Magmatic Differentiation at Dabbahu Volcano, Afar

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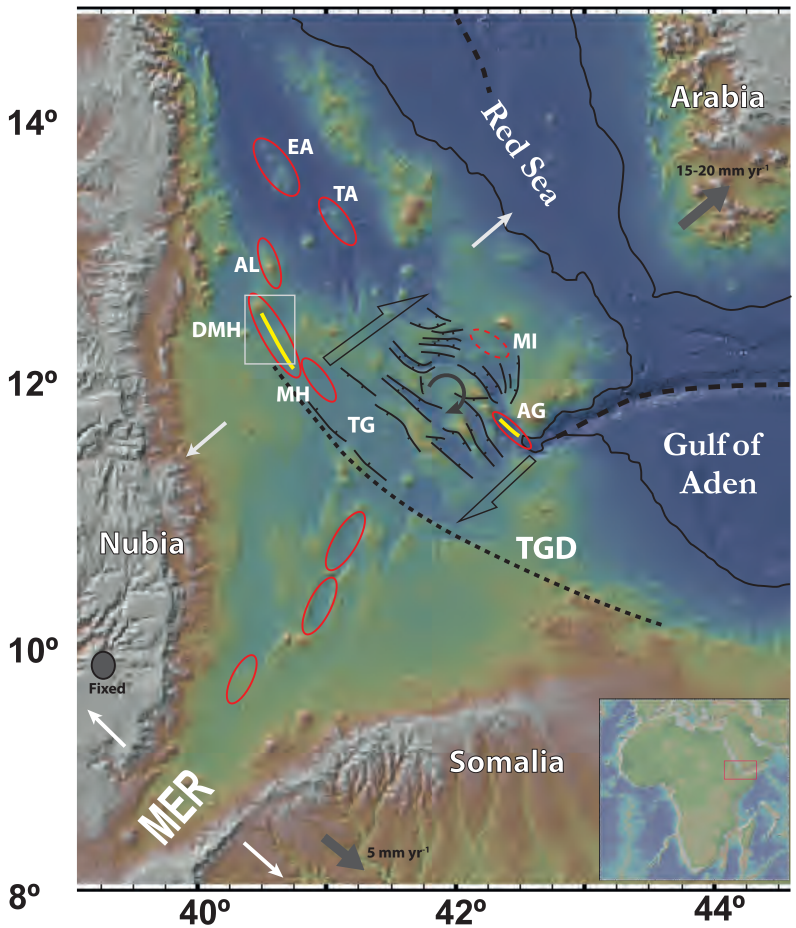
