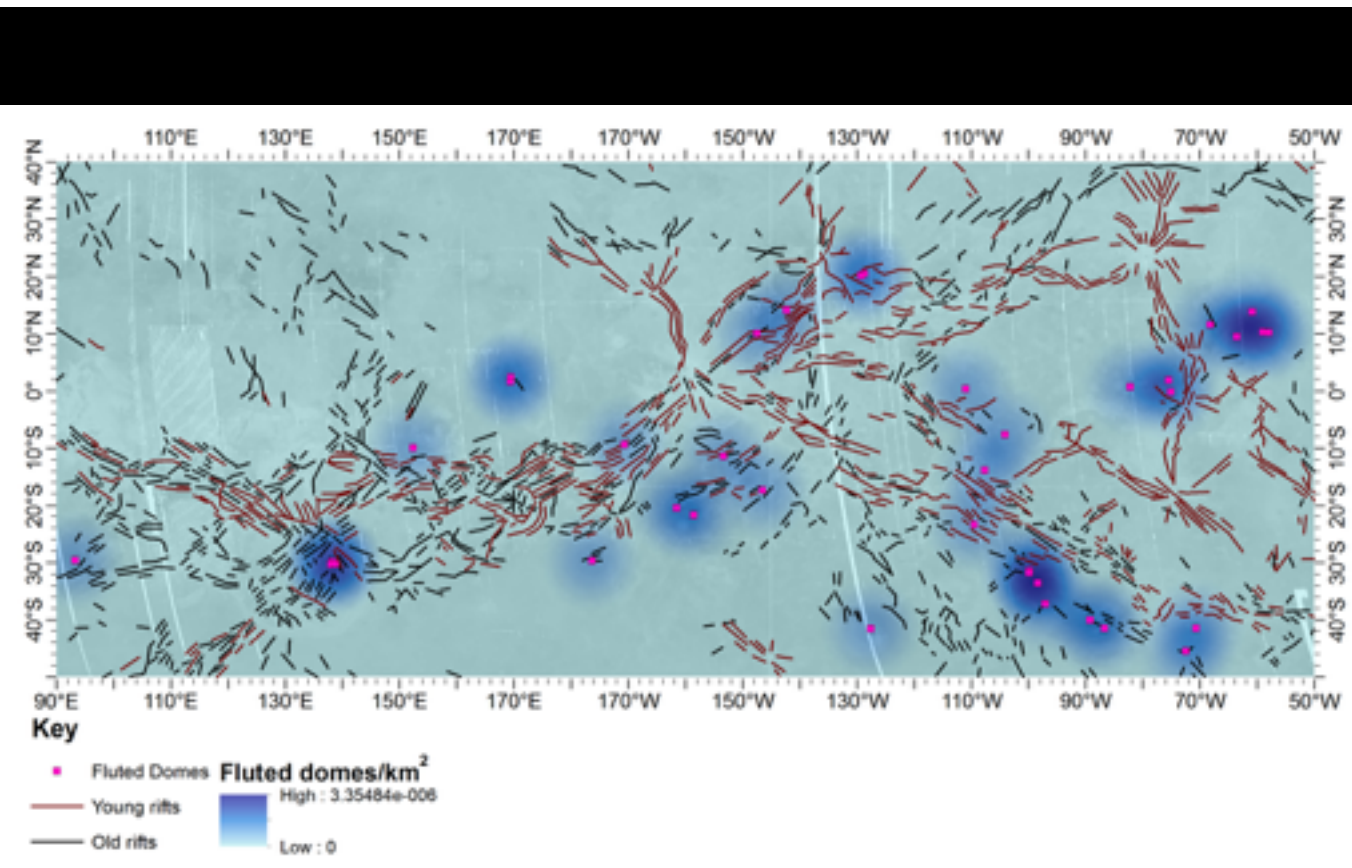
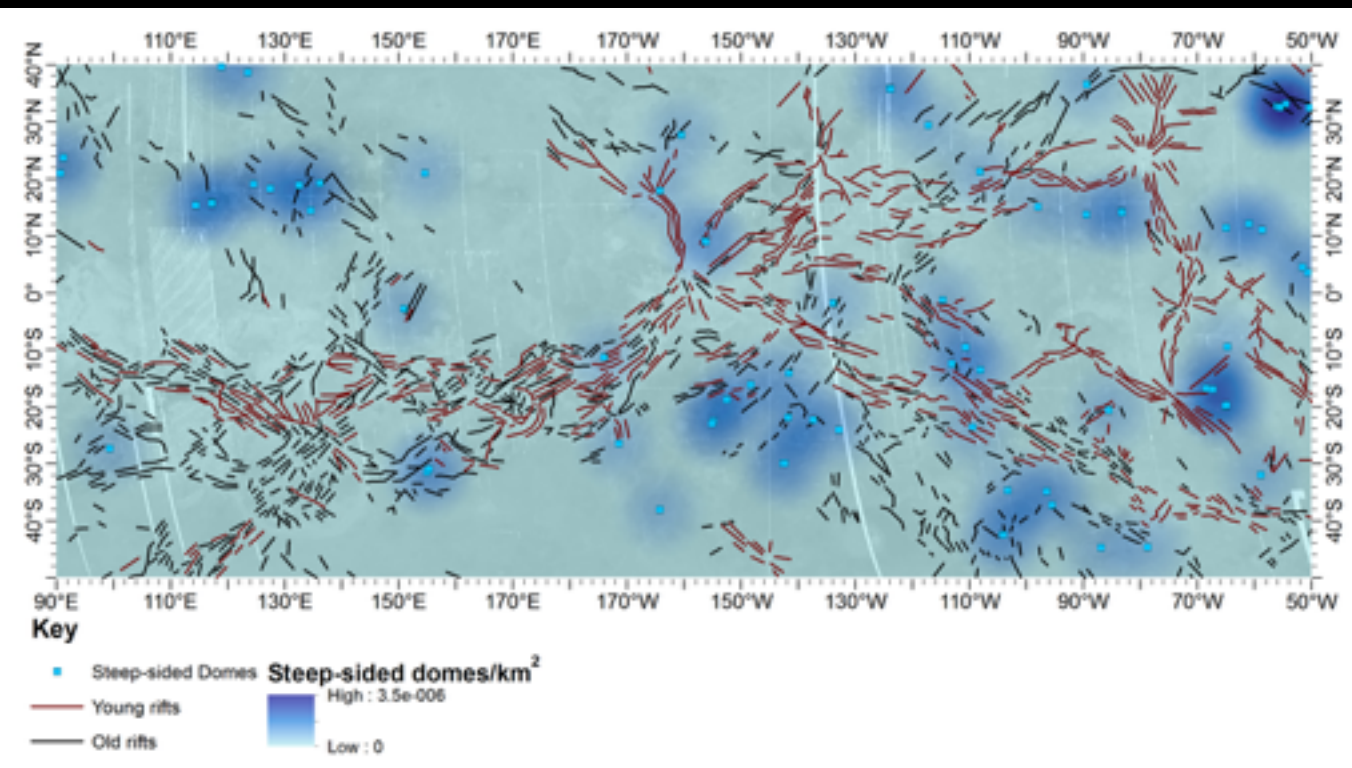
Group I - Domes



