Melting of a deep subcontinental lithospheric mantle during the early stages of rifting

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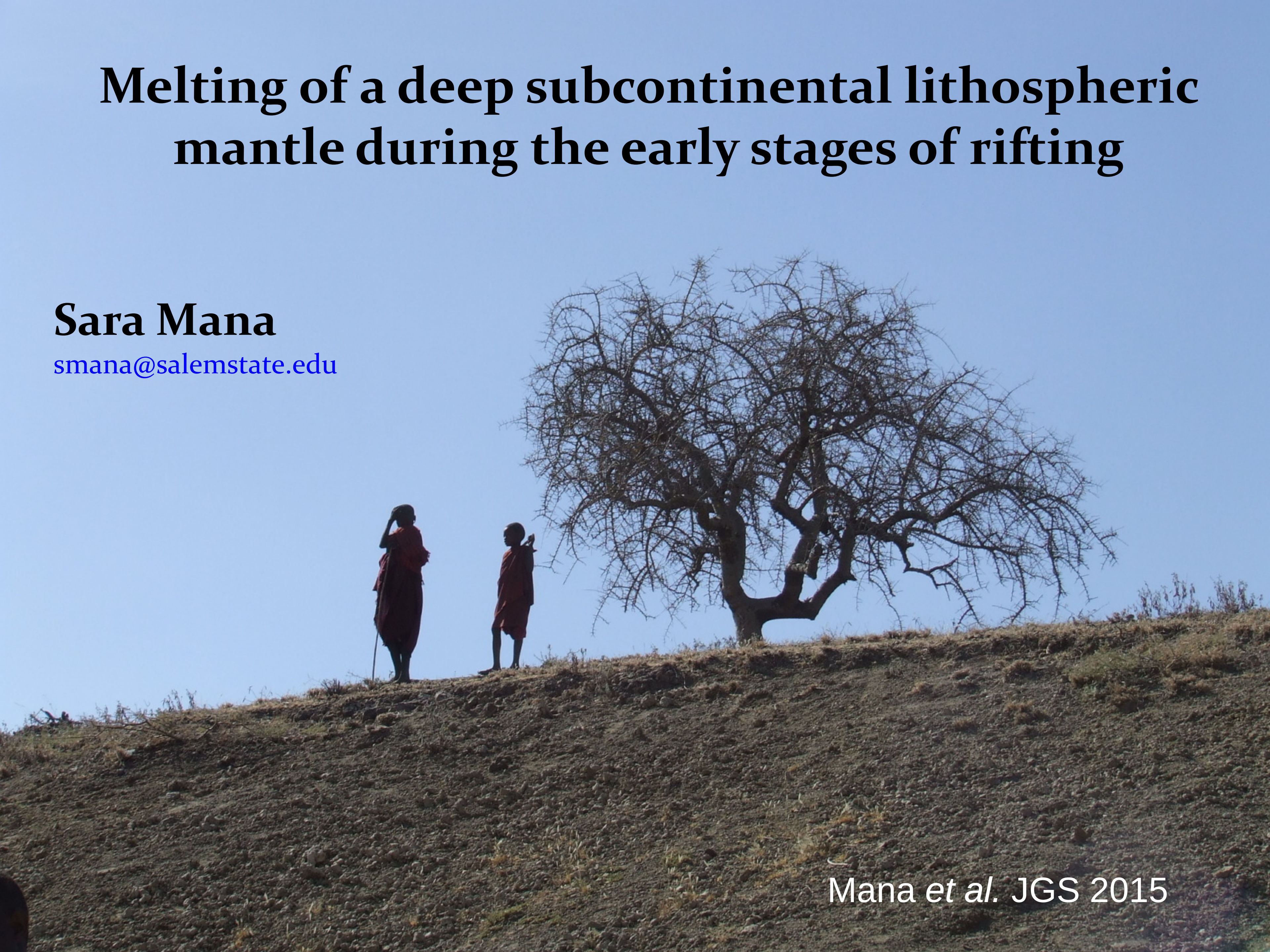
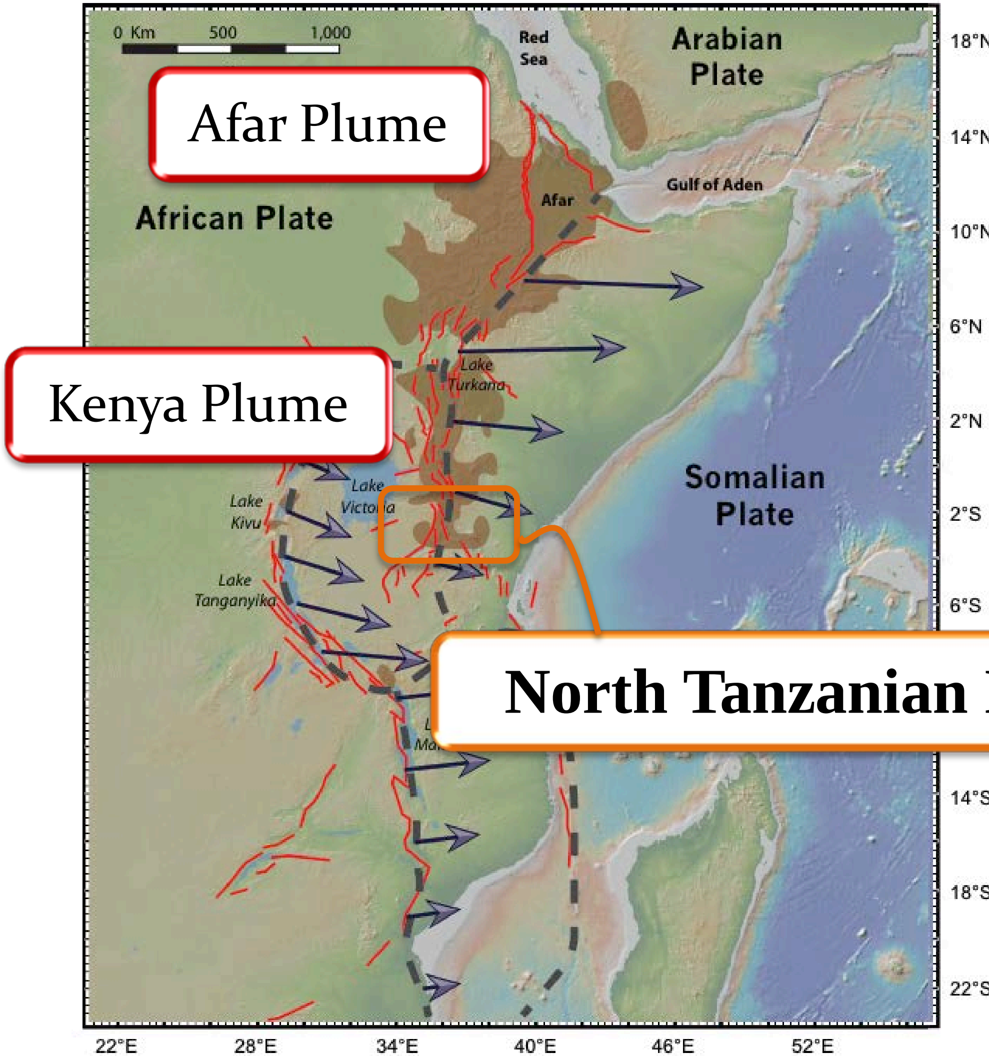


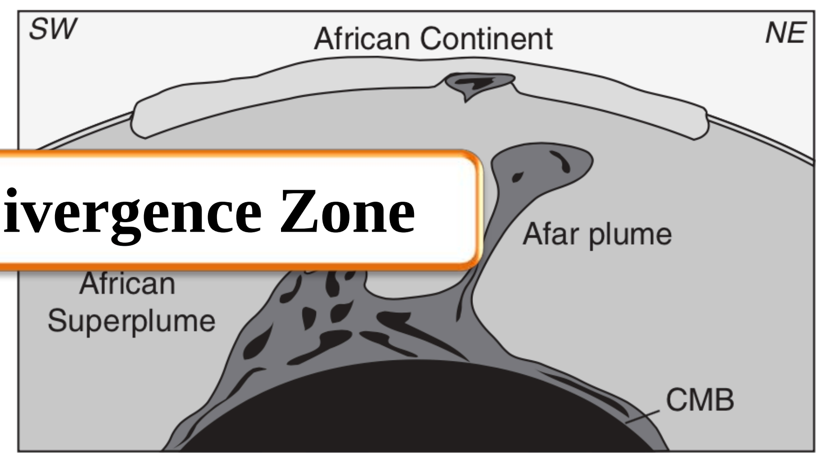
Mana *et al.* JGS 2015

East African Rift System (EAR)