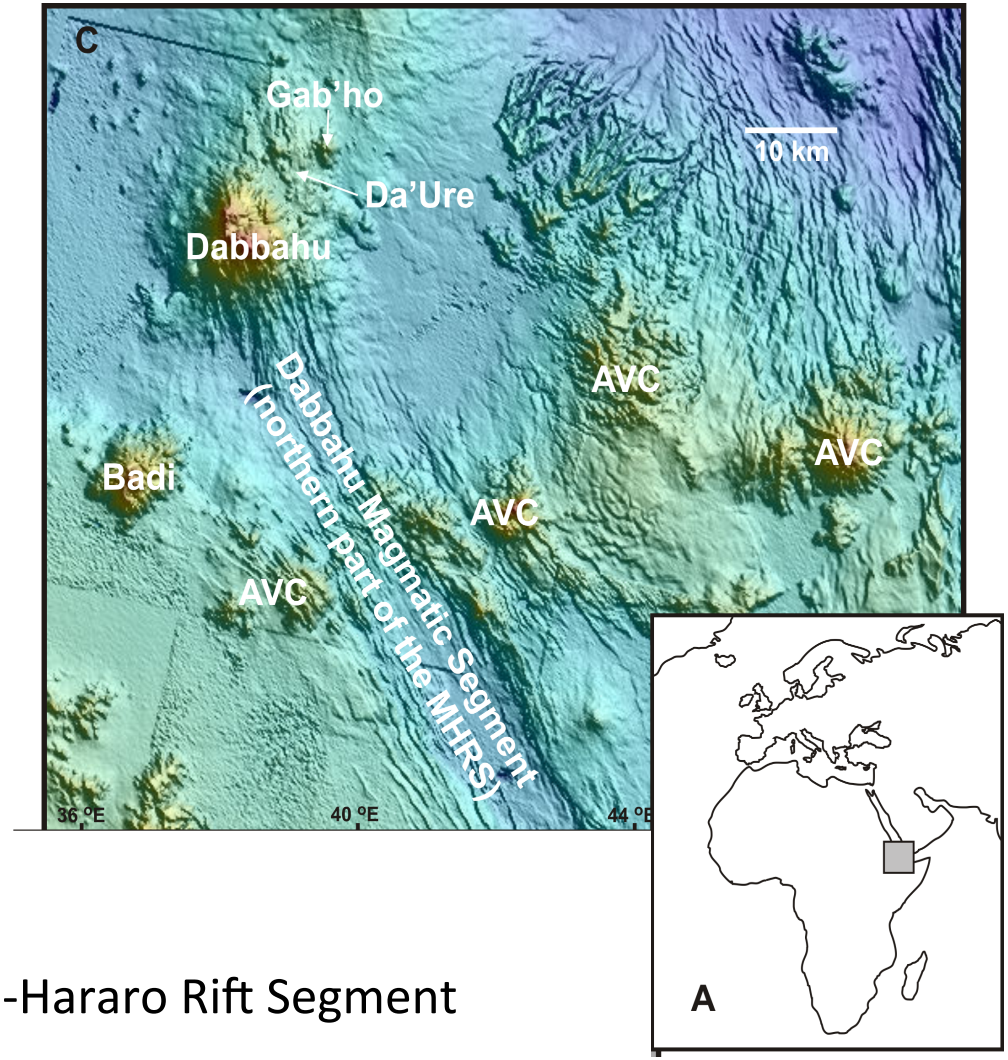
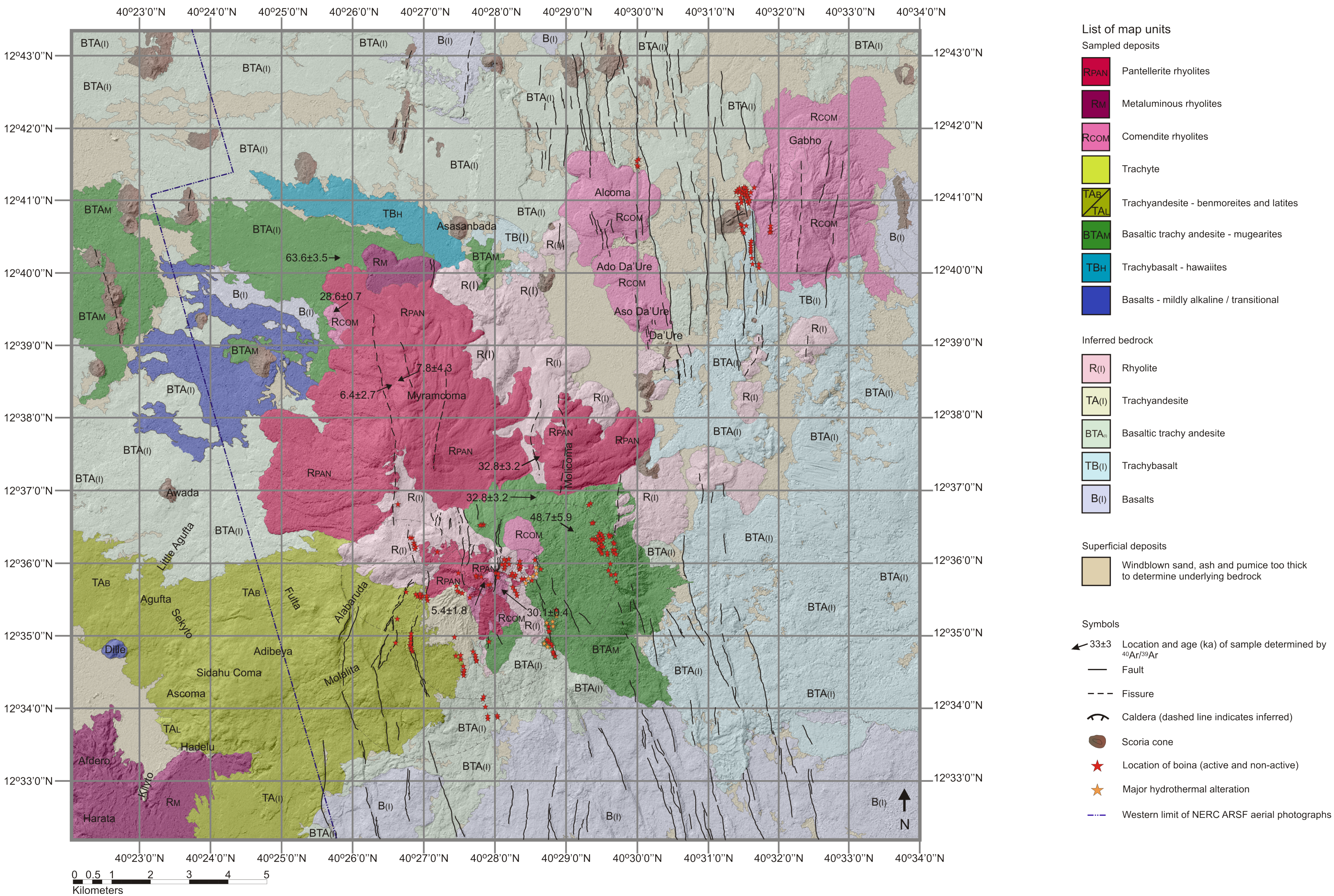
Dabbahu Composite Volcano