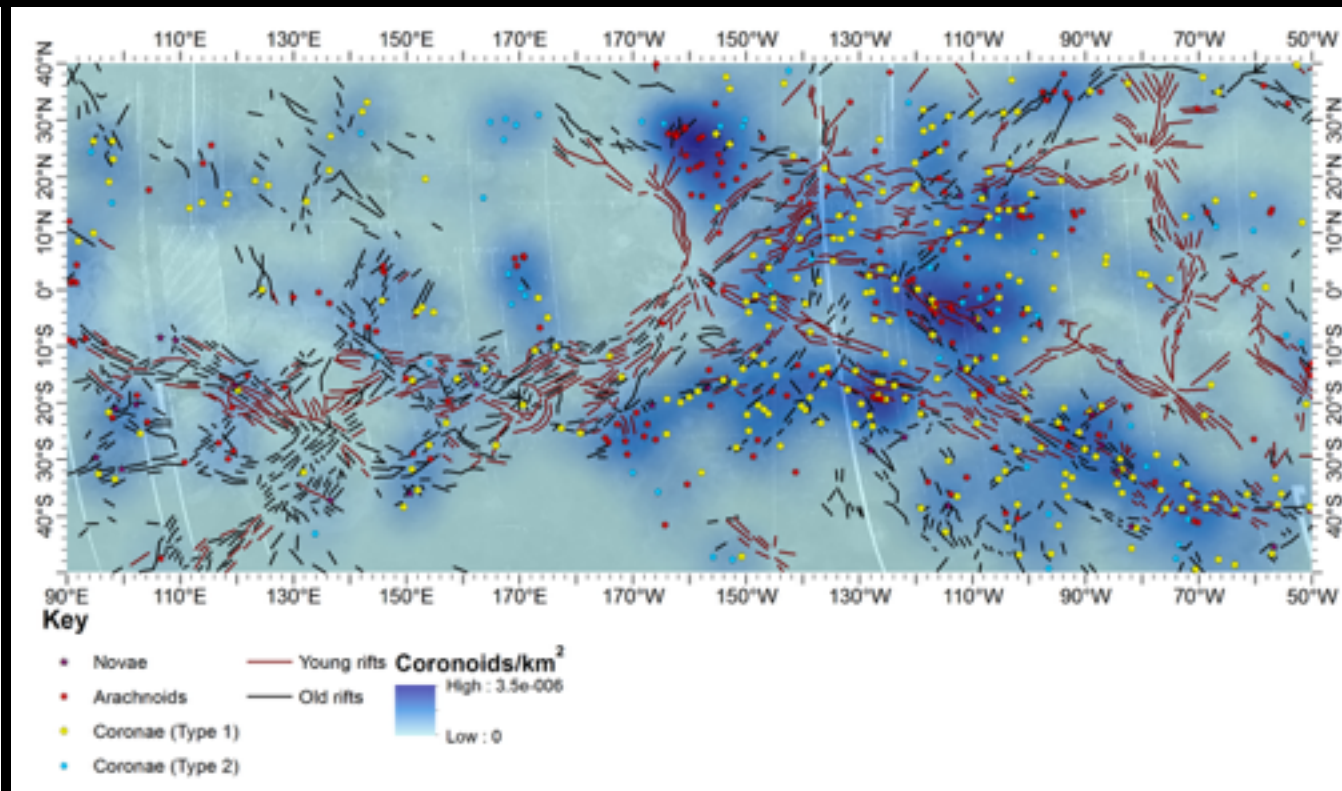
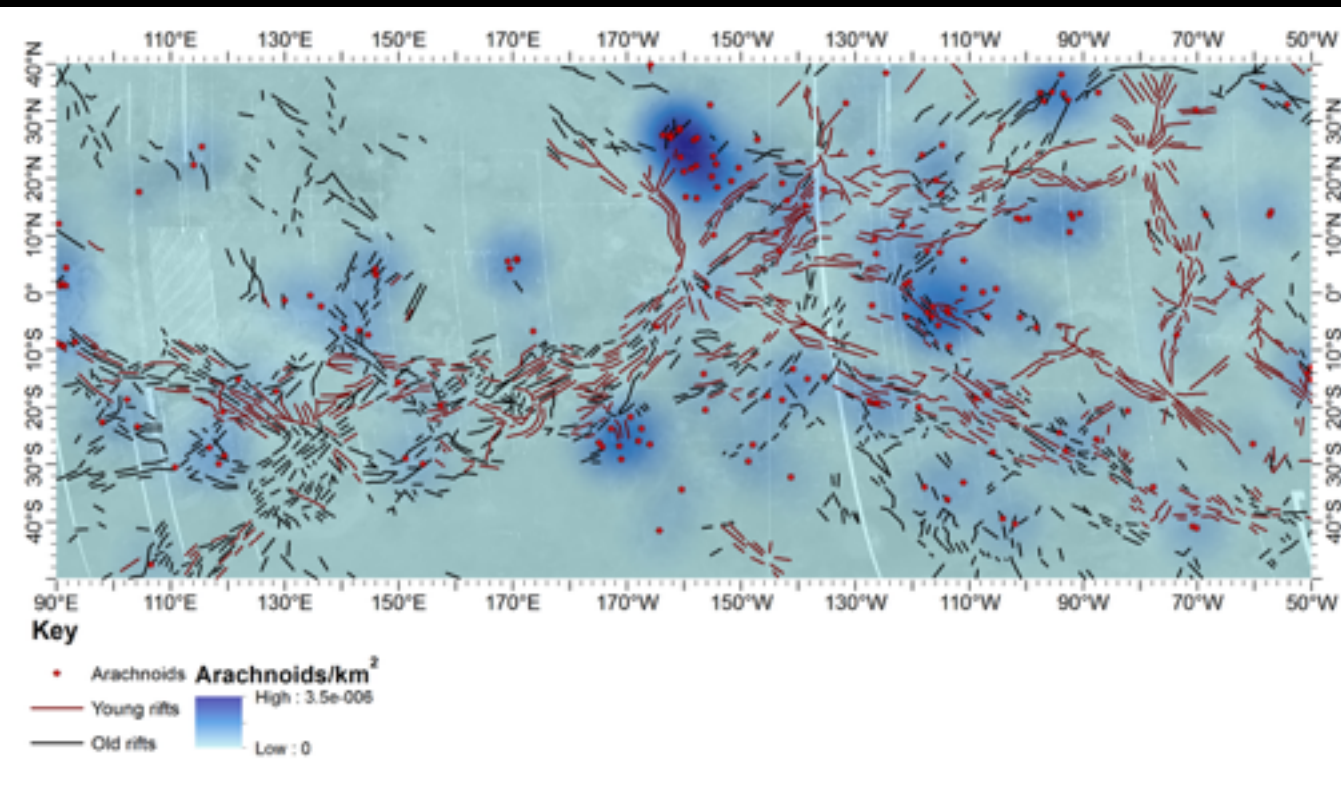