Modified from *GeoMapApp* after Chorowicz 2005
Plate borders and velocity vectors as in Stamps *et al.* 2008

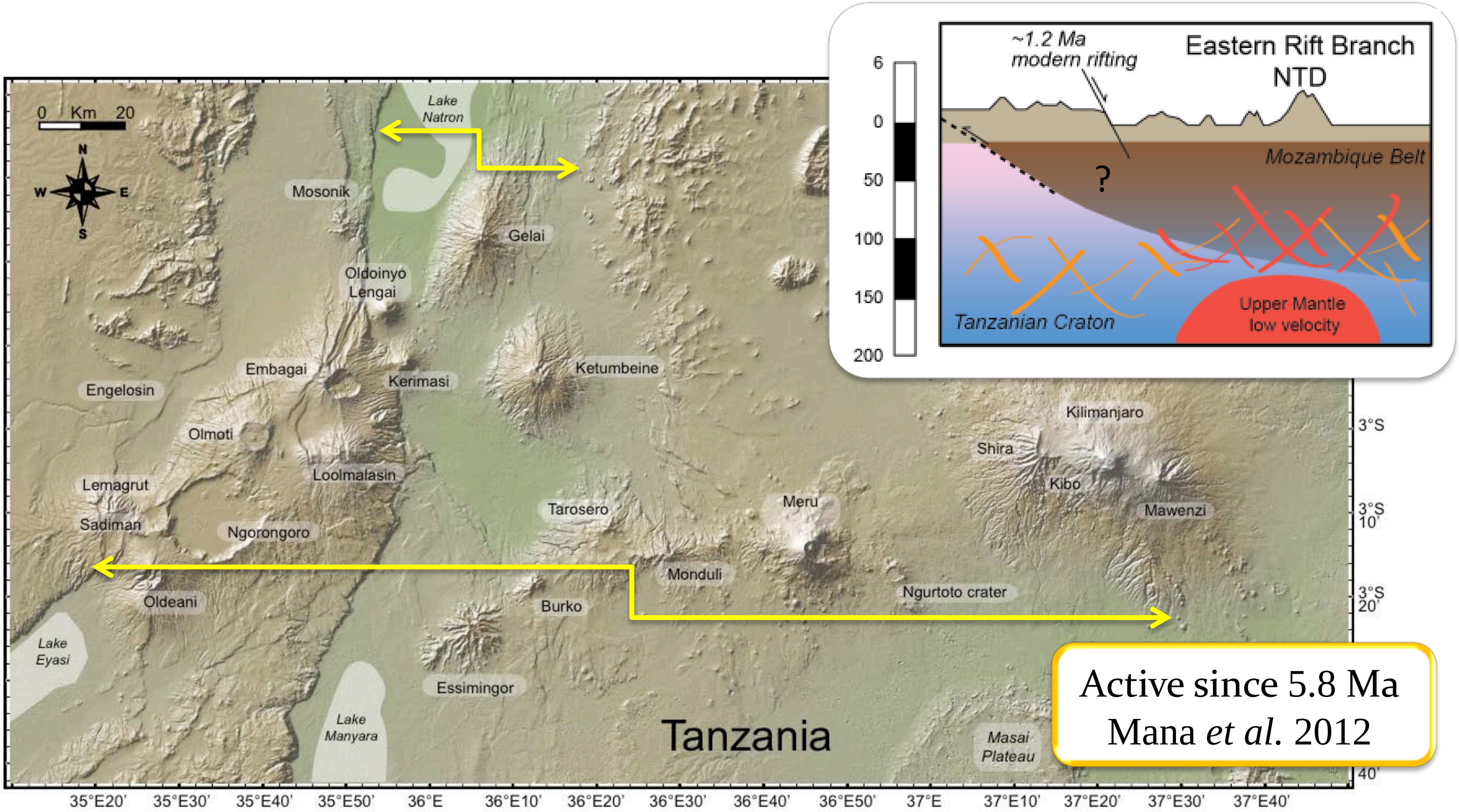
- Continental Rifting
- Extensional Setting
- Mantle Plume(s) ?



Nelson *et al.* 2012

e.g. Ebinger & Sleep 1998; George *et al.* 1998; Nyblade *et al.* 2000; Lin *et al.* 2005; Furman *et al.* 2006; Pik *et al.* 2006, Rogers *et al.* 2006; Chang & Van der Lee 2011

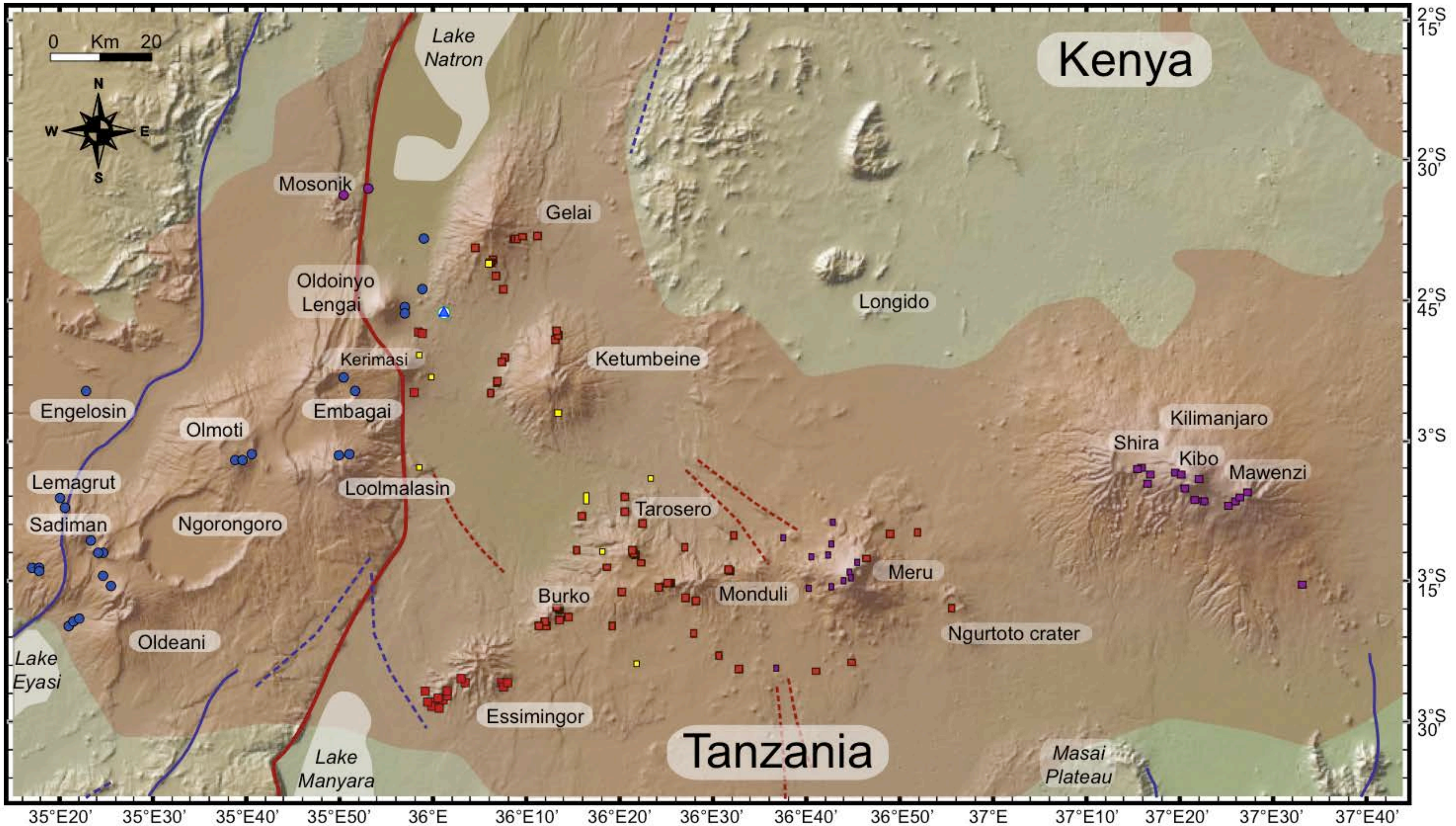
North Tanzanian Divergence zone (NTD)