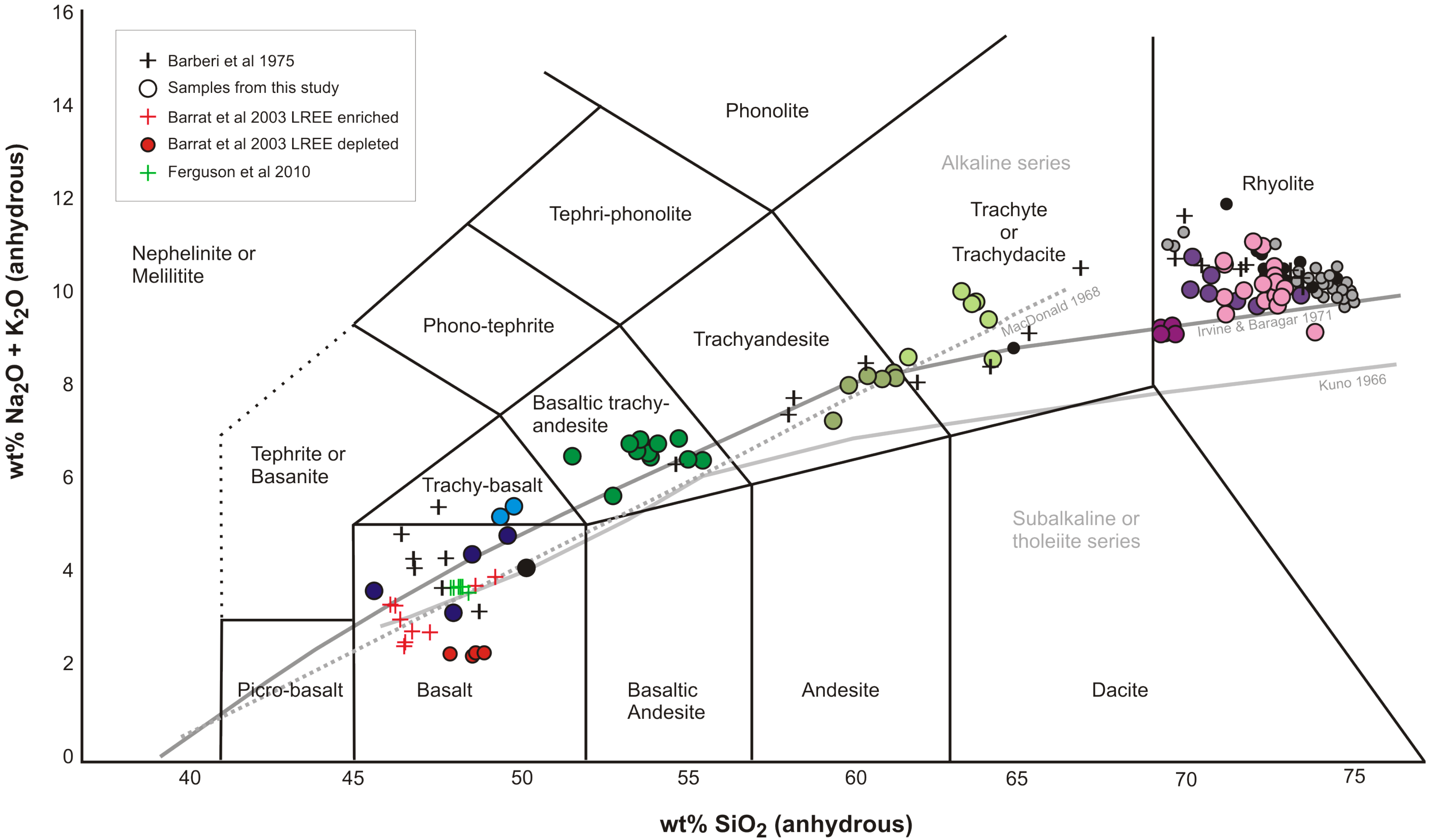


Northernmost end of active Manda-Hararo Rift Segment
West of 2005 Da'Ure Vent
Small offset from Alayta Rift Segment to North