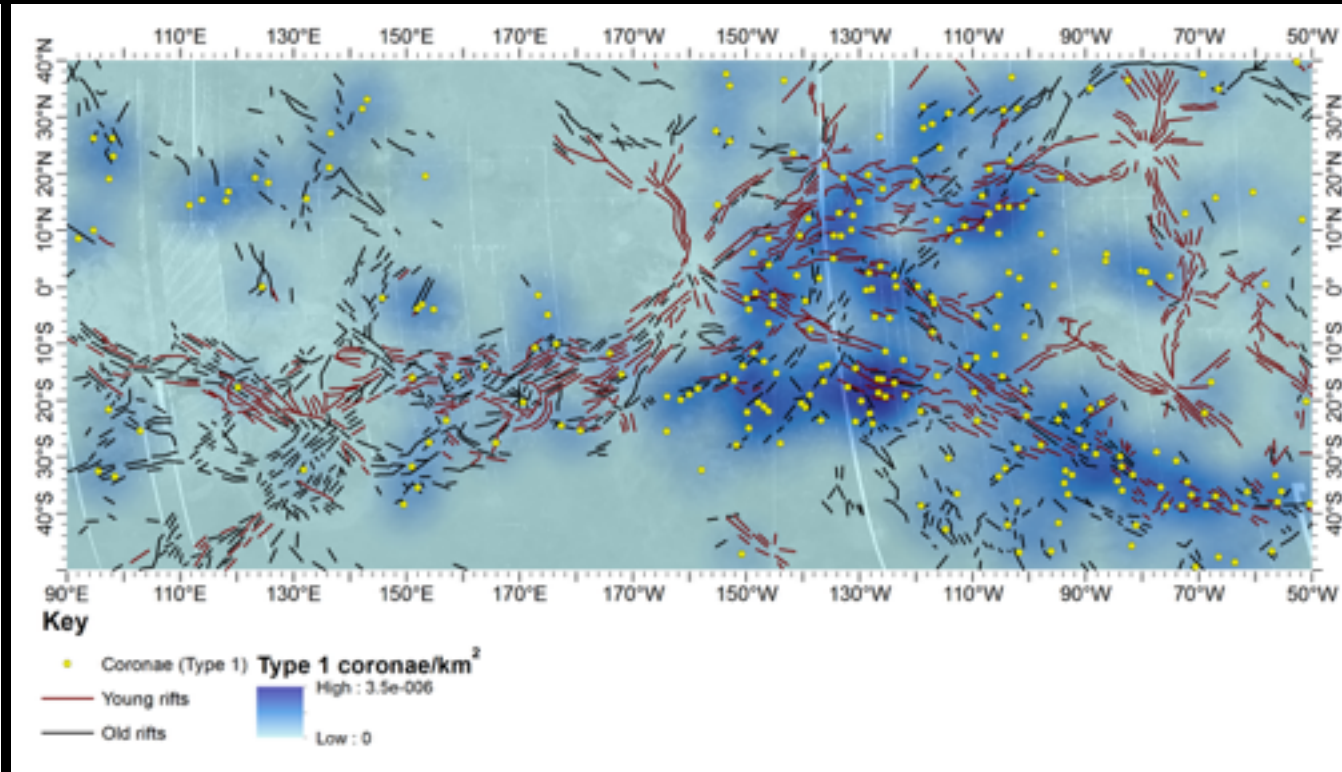