Active since 5.8 Ma
Mana *et al.* 2012

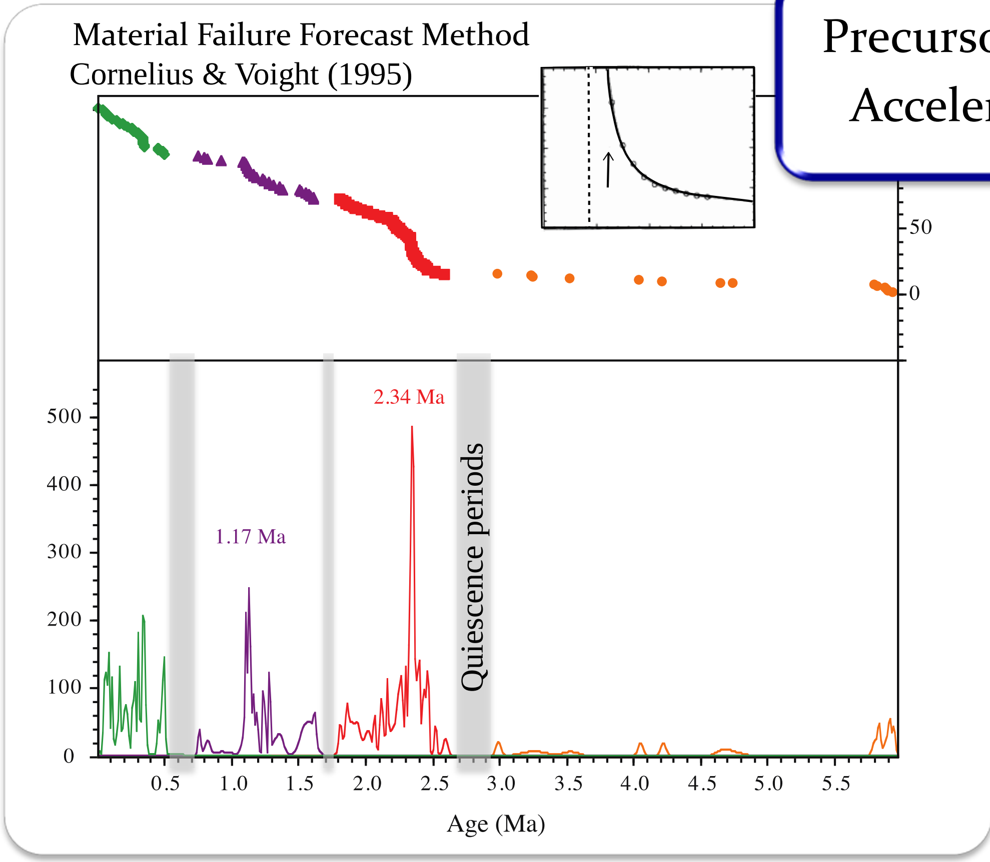
Modified from *GeoMapApp* – Rift Escarpment age from MacIntyre *et al.* 1974

NTD Samples Distribution



Ages from: Evans *et al.* 1971; Fairhead *et al.* 1972; Isaac *et al.* 1974; MacIntyre *et al.* 1974; Hay *et al.* 1976; Wilkinson *et al.* 1986; Mollel *et al.* 2008-2011; Nonnotte *et al.* 2008; Mana *et al.* 2012; Sherrod *et al.* 2013; Mana *et al.* 2015

Stages of Magmatic Activity



Precursory phenomena = volcanic eruption

Accelerating volcanism = onset of rifting

Rifting 1.2-2 Ma

MacIntyre *et al.* 1974

Activity was episodic

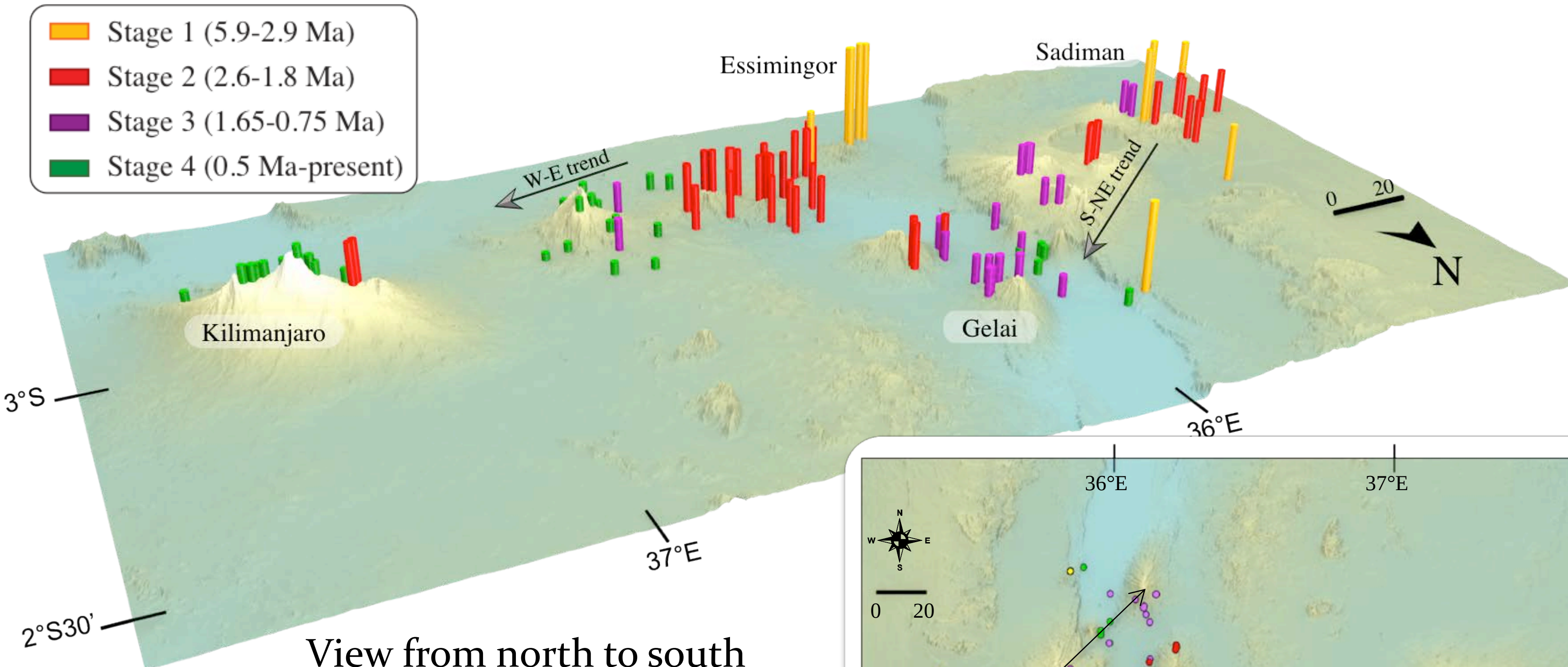
- Stage 1 (5.9-2.9 Ma)
- Stage 2 (2.6-1.8 Ma)
- Stage 3 (1.65-0.75 Ma)
- Stage 4 (0.5 Ma-present)

Ages from: Isaac *et al.* 1974; Wilkinson *et al.* 1986; Mollel *et al.* 2008-2011; Nonnotte *et al.* 2008; Mana *et al.* 2012; Sherrod *et al.* 2013; Mana *et al.* 2015