Wide range of magma types erupted from same vent/fissure system

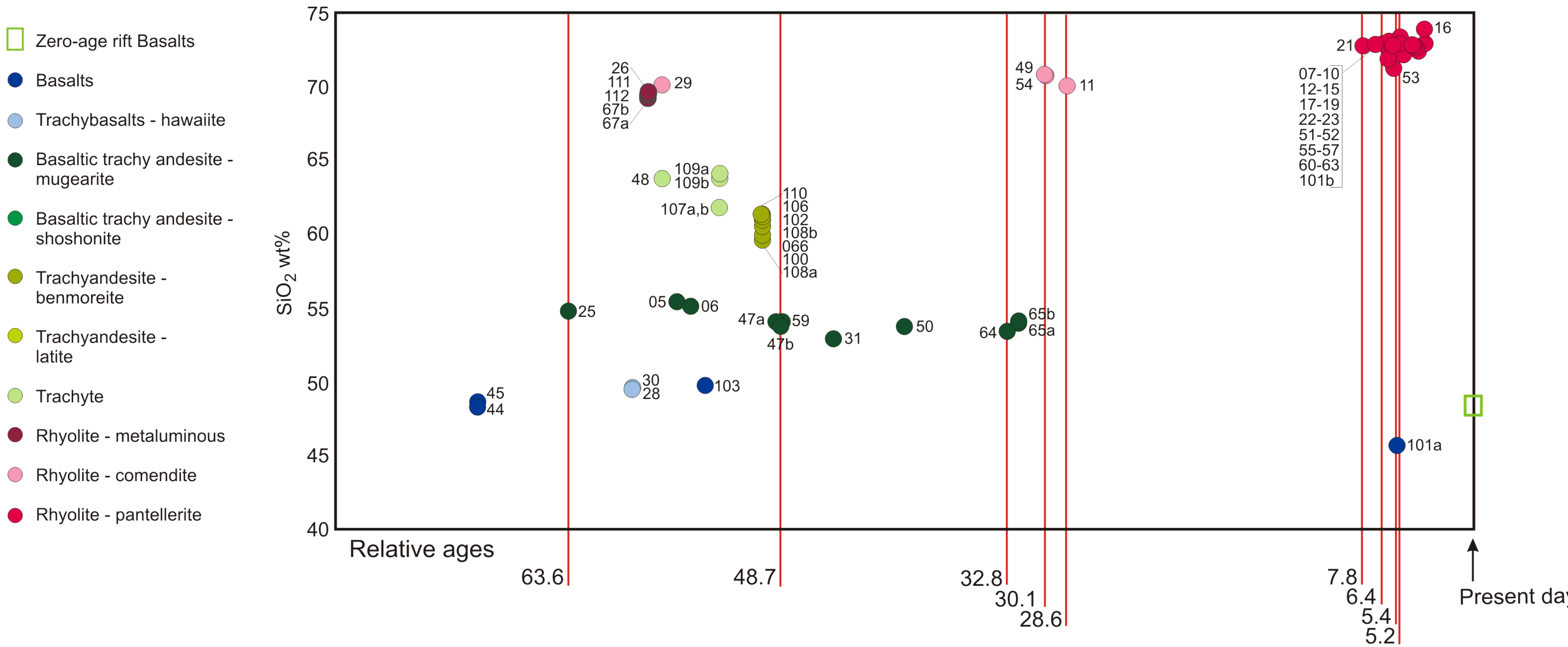
Extreme chemical differentiation



Rocks are phenocryst-poor – close to liquid compositions

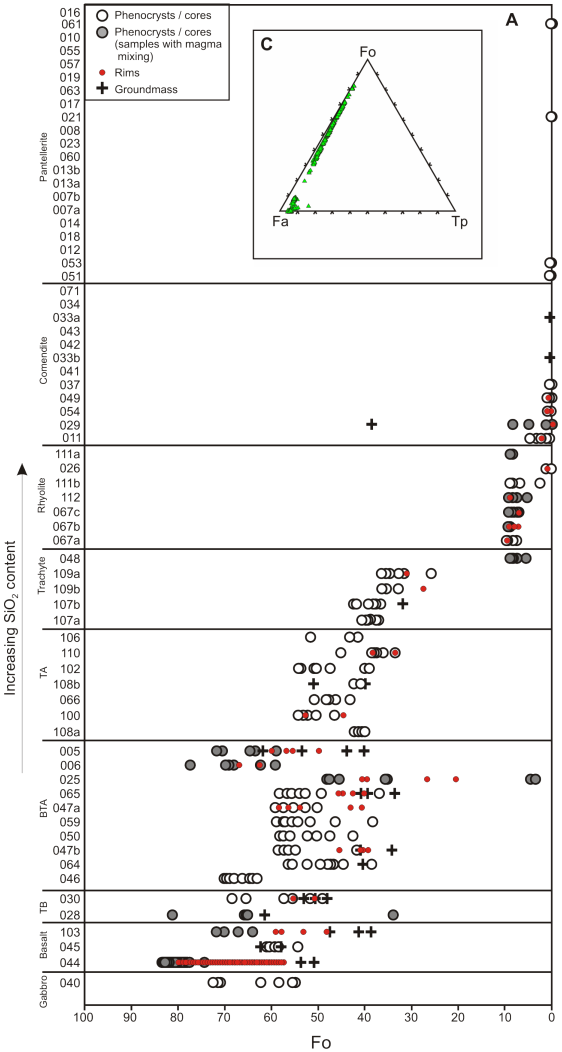
Olivine + plagioclase + cpx stable over entire differentiation trend

