Cretaceous continental magmatism in North-Eastern India

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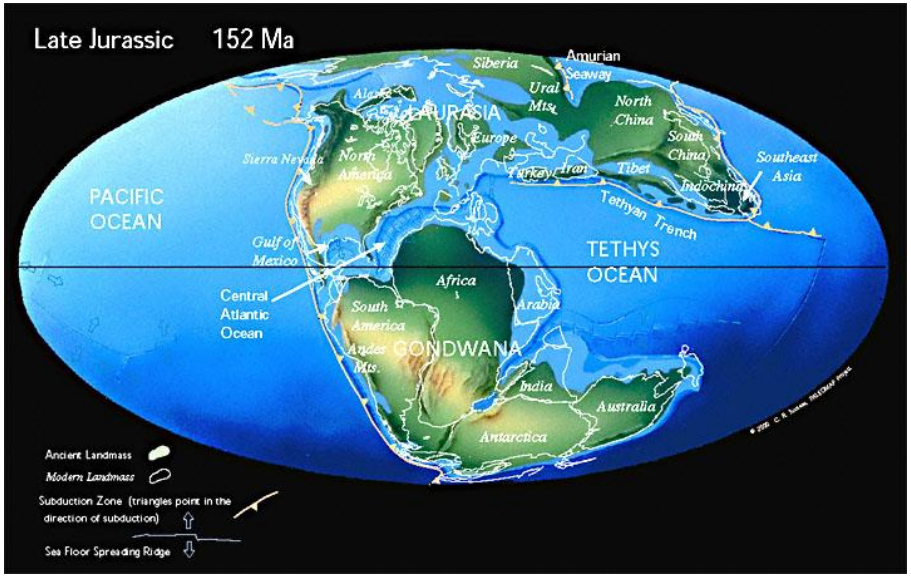
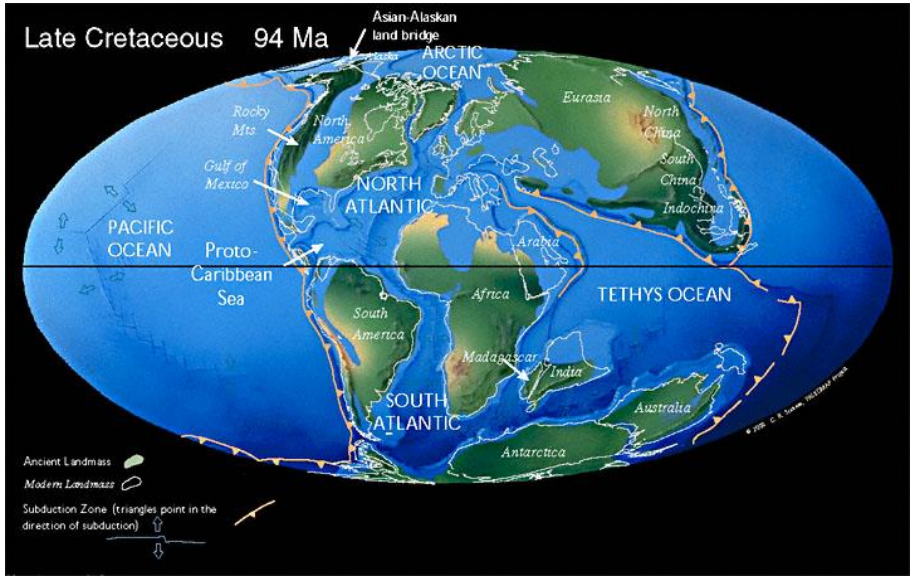
The Cretaceous Period (144-66 Ma)