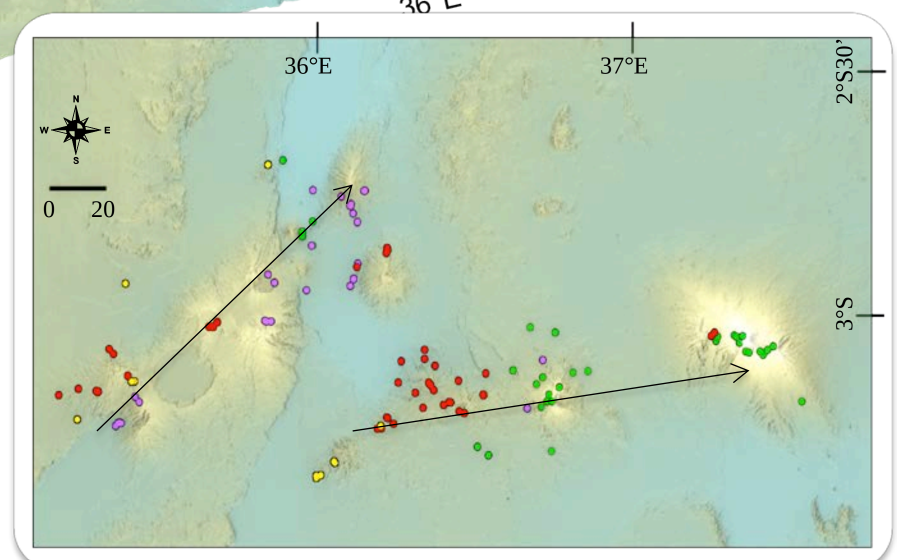
New Chronological Framework

Two pulses of enhanced magmatism

Two main volcanic lineages



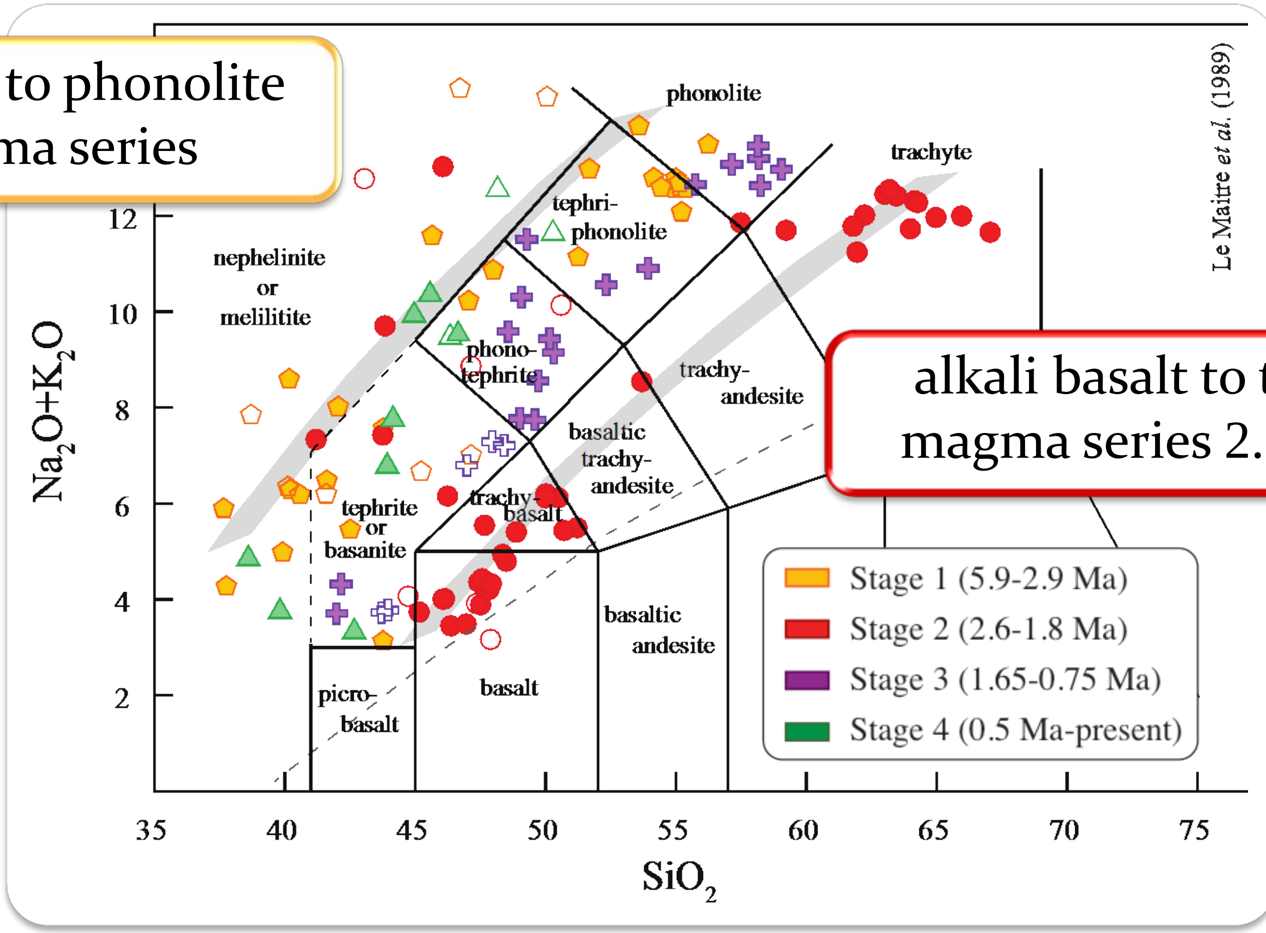
View from north to south



Ages from: Isaac *et al.* 1974; Wilkinson *et al.* 1986; Mollel *et al.* 2008-2011; Nonnotte *et al.* 2008; Mana *et al.* 2012; Sherrod *et al.* 2013; Mana *et al.* 2015

Synrift Major Elements Variation

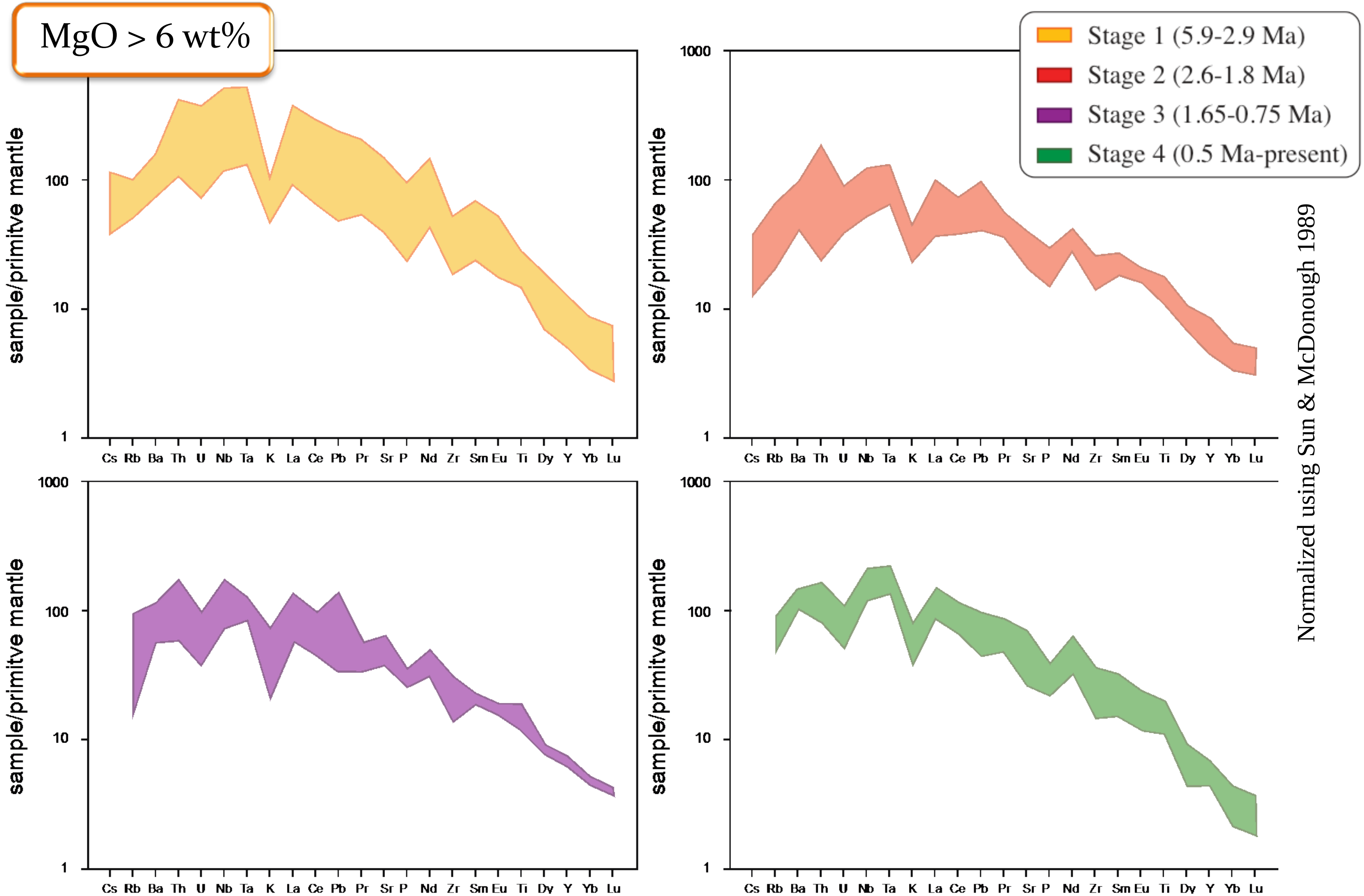
basanite to phonolite magma series



alkali basalt to trachyte magma series 2.6-1.8 Ma

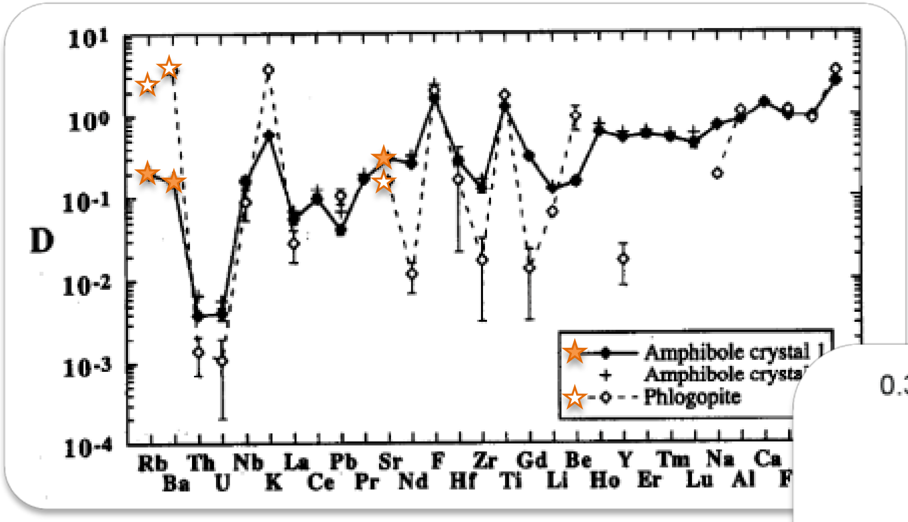
Empty symbols represent undated samples – Mana *et al.* 2015; Paslick *et al.* 1995-96