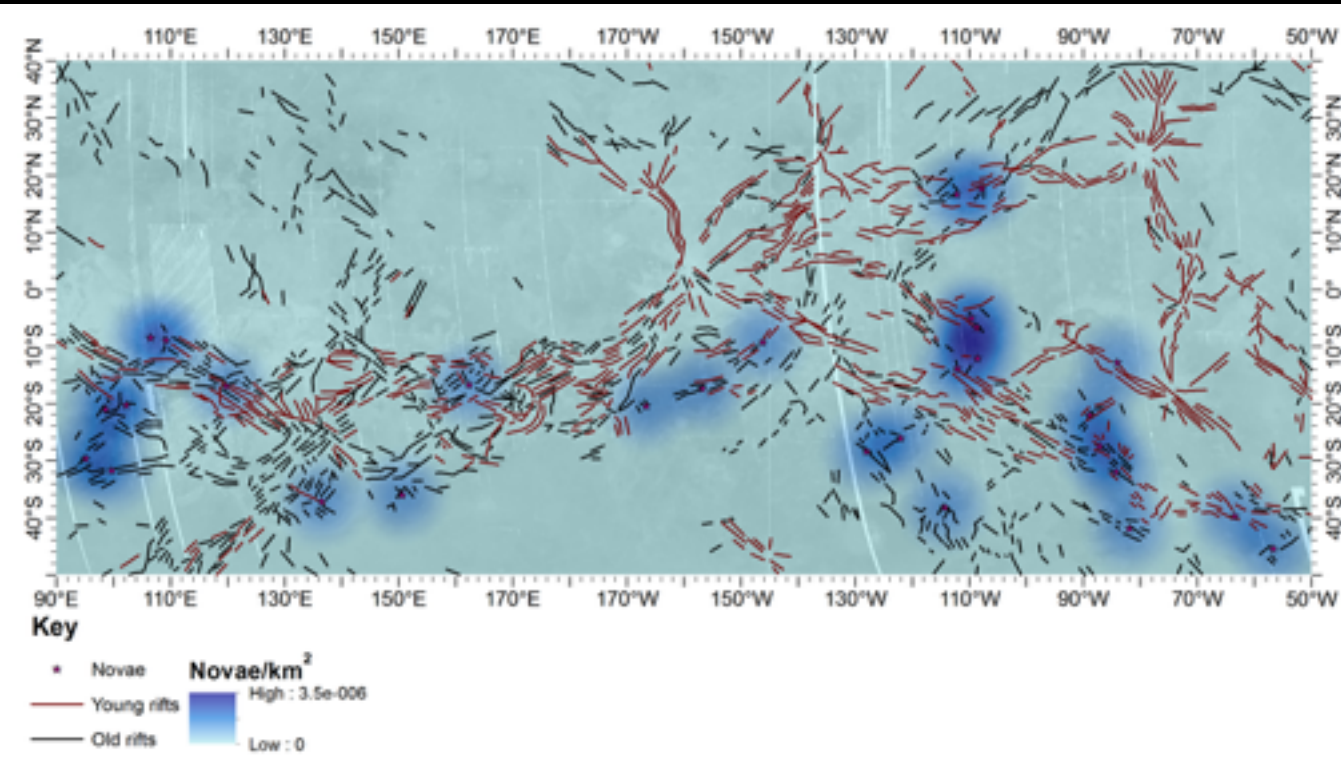
Group III - Volcanoes