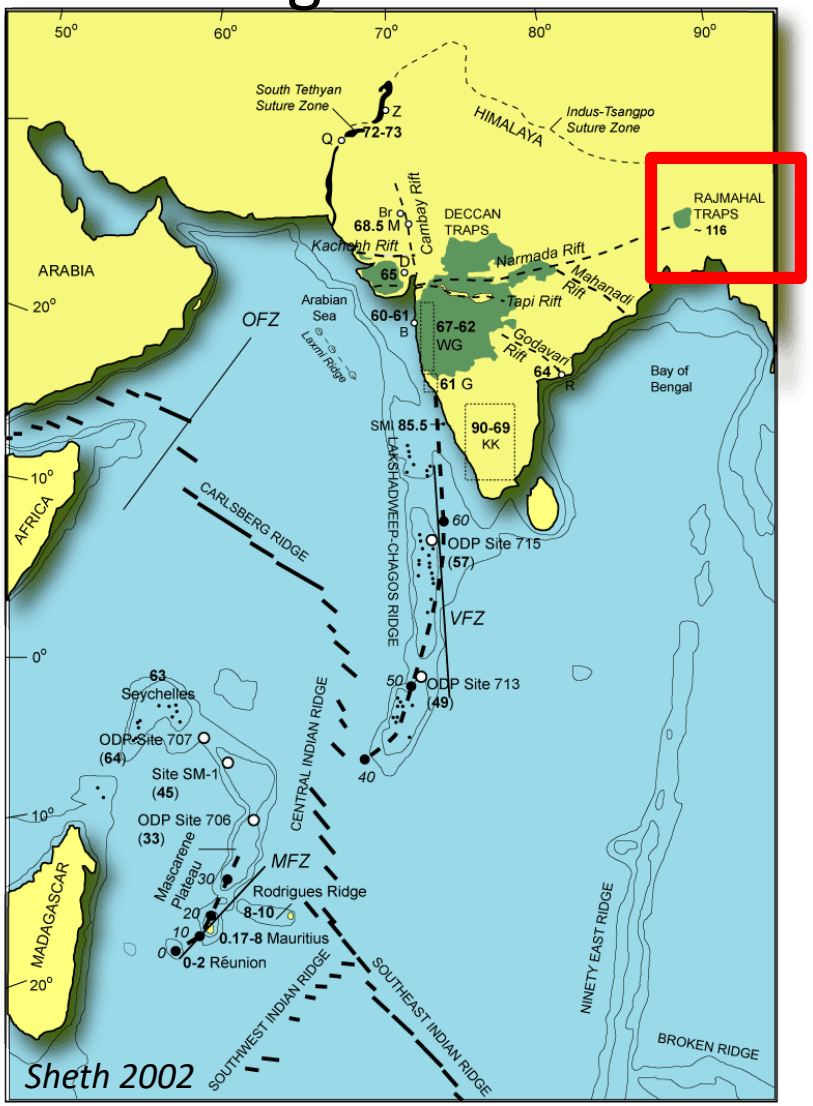
144 Ma

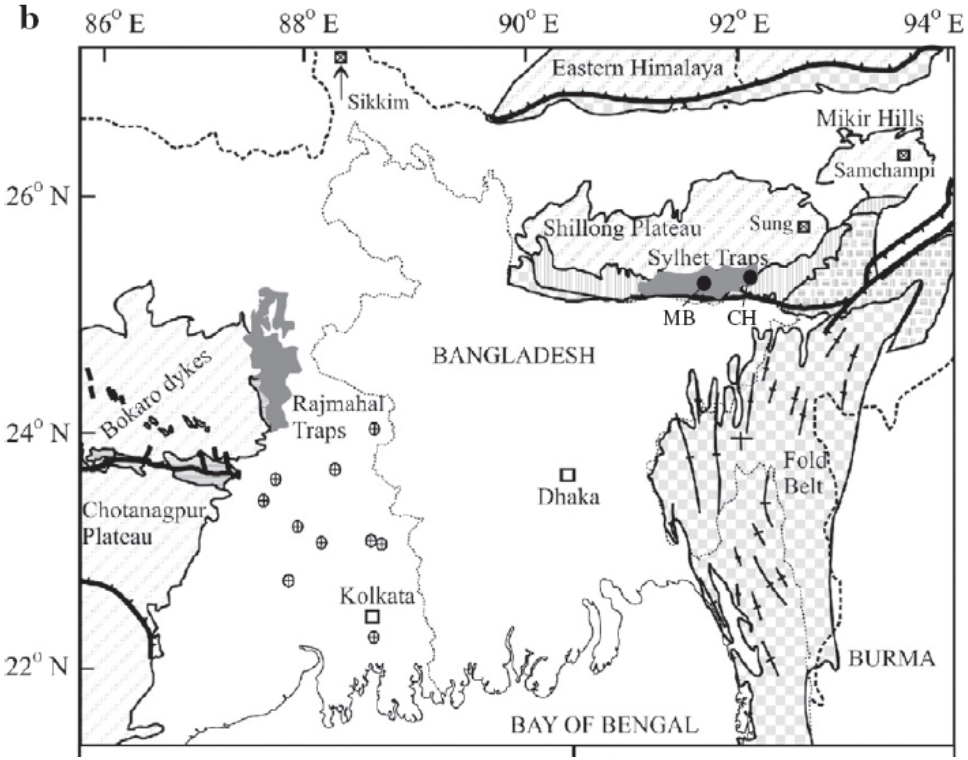
70-65 Ma

66 Ma

Cretaceous geological records in NE India

Magmatism





1) Sylhet Basaltic Traps
2) Carbonatite-Alkaline Complexes

Fundamental Questions

- When and how did India separate from the Gondwanaland?
- What was the nature of mantle beneath the Indian plate during Cretaceous?
- How are carbonatites and alkaline silicate rocks related?
- What is the continued source of carbon for carbonatites?

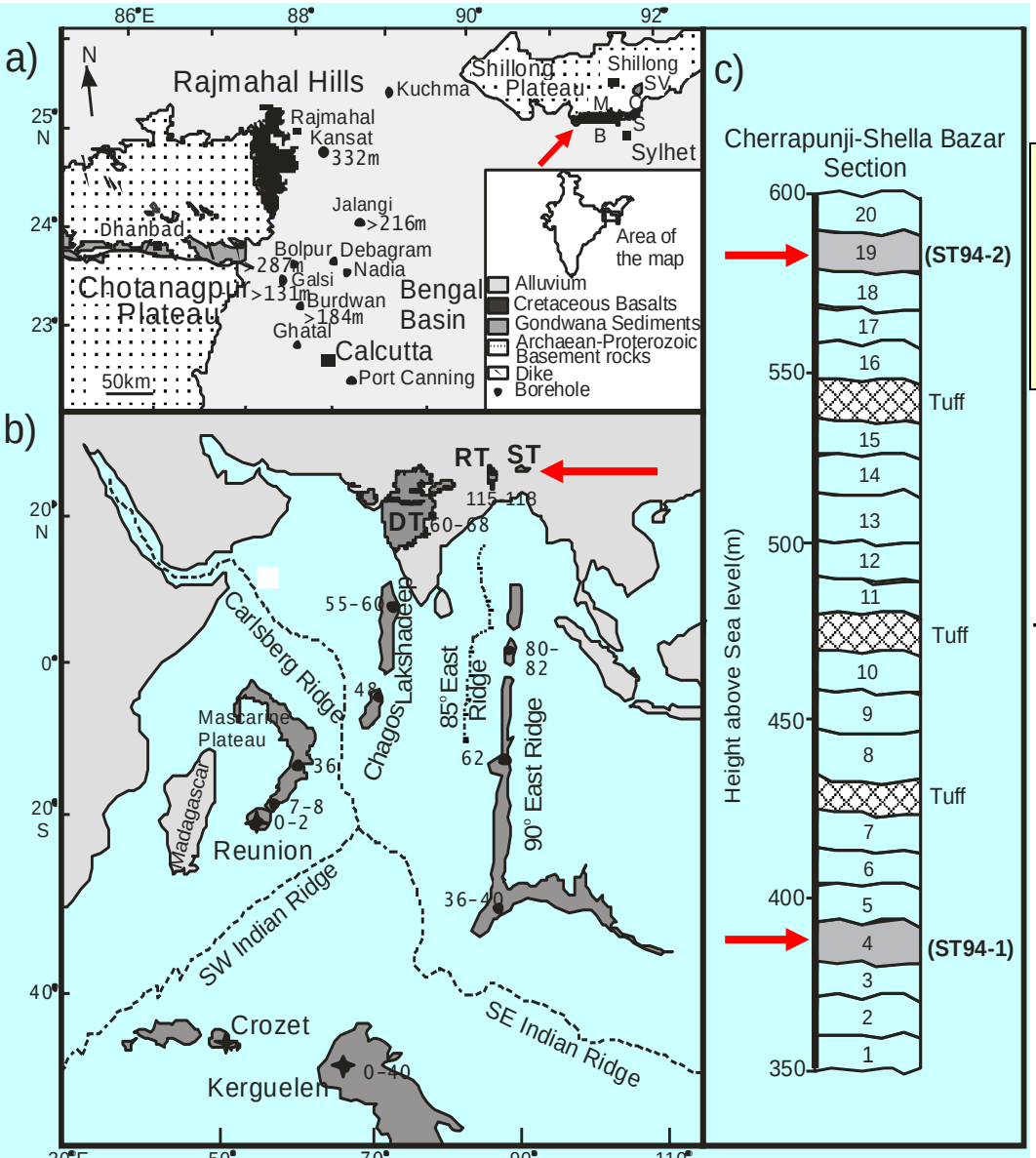
Cretaceous magmatism of NEI: Major Objectives

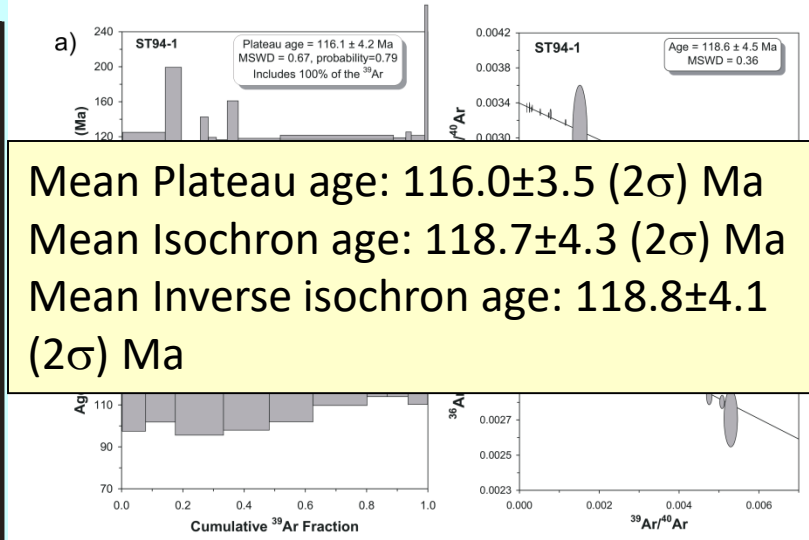
- Age and duration of Sylhet Traps and its connection to Kerguelene hotspot and Gondwanaland breakup?
- Age of carbonatite magmatism associated with the traps?
- Relationship of basaltic-carbonatite magmatism with Aptian (~116 Ma) Mass Extinction event?
- Nature of the mantle sources and evolution of carbonatite-alkaline magmas?