New Ar-Ar dating

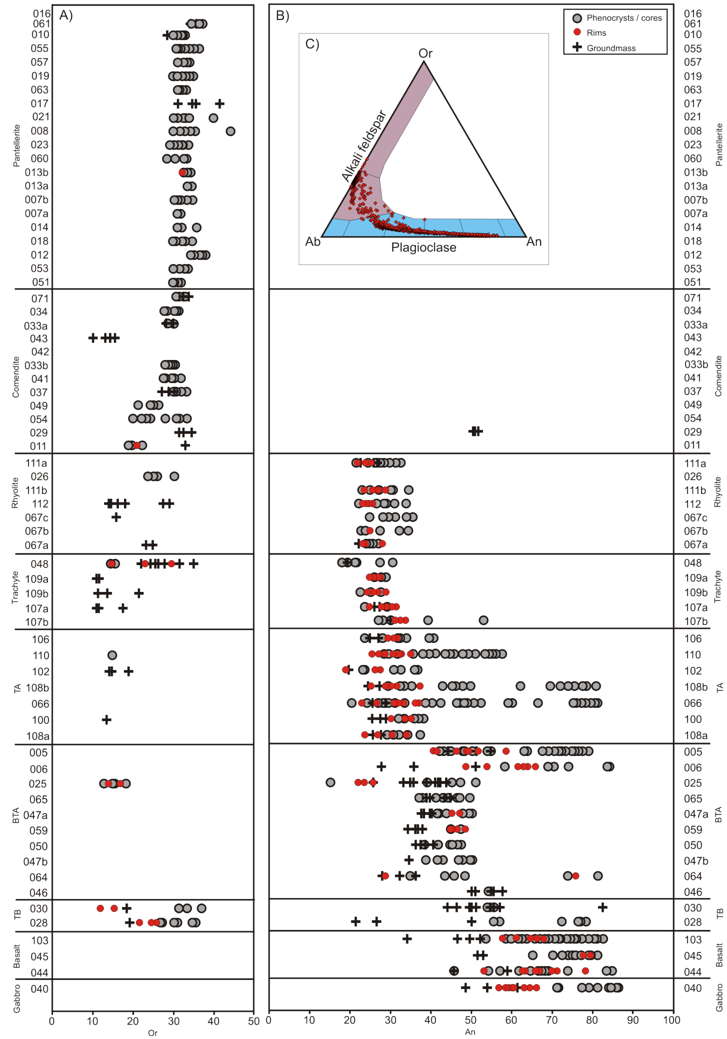


- Dabbahu is ≤100,000 years old
- ~35 km^3 erupted volume = 0.01 $m^3\ s^{-1}$
- No evidence of temporal chemical evolution