Trace Elements Variations



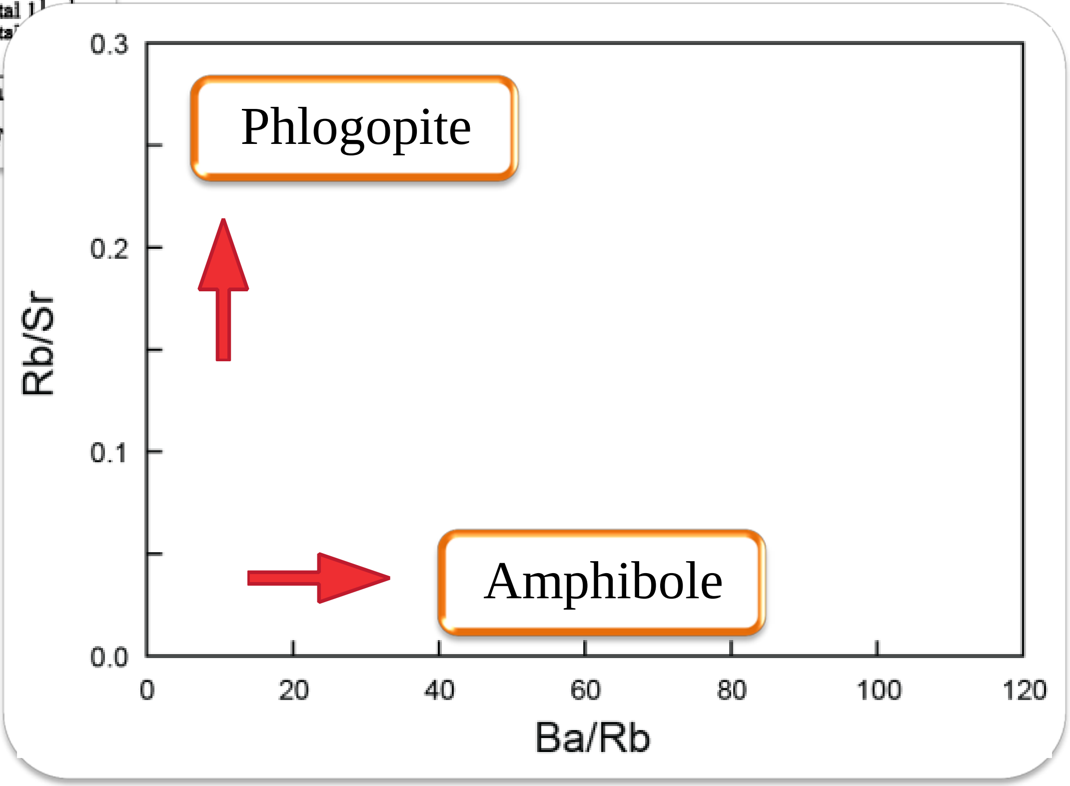
e.g. Williams 1969; Paslick *et al.*1995; Hayes 2004; Mollel *et al*. 2008; Nonnotte *et al.* 2011; Mana *et al.* 2012; Mana *et al.* 2015

Hydrous Phases: Phlogopite vs Amphibole

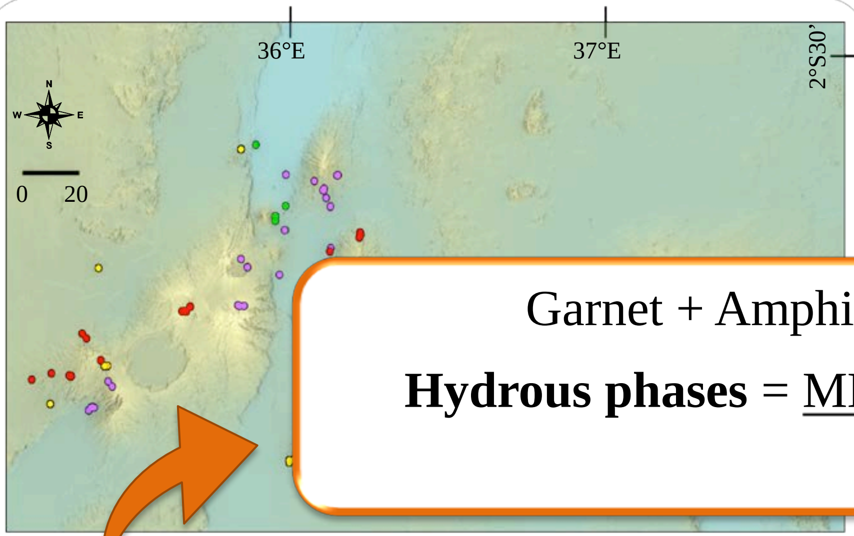


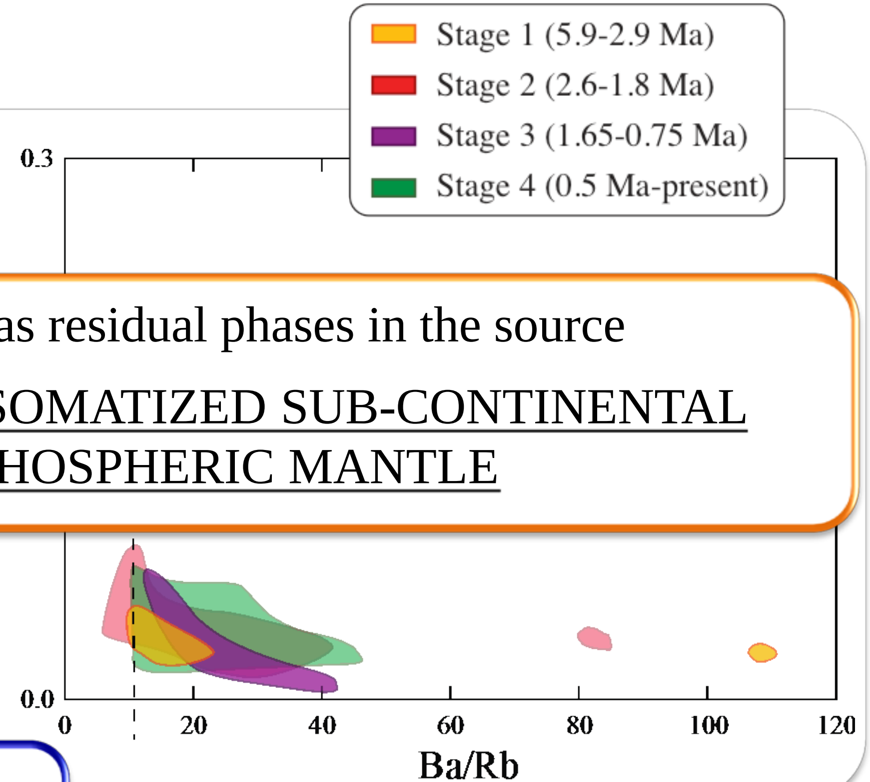
LaTourette *et al.* 1995

Partitioning of large-ion lithophile elements (LILE)