Methodologies

- ^{40}Ar-^{39}Ar geochronology
- Major/Trace element geochemistry
- Radiogenic isotope (Sr-Nd) geochemistry
- ^{142}Nd isotopic composition
- Stable (C-O) isotope geochemistry
- Mathematical modeling

Age of the Sylhet Traps





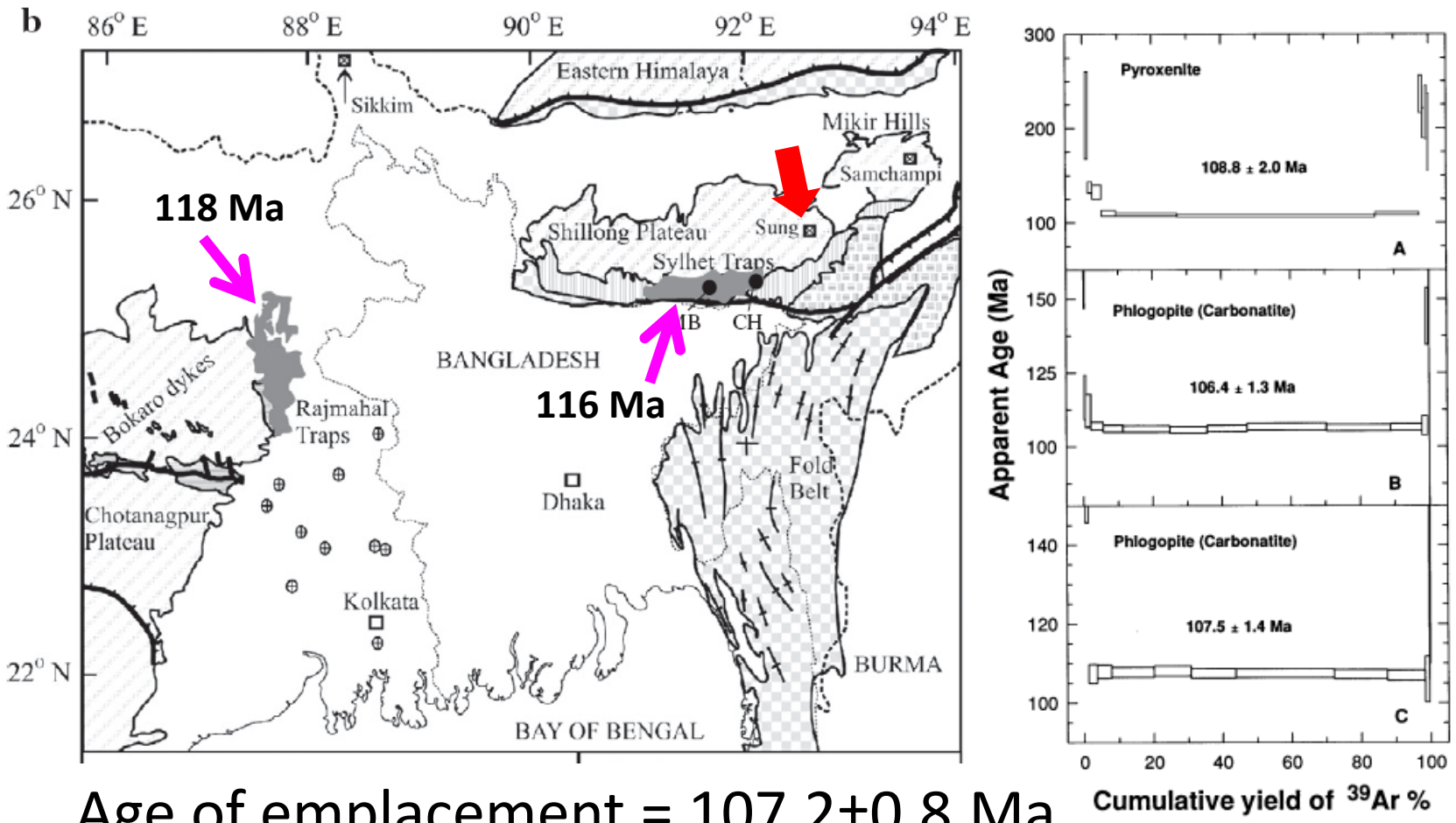
Mean Plateau age: 116.0±3.5 (2σ) Ma
Mean Isochron age: 118.7±4.3 (2σ) Ma
Mean Inverse isochron age: 118.8±4.1 (2σ) Ma

Implications

- Rapid emplacement at 116 Ma
- Synchronous with Rajmahal Traps
- Kerguelen Plume derivation
- Kerguelen hotspot was close to the eastern Indian margin during its initiation.

Ray et al., 2005

Age of Sung Valley Carbonatite Complex



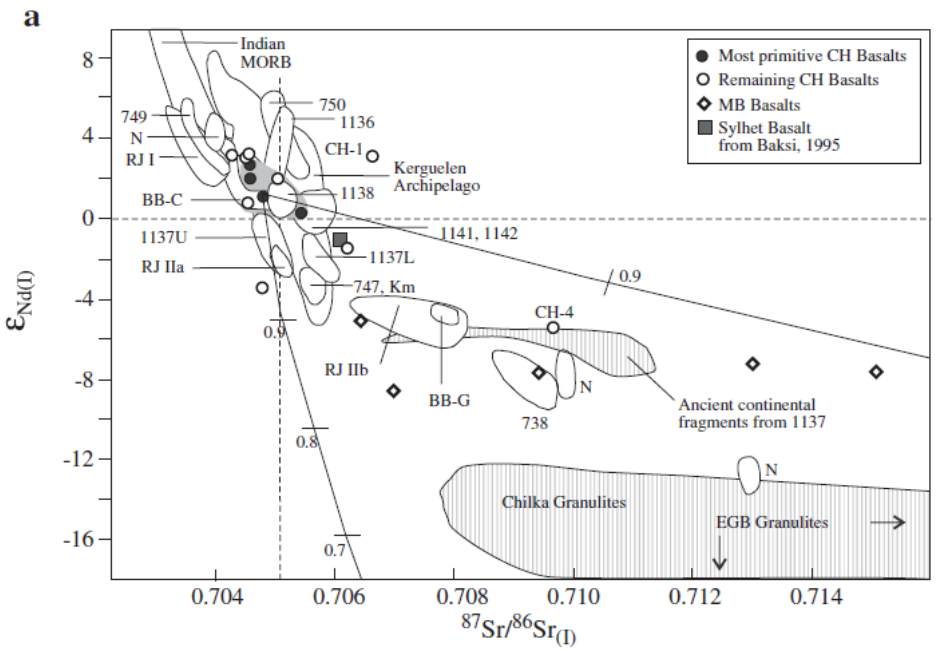
Age of emplacement = 107.2±0.8 Ma

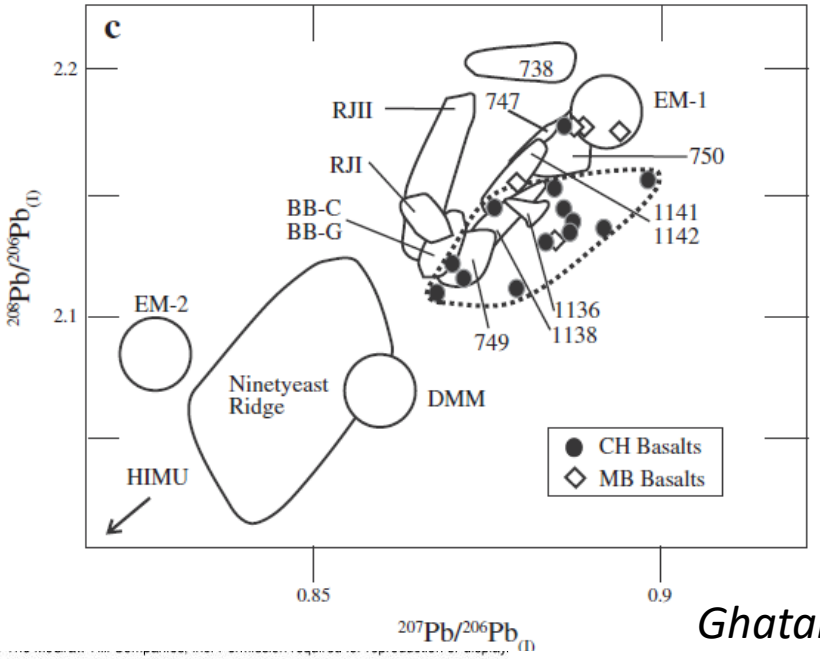
(Ray et al., 2001: Rb-Sr age 106±11 Ma; Srivastava et al., 2005: U-Pb age 115±5 Ma)

Magmatic Activity: 118 – 107 Ma (~11 Ma)