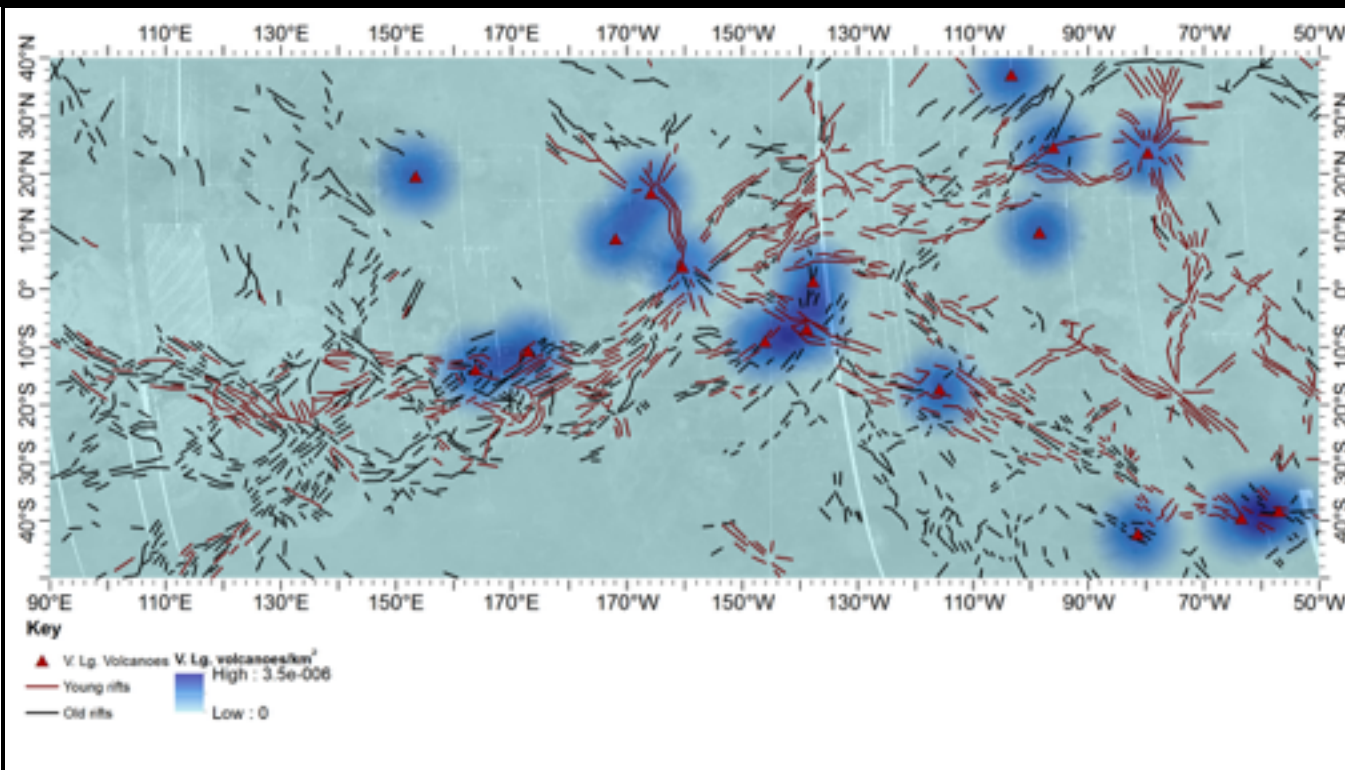
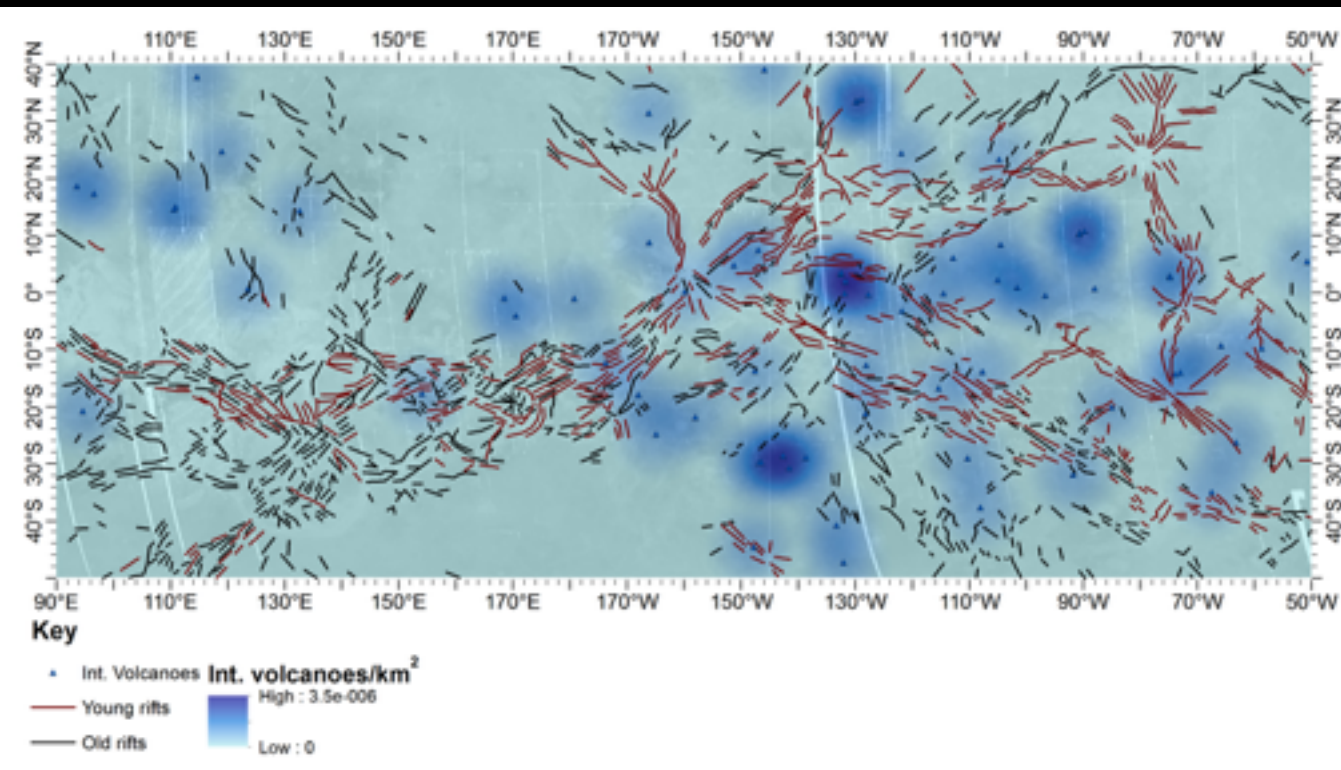