Evidence for a Metasomatized Source





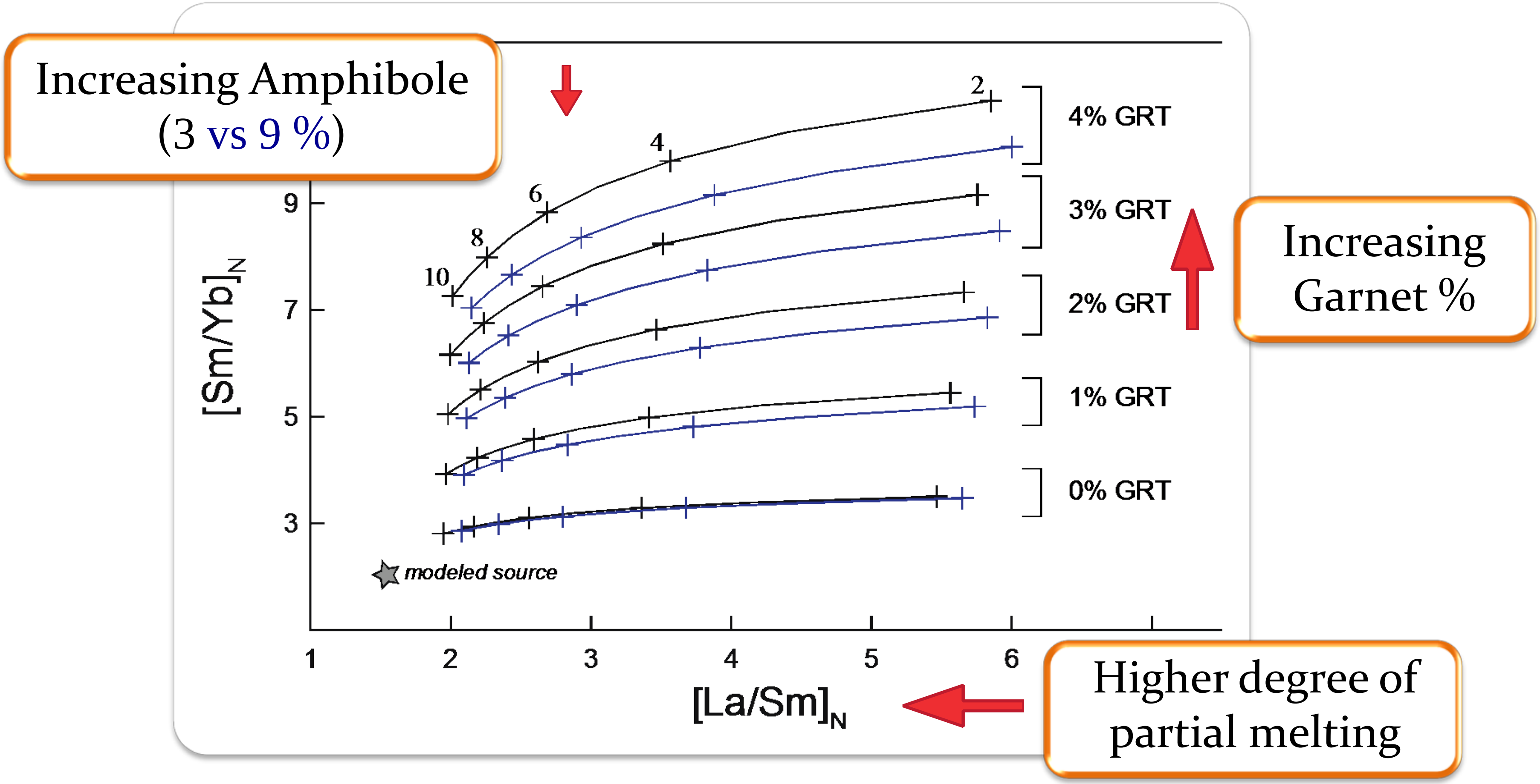
Garnet + Amphibole as residual phases in the source

Hydrous phases = METASOMATIZED SUB-CONTINENTAL LITHOSPHERIC MANTLE

Amphibole is present **ubiquitously** during the evolution of the NTD volcanism

Sun & McDonough 1989

Partial Melting Model



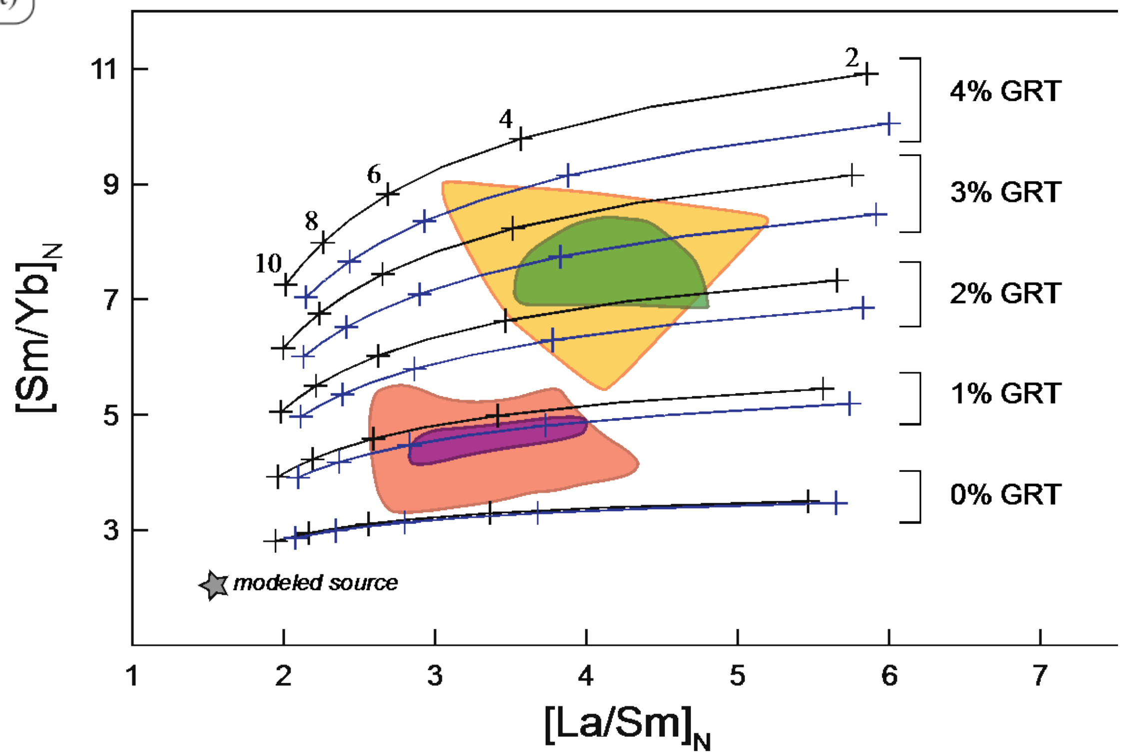
Normalized using Sun & McDonough 1989

Partial Melting Model

Stage 1 (5.9-2.9 Ma)
Stage 2 (2.6-1.8 Ma)
Stage 3 (1.65-0.75 Ma)
Stage 4 (0.5 Ma-present)