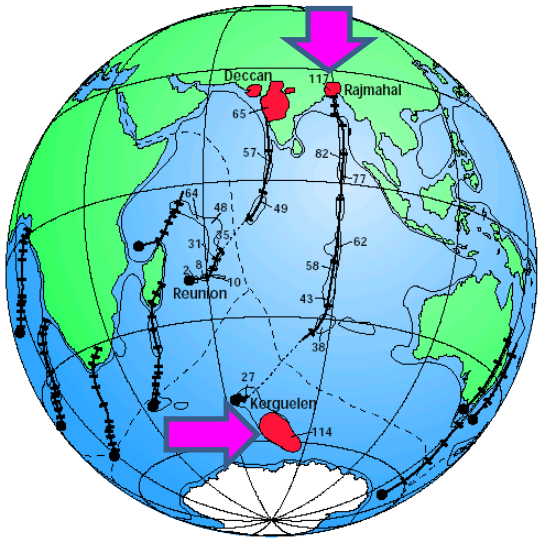
Ray et al., 1999; Ray & Pande, 2001; Ray et al., 2001

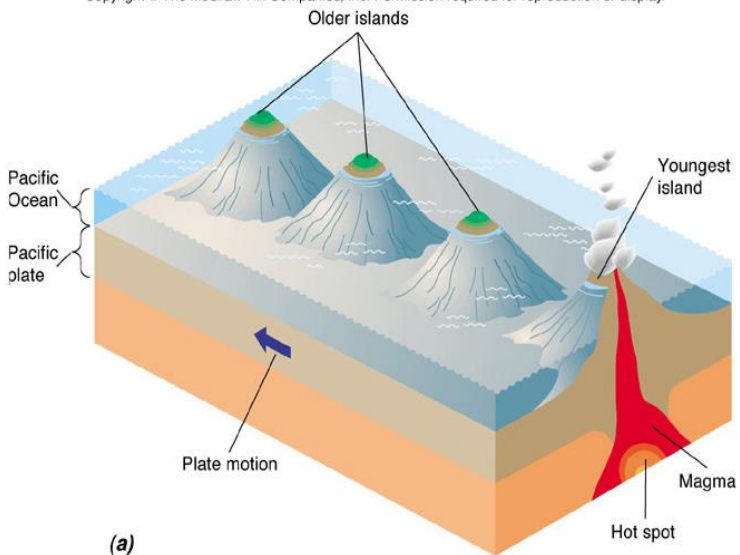
Isotopic fingerprinting: Kerguelen hotspot source