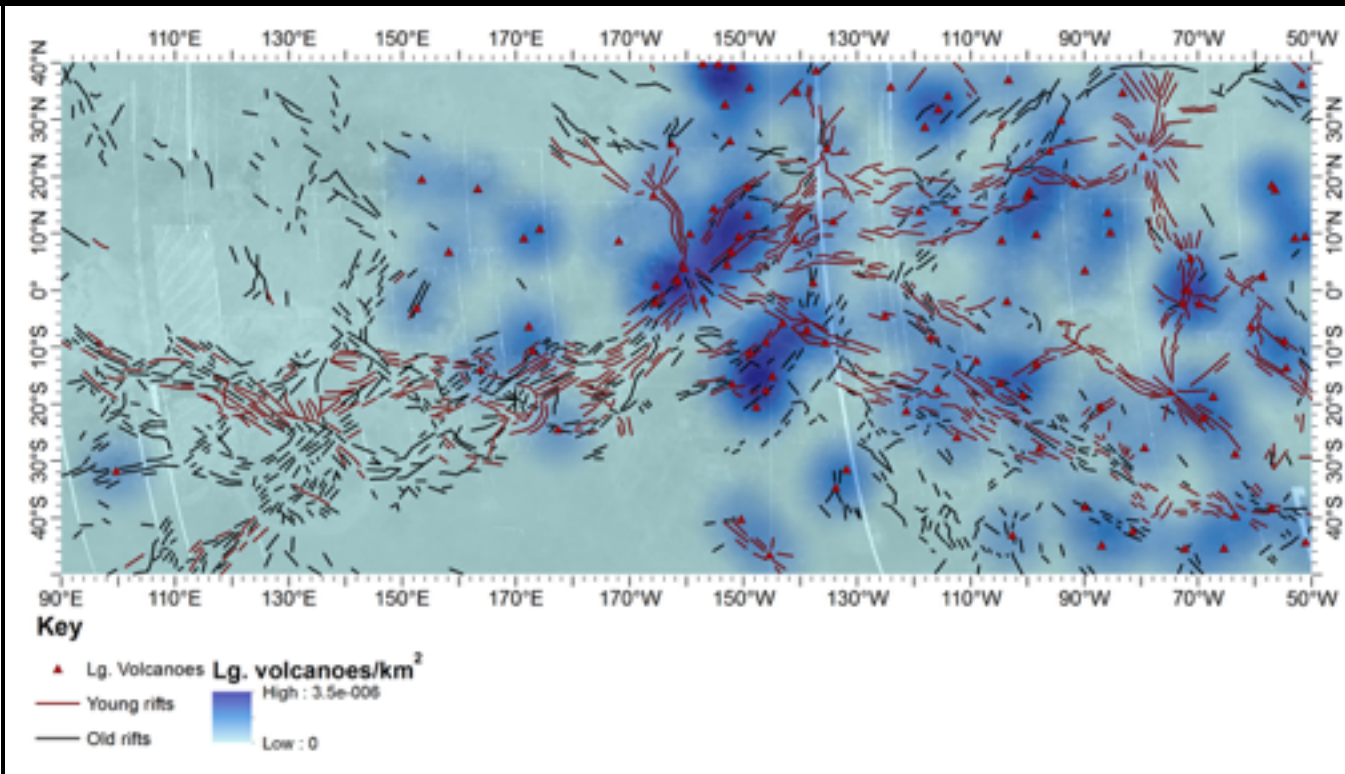
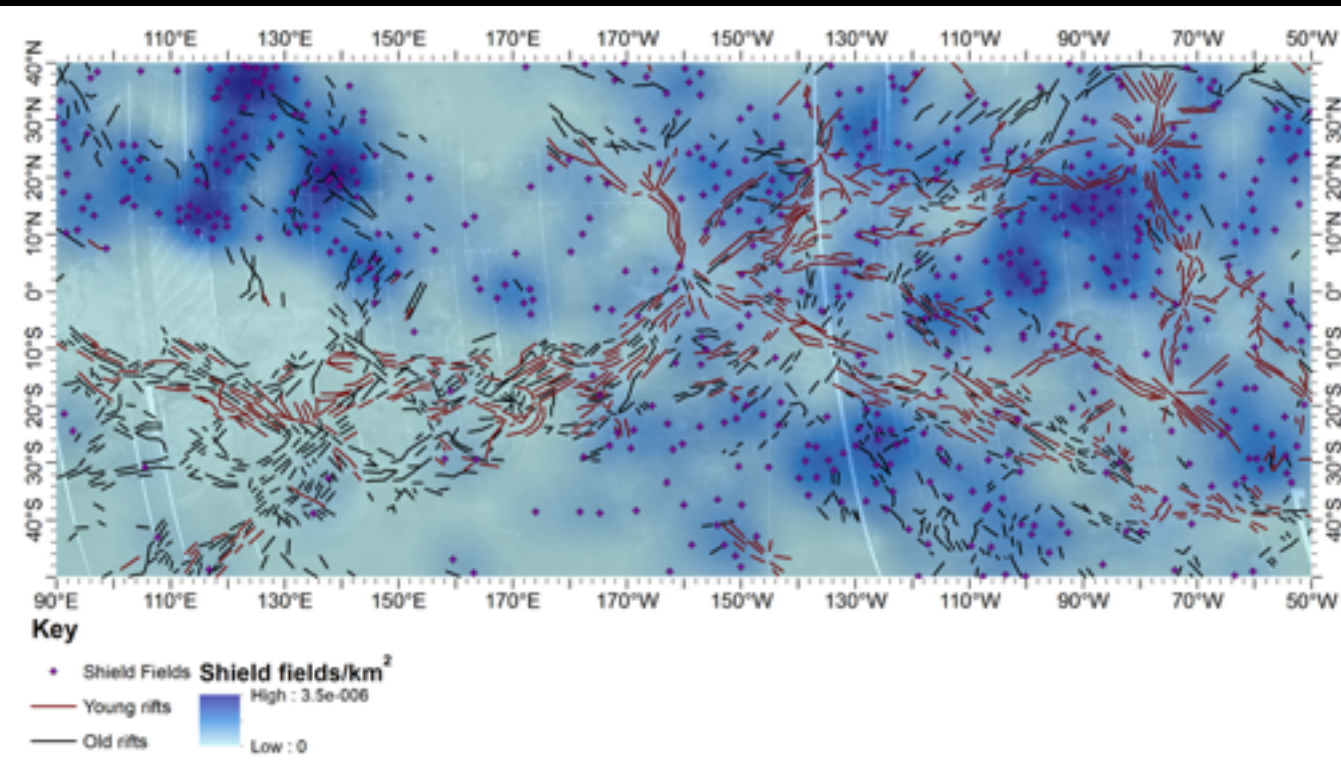
FEATURE DENSITY - GROUP I