Melting in the Garnet stability zone

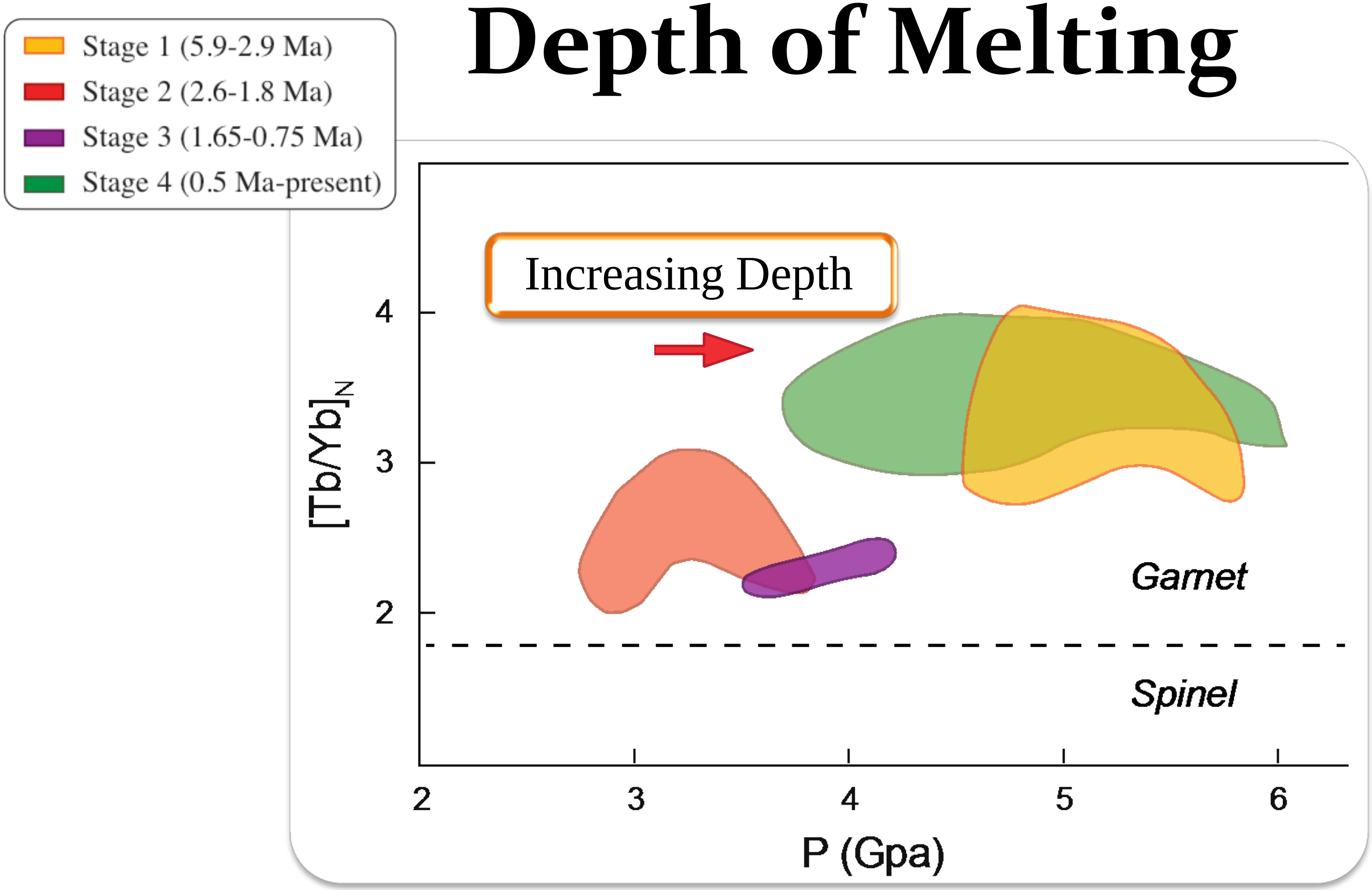
MgO > 6 wt%   Ol & Cpx corrected



Variation in GARNET content through time = DEPTH ???

Normalized using Sun & McDonough 1989

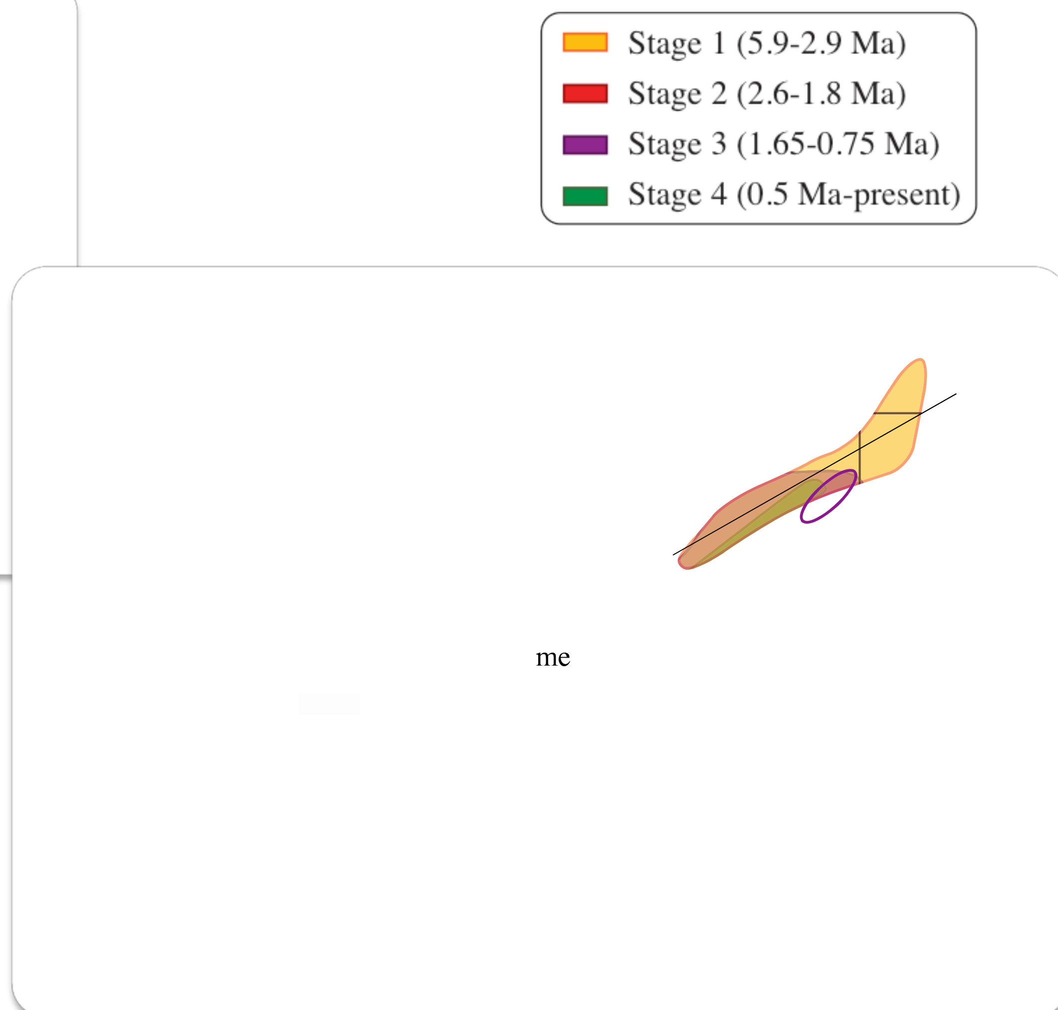
Depth of Melting



P (Gpa) from algorithm developed by Haase 1996 after correcting SiO_2 for fractional crystallization

Spinel-Garnet transition from Wang *et al.* 2002

Sr-Nd and Pb Isotopic Signature

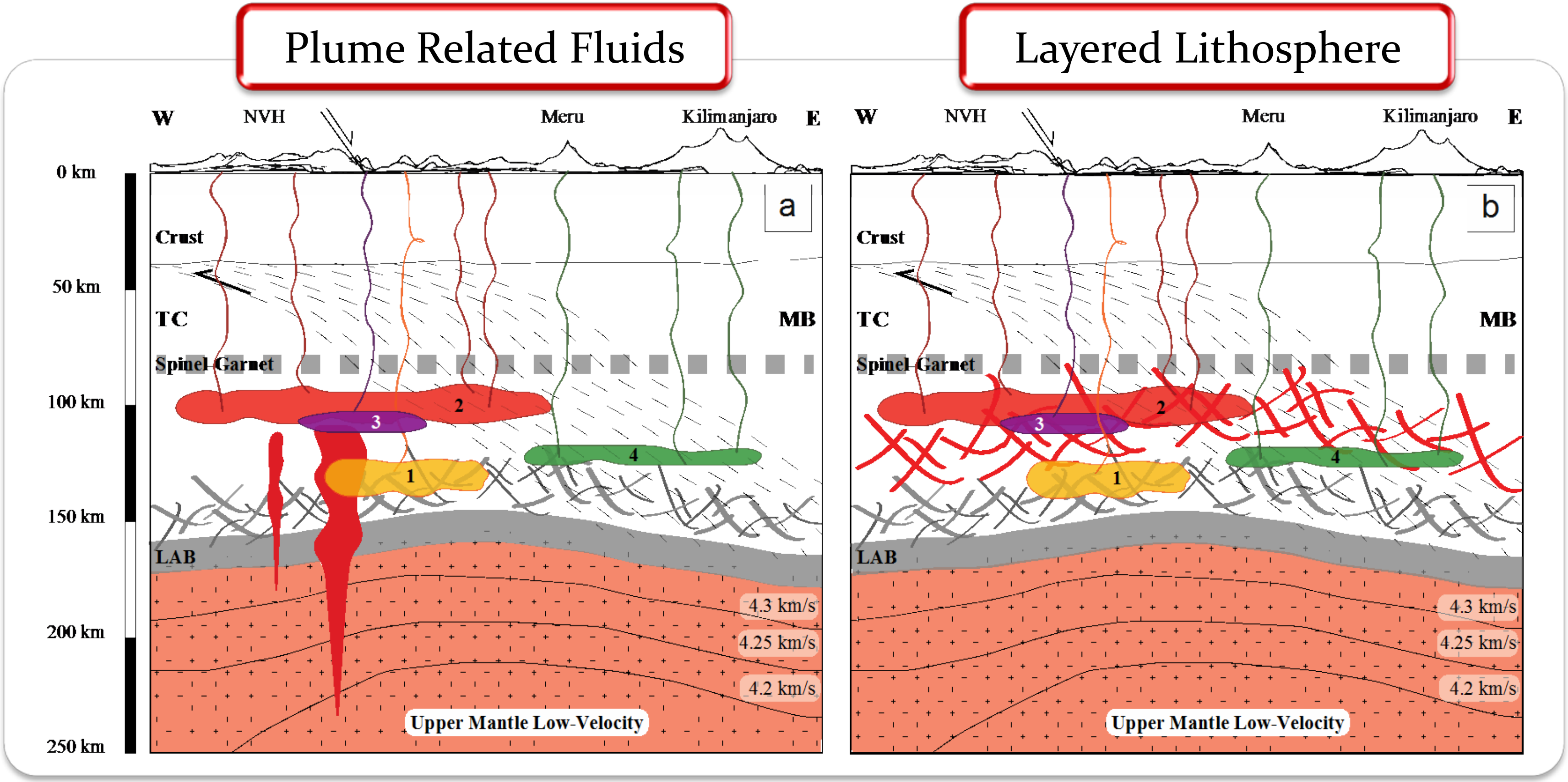


NHRL (Hart 1984); EACL (Bell & Simonetti 2010); C (Hanan & Graham 1996); Afar Plume (Furman *et al.* 2006) and ref. therein; Kenya Plume (Aulbach *et al.* 2011); Kerimasi (Kalt *et al.* 1997); Oldoinyo Lengai (Bell & Simonetti 1996; Bell & Tilton 2001)