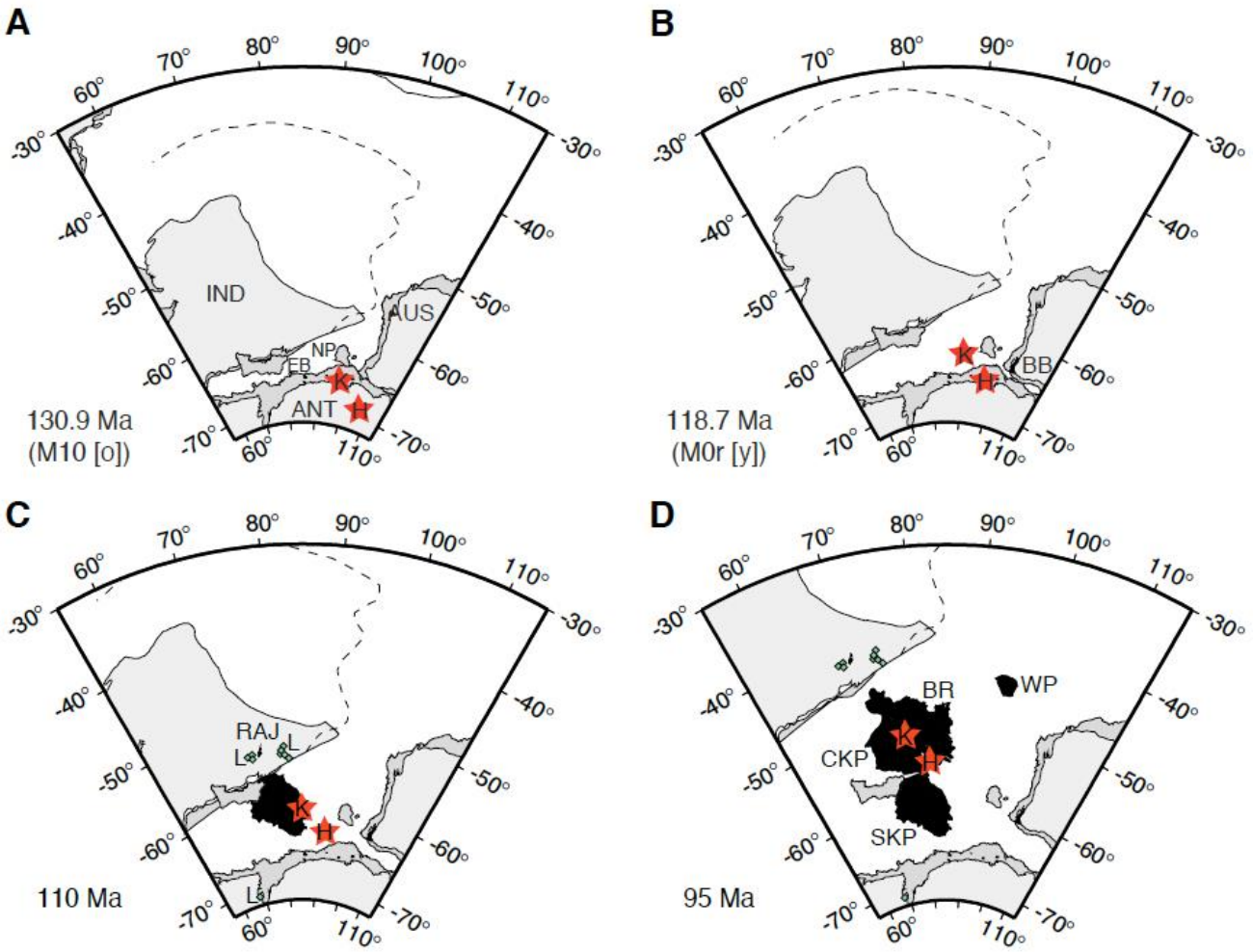


Ghatak & Basu 2011





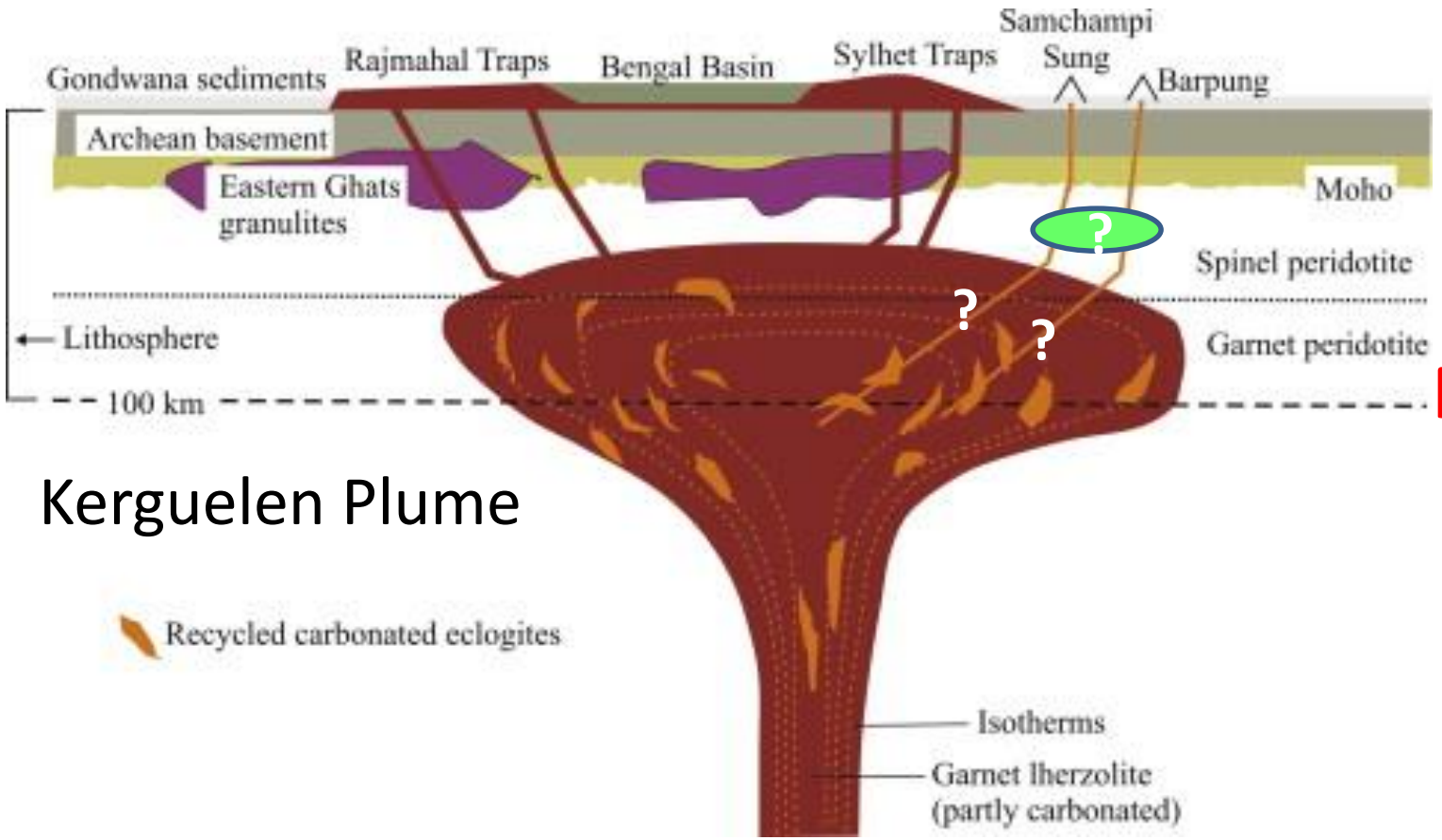
Implication for breakup of Gondwanaland



Coffin et al., 2002
Ray & Pande, 1999

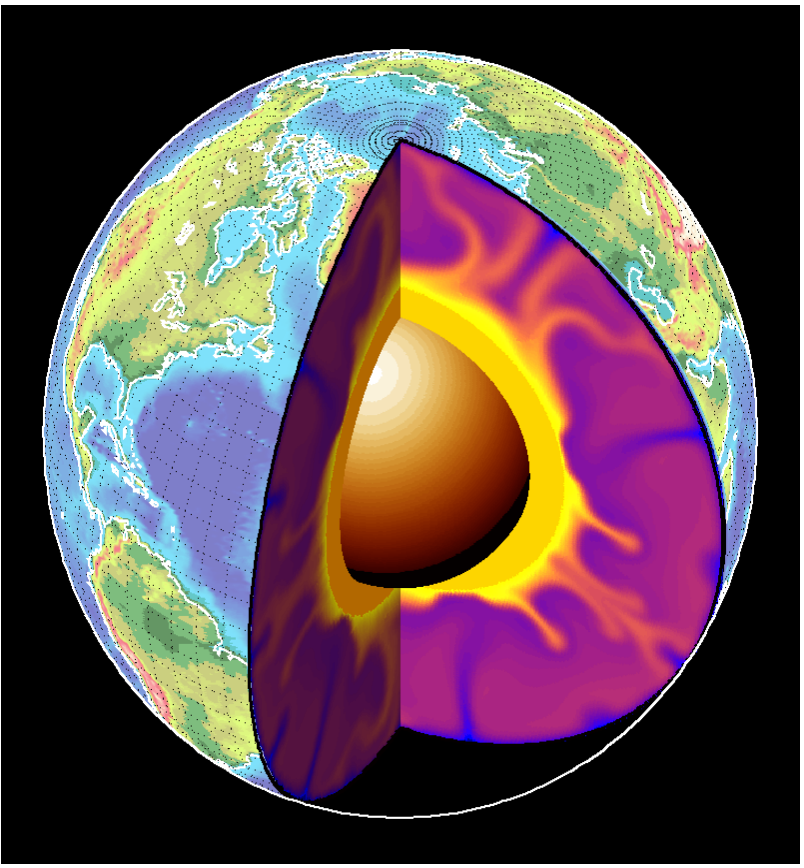
The final separation of Greater India from Gondwanaland: 118-107 Ma
Rajmahal-Sylhet-Carbonatite magmatism – cause for Aptian extinction

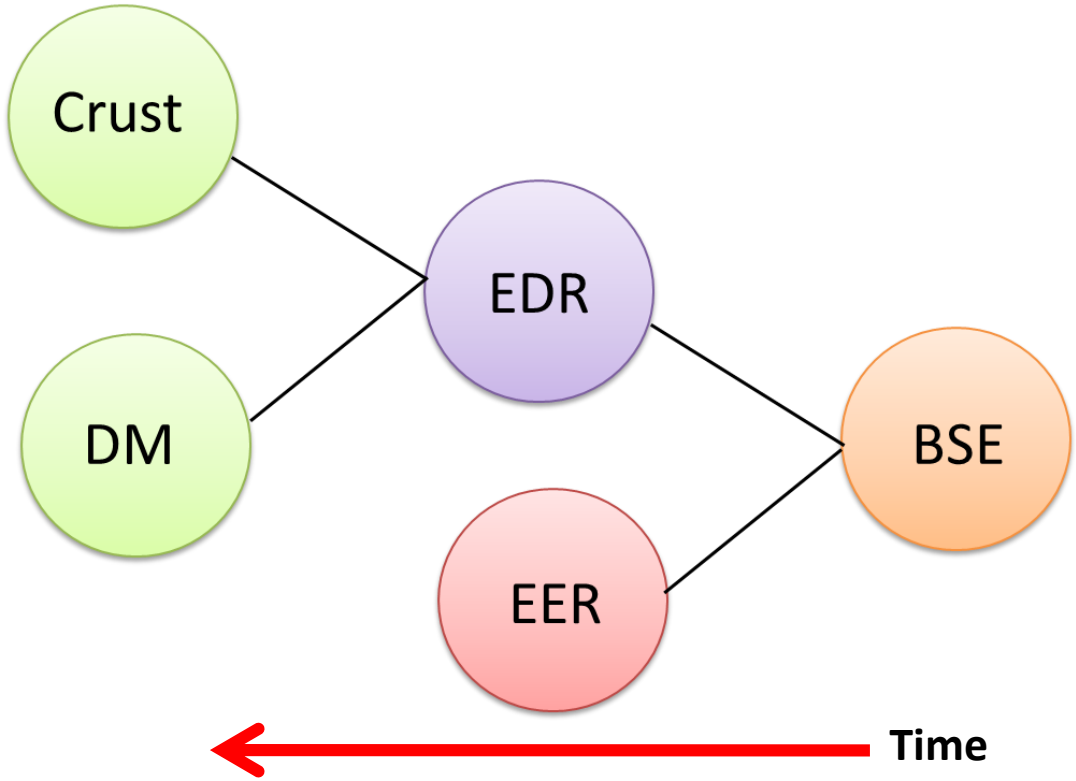
Mantle Sources of Cretaceous Magmas of NEI



Ghatak & Basu 2013; Gautam et al. in prep

Early Silicate Earth Differentiation





$^{146}Sm \Rightarrow {}^{142}Nd$ ($T_{1/2}$= 103 Ma)

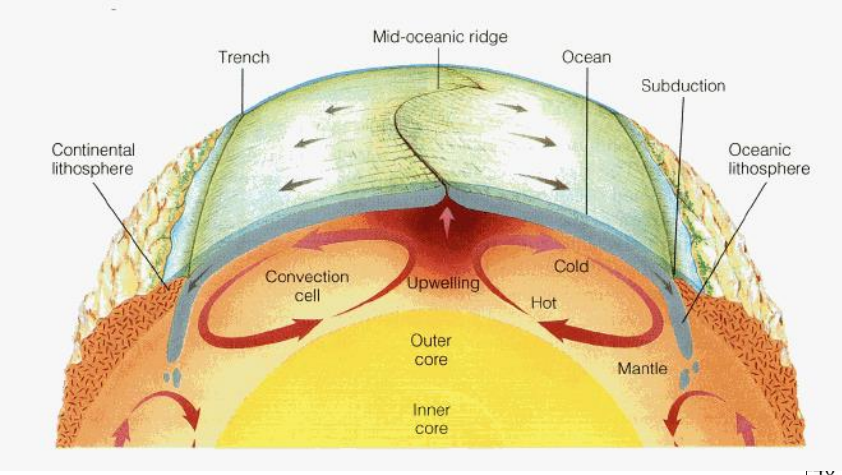
$^{147}Sm \Rightarrow {}^{143}Nd$ ($T_{1/2}$= 106 Ga)