FEATURE DENSITY - GROUP II



FEATURE DENSITY - GROUP III



SPATIAL RELATIONSHIPS

Group I:

- Strong clustering
- Rift distance inconclusive

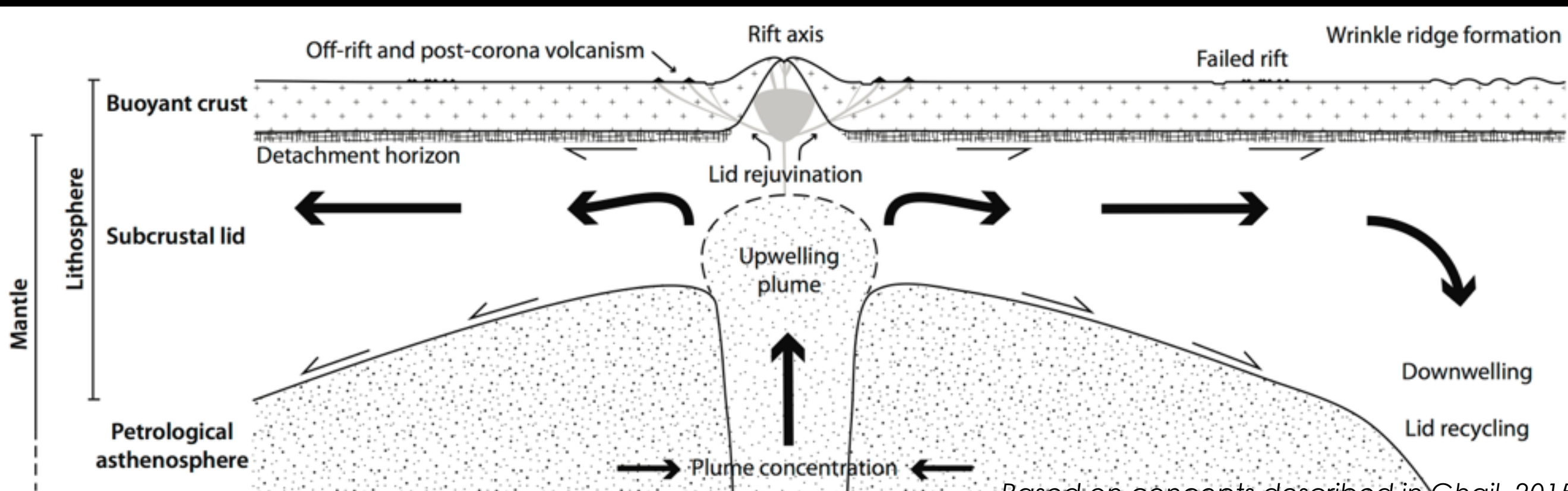
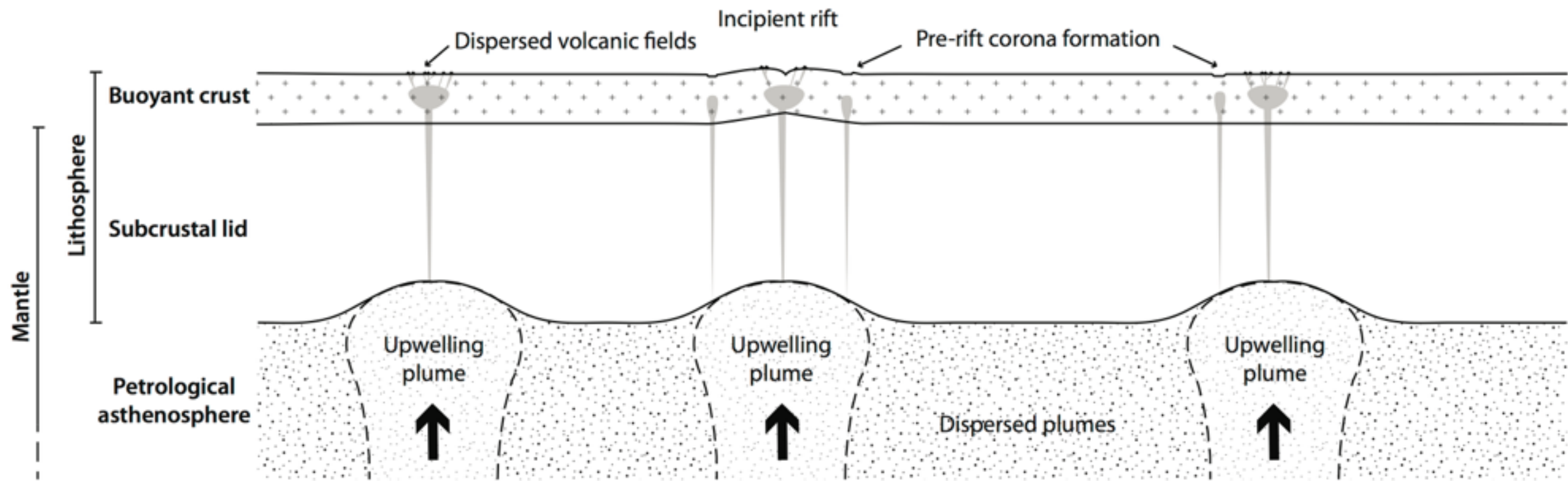
Group II:

- Strong clustering (slightly less so than Group I)
- Coronae (1) appear random locally, clustered regionally
- Much stronger association with 'all rifts', and therefore with older terrain/minor rifting

Group III:

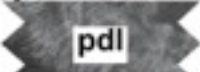
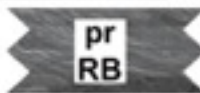
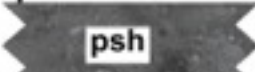
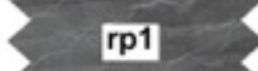
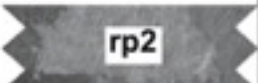
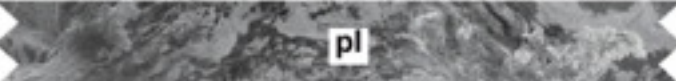
- Int. volcanoes appear random but display off-rift peak
- Shield field clustering associated with old rifts (shield plains)
- Large volcano association more prominent with young rifts
- Of 'Very Large' (>500 km) subset, ~75% occur within 350 km of young rifts