Two Proposed Tectonic Models

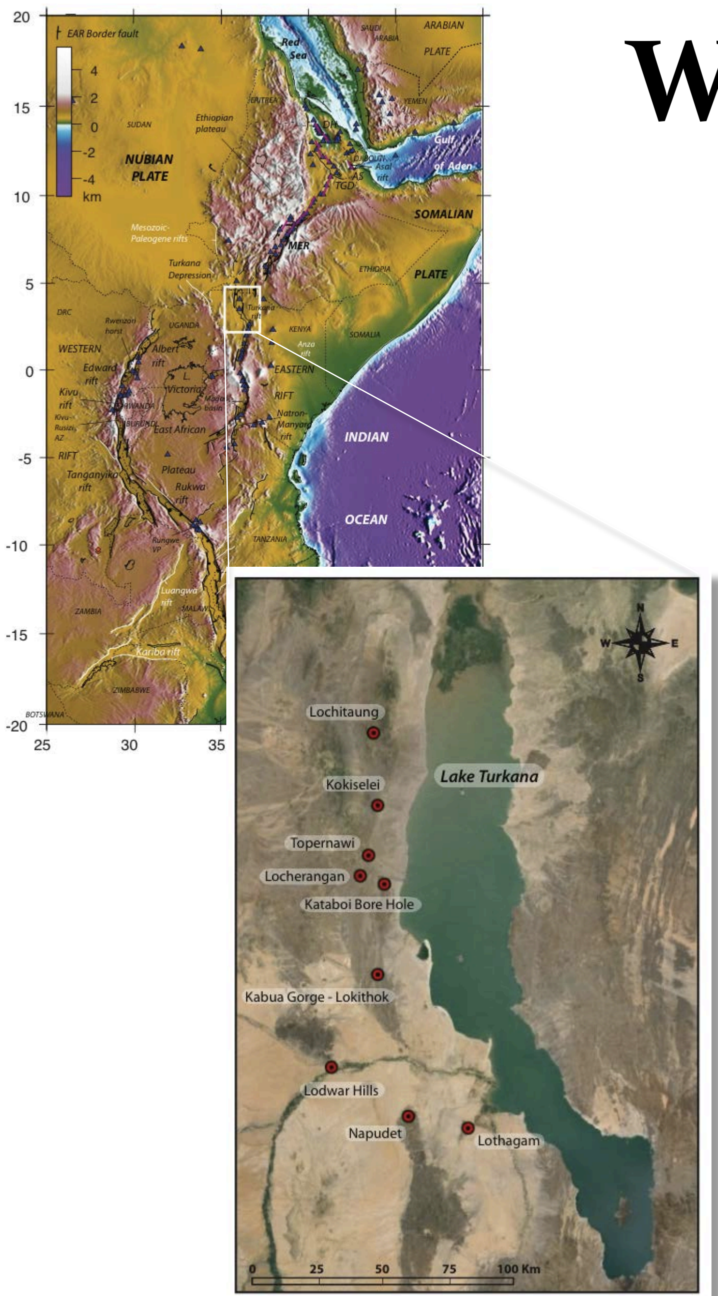
Stage 1 and 4 - Melting of Amphibole Rich Veins

Stage 2 and 3 - Contributions from hydrous veins was drowned out by melting of a different source component



Upper mantle low-velocity from 3-D shear wave velocity model presented by Adams *et al.* (2012)

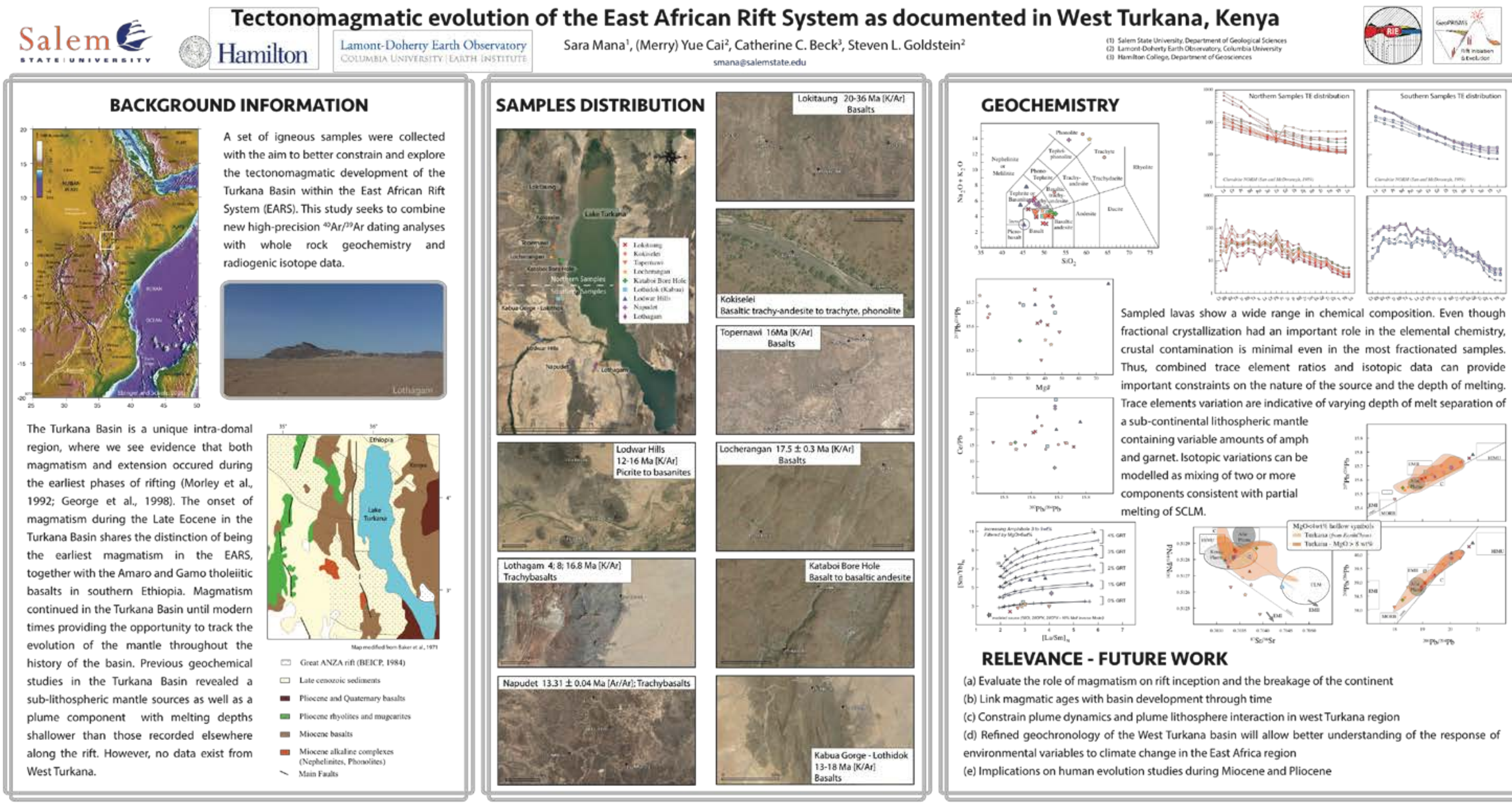
West Turkana Basin



- unique intra-domal region
- evidence for the **earliest** phases of both magmatism and extension co-occur
- opportunity to track magma evolution throughout the history of the basin and constrain **plume-lithosphere interactions**

EAR map modified from Ebinger and Scholz, 2011

Preliminary data…



…Come to see my poster

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Thank you!

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Cat Beck – Hamilton College
Tanya Furman – Penn State University
Carl Swisher – Rutgers University
Craig Feibel – Rutgers University

Oldoinyo Lengai 2010