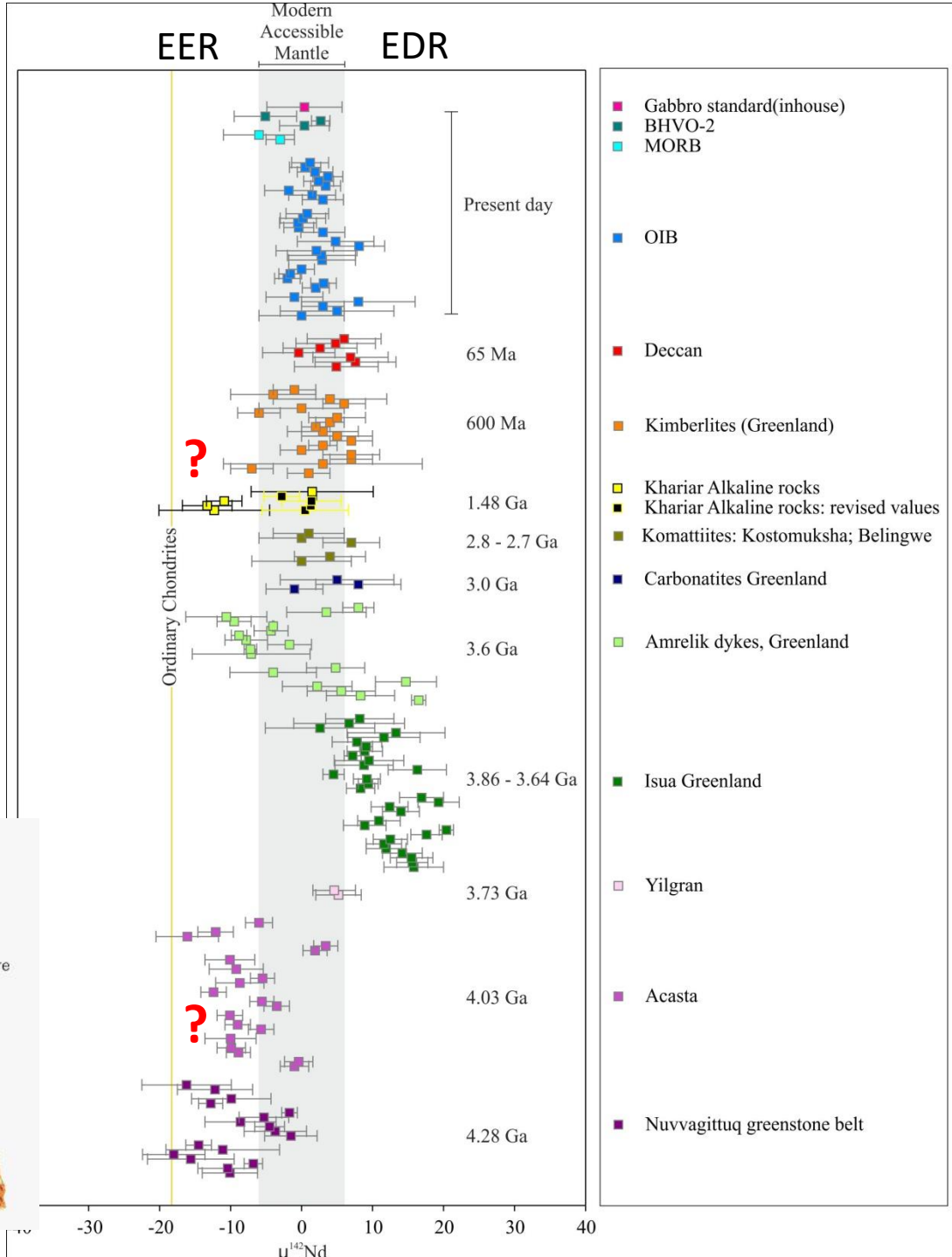
Early & subsequent differentiations

Search for evidence for EER in Non-Convecting Mantle (Plume or SCLM)?

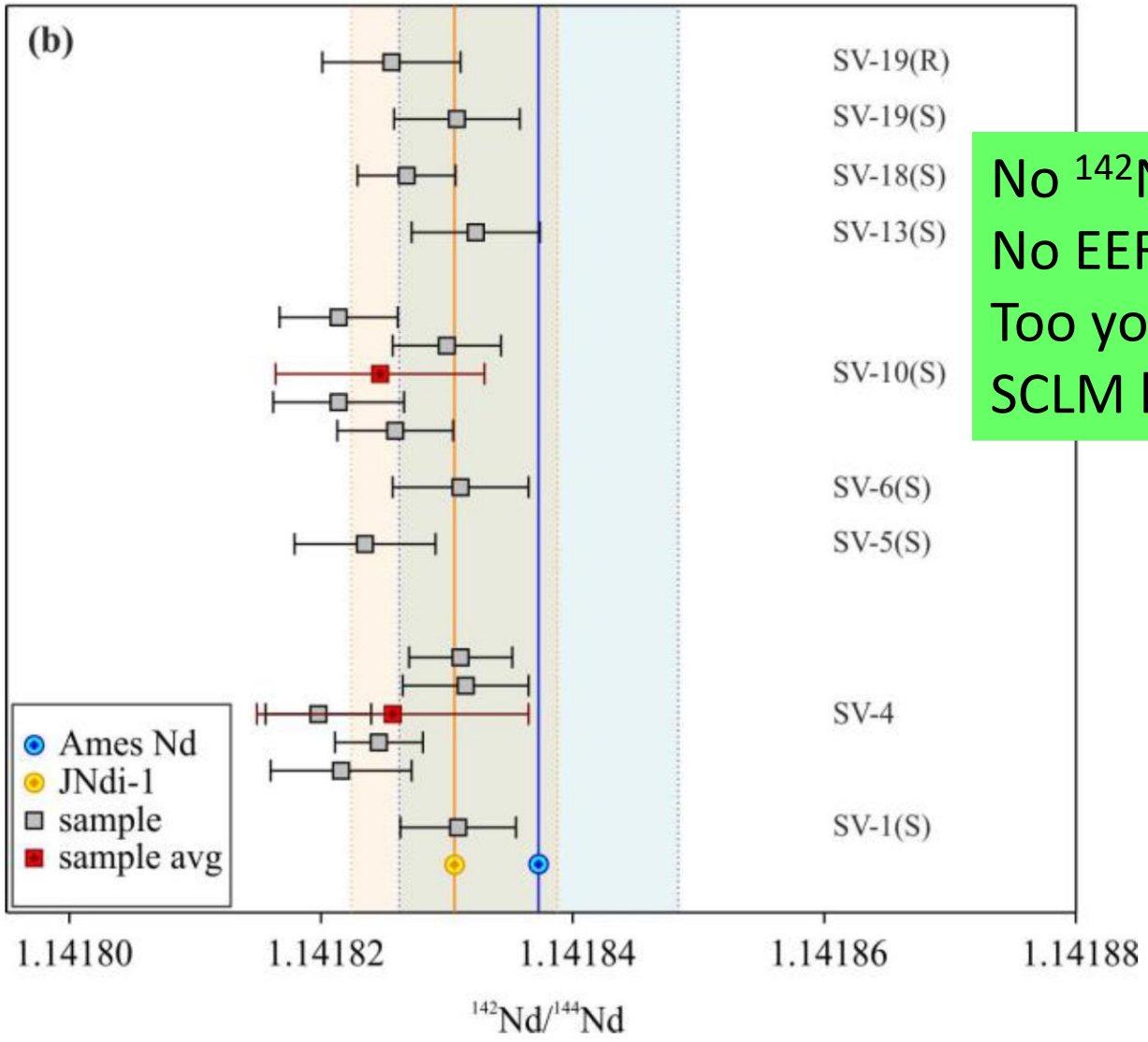
$$\varepsilon^{142}\text{Nd} = \left[\frac{(^{142}Nd/^{144}Nd)i}{(^{142}Nd/^{144}Nd)Ter.Std.} - 1\ \right] \times 10^4$$