TIMING AND TECTONIC MODEL



Based on concepts described in Ghail, 2015

SYNTHESIS OF EVIDENCE

PRE-FORTUNIAN PERIOD	FORTUNIAN PERIOD 1.47T +/- 0.46	T			0				
PRE-FORTUNIAN SYSTEM	FORTUNIAN SYSTEM	GUINEVERIAN SYSTEM			ATLIAN SYSTEM				
?									
?	GLOBAL TECTONIC REGIME		GLOBAL VOLCANIC REGIME		NETWORK RIFTING-VOLCANISM REGIME		Regime		
?	earlier phase	later phase					Dominant strain		
?	Contraction (tessera ridges, ridged plains) dominates, some stretching (pdl)		Extension (groove belts, coronae) dominates		Contraction (wrinkle ridges), dike-related graben dominate		Extension (rift zones, BAT-coronae) dominates		
?							Extension		
?							Contraction		
?	Plateau-like highs and regional lows (basins) formed; global-scale topographic pattern established		Volcanic filling of basins; epeirogenic readjustment of global-scale topography		Rifted rises continue to develop		Regional topo.		
?	(a) Consistent observations of more widespread extensional features on pre-'rp' terrains		(c) Dispersed clustering of all domes, calderas, and int. volcanoes consistent with dispersed plume pre-'rp' activity		(e) Wrinkle ridge formation and major localised rifting consistent with onset of proposed subcrustal spreading at this time		Supporting evidence (this study)		
	(b) Closer association of coronae with 'all rifts' (i.e. 'gb') than with 'young rifts' (i.e. 'rz') consistent with timing		(d) Shield field clustering dichotomy consistent with occurrences of 'psh' (abundant) and 'rp' (rare)		(f) Large volcanoes, especially very large volcanoes, dominate 'rz' with close spatial association consistent with plume concentration				

Modified from
Ivanov and Head, 2015

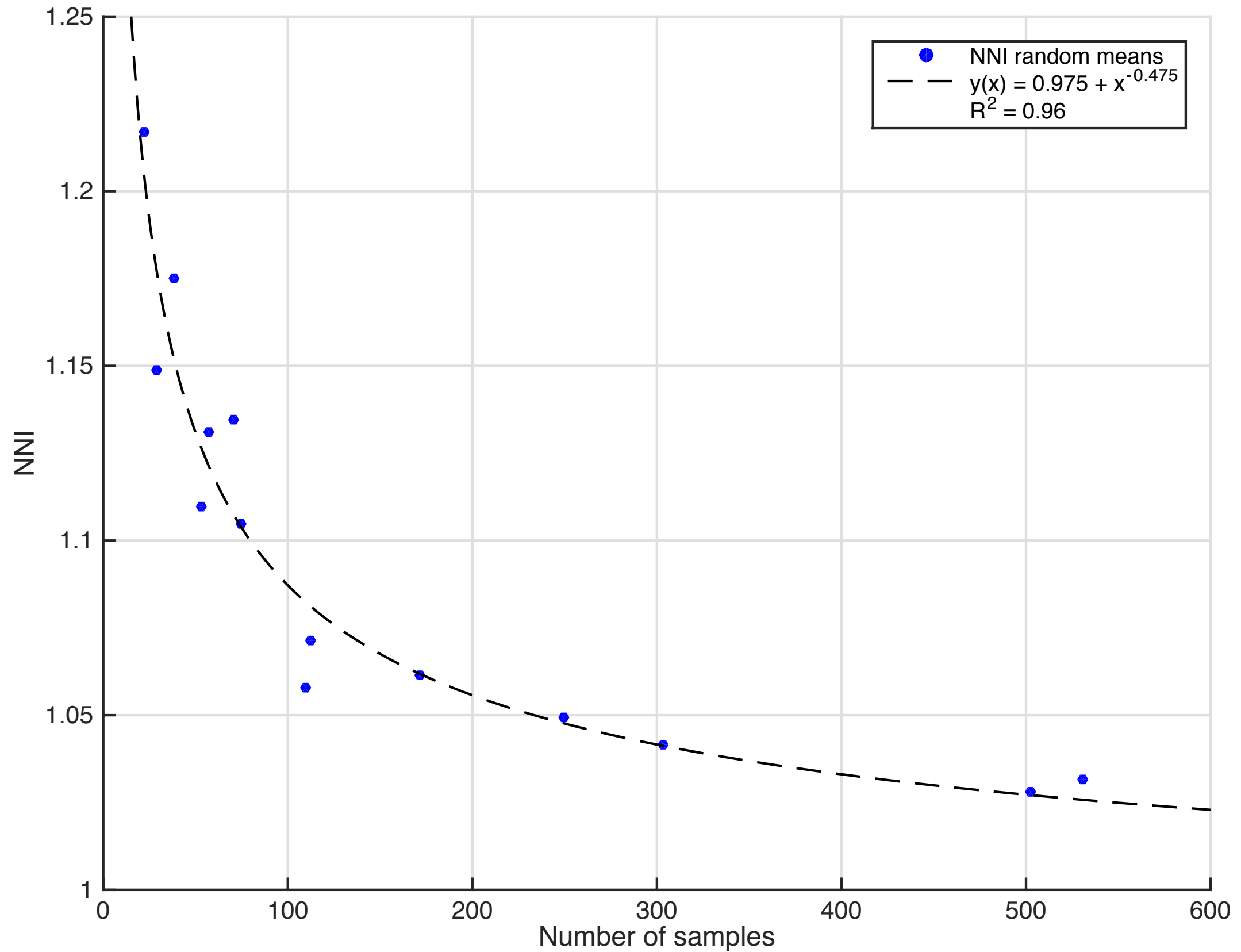
CONCLUSIONS

- New method **broadly consistent** with previous studies (e.g. Krassilnikov et al. 2012, Ivanov and Head 2015 etc. and related)
- NNI study shows tendency for **non-random distributions** except shield fields and large volcanoes (appear random)
- **Rift associations (all rifts) unclear** except coronoid
- Young rifts - association weaker in **coronoids: older**
- Young rifts - association stronger in **large volcanoes: younger**
- Focussing of volcanism indicative of global **shift towards subsurface spreading** model (localised)
- Possibly a phase in **longer-term cycle**

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END OF PRESENTATION

NNI vs SAMPLE SIZE



DISTANCE TO NEAREST RIFT