$$\mu^{142}Nd = 100 \times \varepsilon^{142}\text{Nd}$$





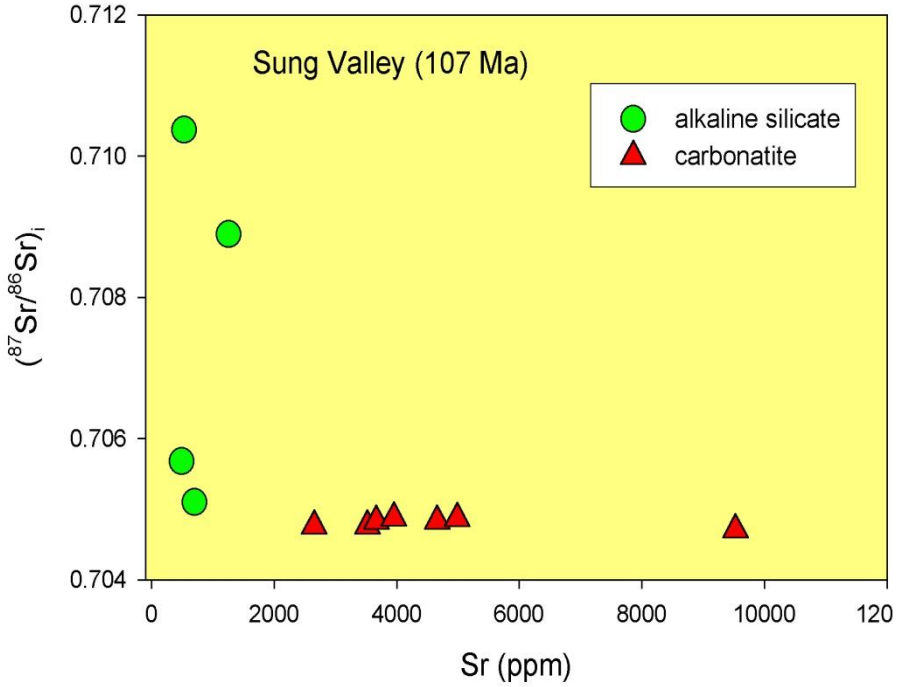
^{142}Nd in Sung Valley Carbonatites

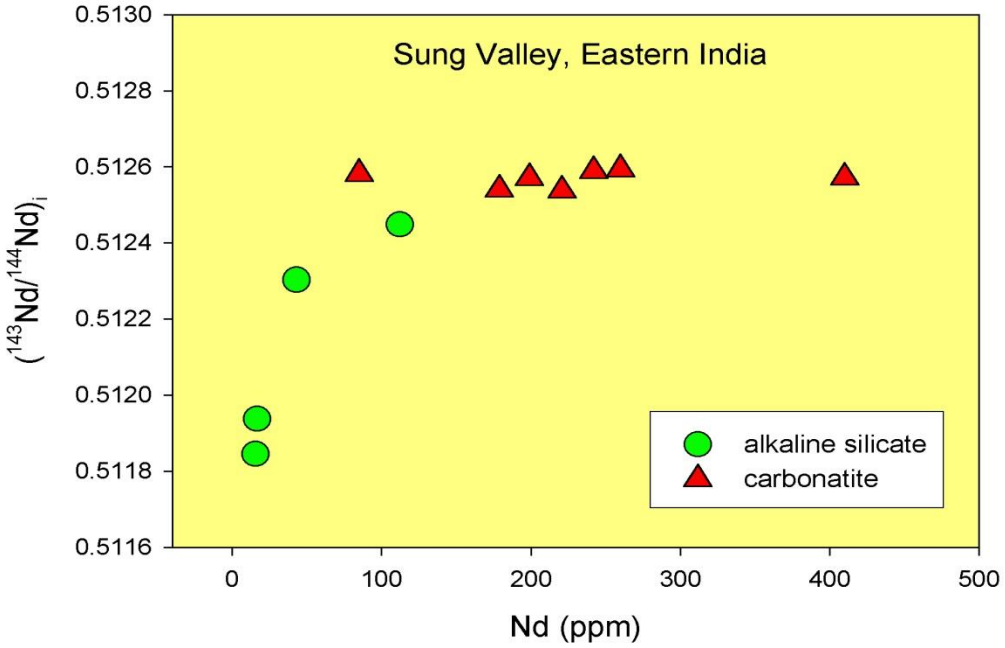


No ^{142}Nd anomaly in Sung
No EER in SCLM
Too young to preserve
SCLM has mixed signal

Gautam et al. in prep

Carbonate-Alkaline Magma Connection

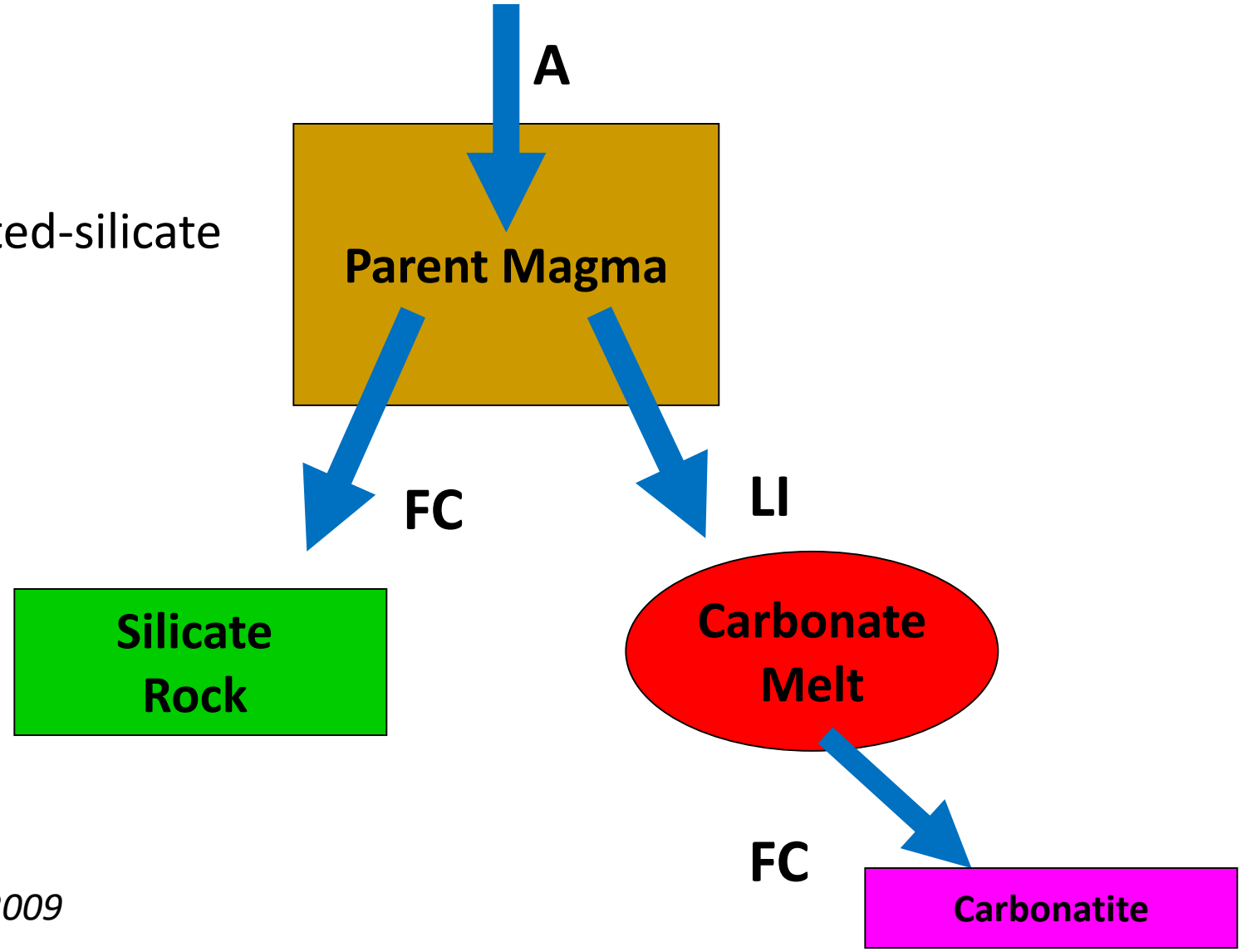




- carbonatites and associated alkaline silicates are coeval.
- Isotopic ratios in silicate rocks are more variable.
- Enrichment trends in alkaline silicate rocks tend to correlate with the degree of differentiation (Mg#).

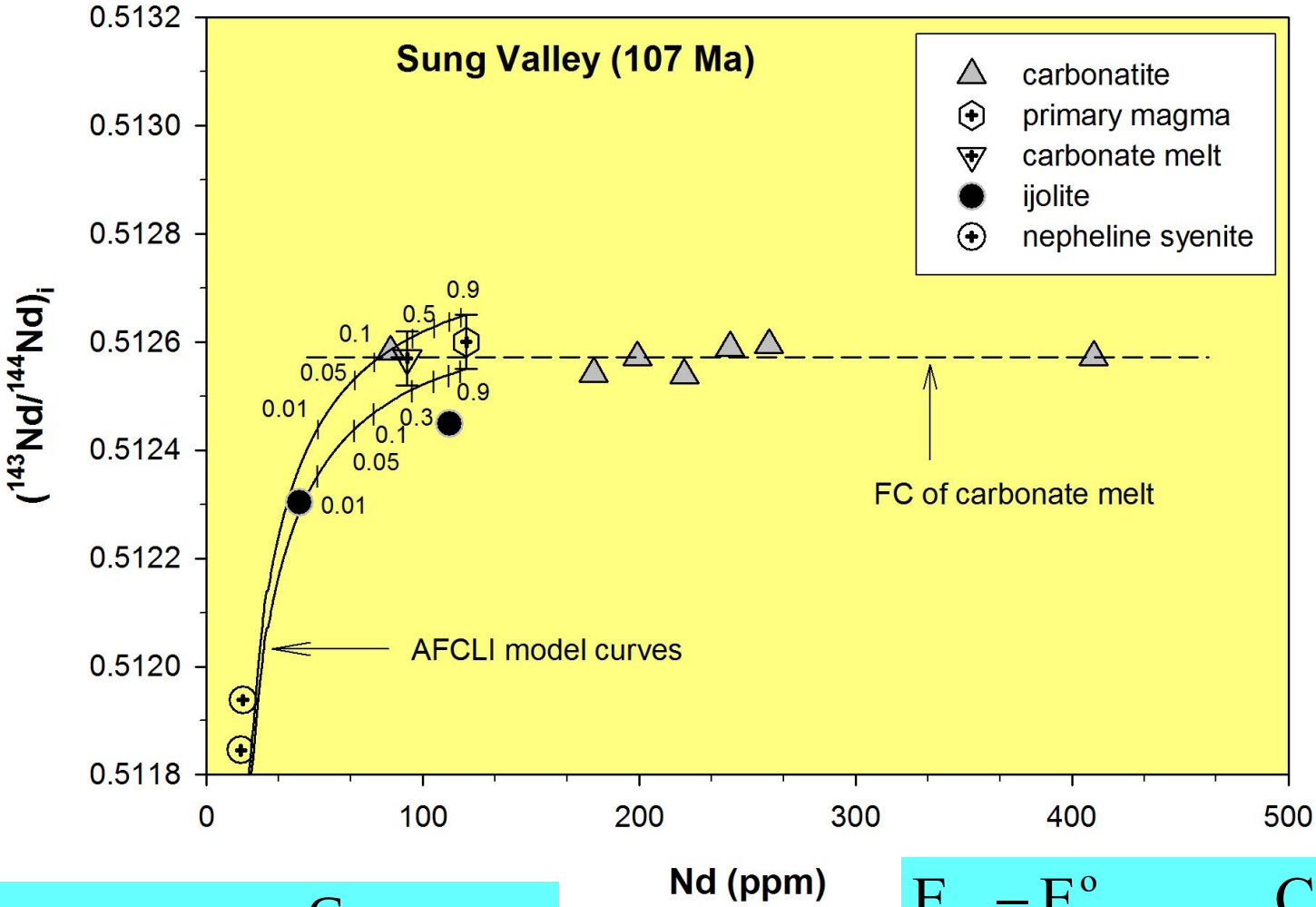
Concurrent Assimilation-Fractional Crystallization-Liquid Immiscibility (AFCLI)

Carbonated-silicate magma



Ray, 1998; 2009

Crustal Assimilation: Cause for Magma Diversification



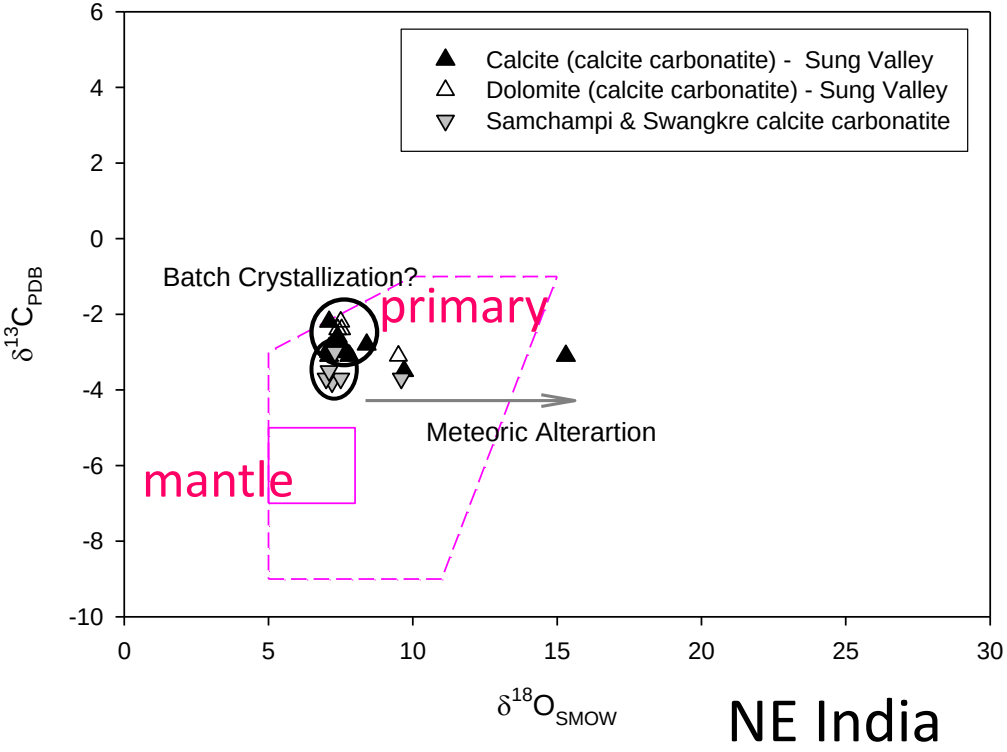
$$C_m = C_m^o F^{-z} + \left(\frac{a}{a-b-1}\right)\frac{C_a}{z}(1-F^{-z})$$

$$\frac{E_m - E_m^o}{E_a - E_m^o} = 1 - \left(\frac{C_m^o}{C_m}\right)F^{-z}$$

Ray, 2009

Recycled crustal carbon as a constant source for carbonatites

Ol Doinyo Lengai



NE India

Ray et al., 1999; Ray & Ramesh, 2006

Summary and Conclusions

- Final separation of India from Gondwanaland occurred during 118-107 Ma with the emplacements of basalts and carbonatites in NEI.

- Carbonatites probably do not possess evidence for Early Silicate Earth differentiation.

- Recycled crustal carbon feeds into continued carbonatite activity.

- Lower crust plays a crucial role in carbonatite-alkaline magma diversification.

Thank You