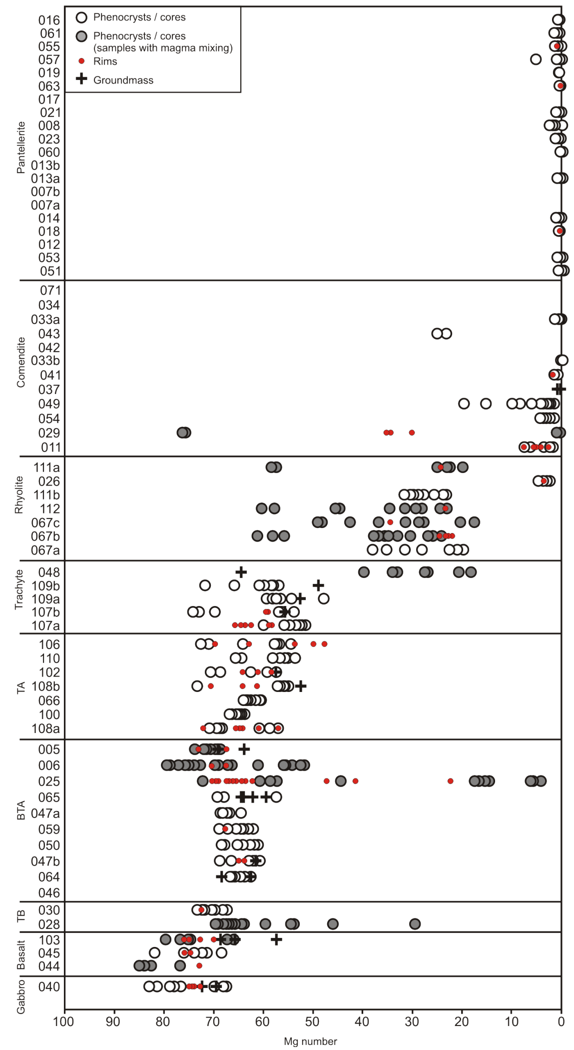
Mineralogical evolution



olivine



feldspar

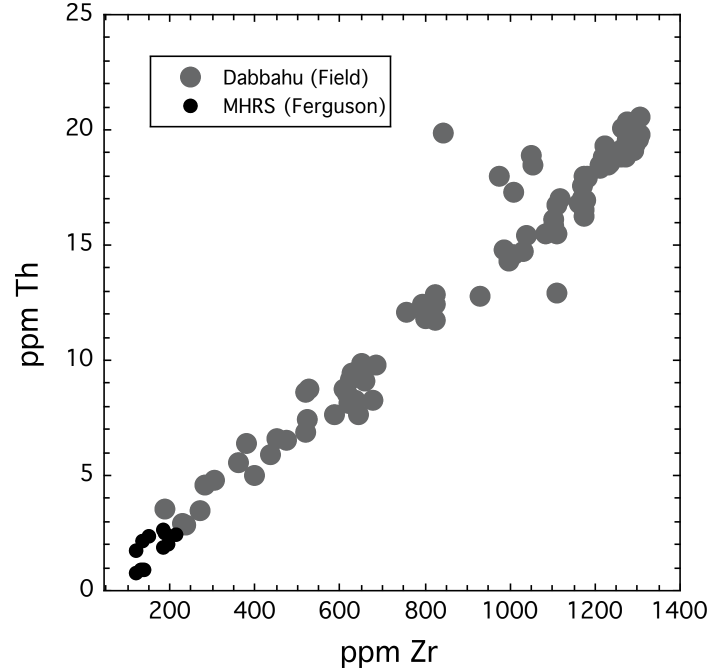


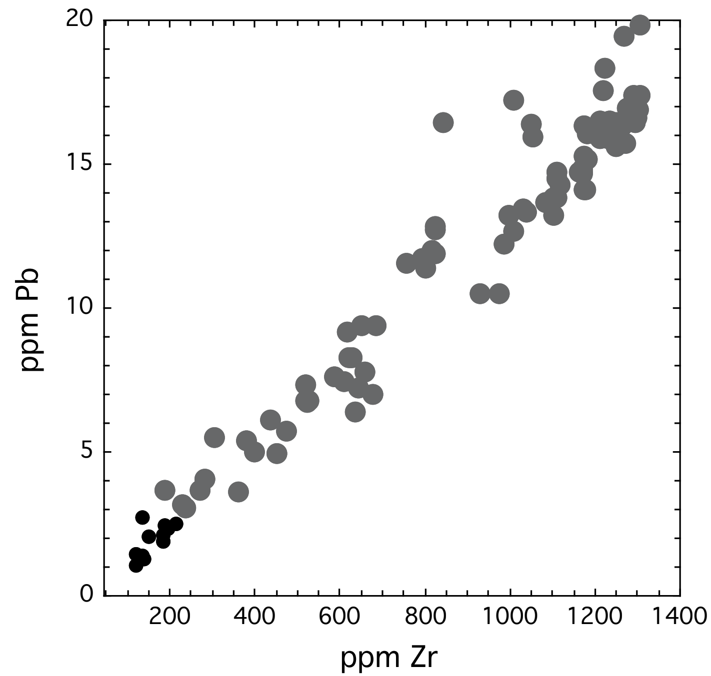
clinopyroxene

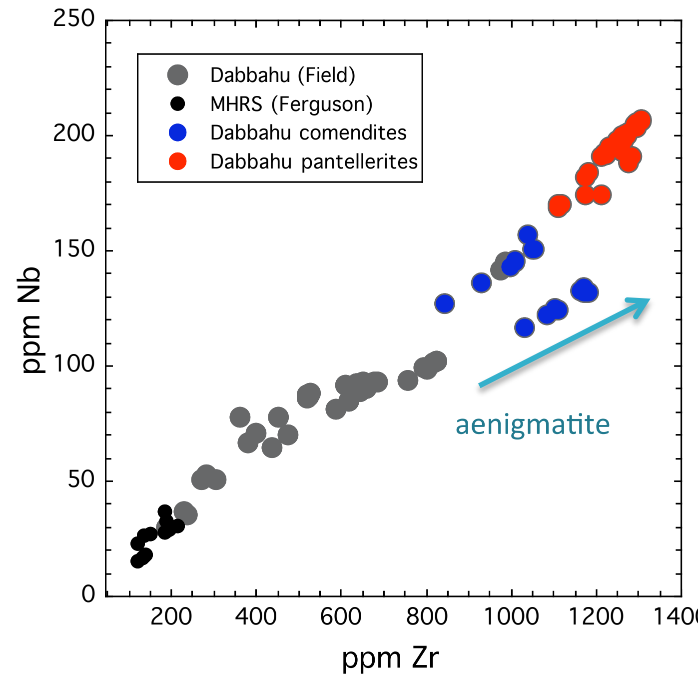
Geochemistry

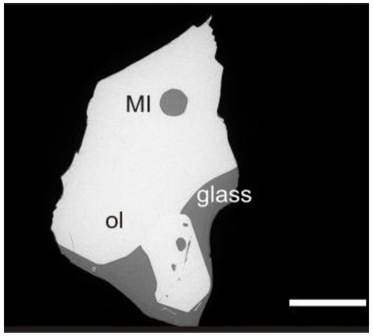
Constant ratios of incompatible elements suggest single magmatic lineage from parental axial basalt

10-fold increase in incompatible trace elements

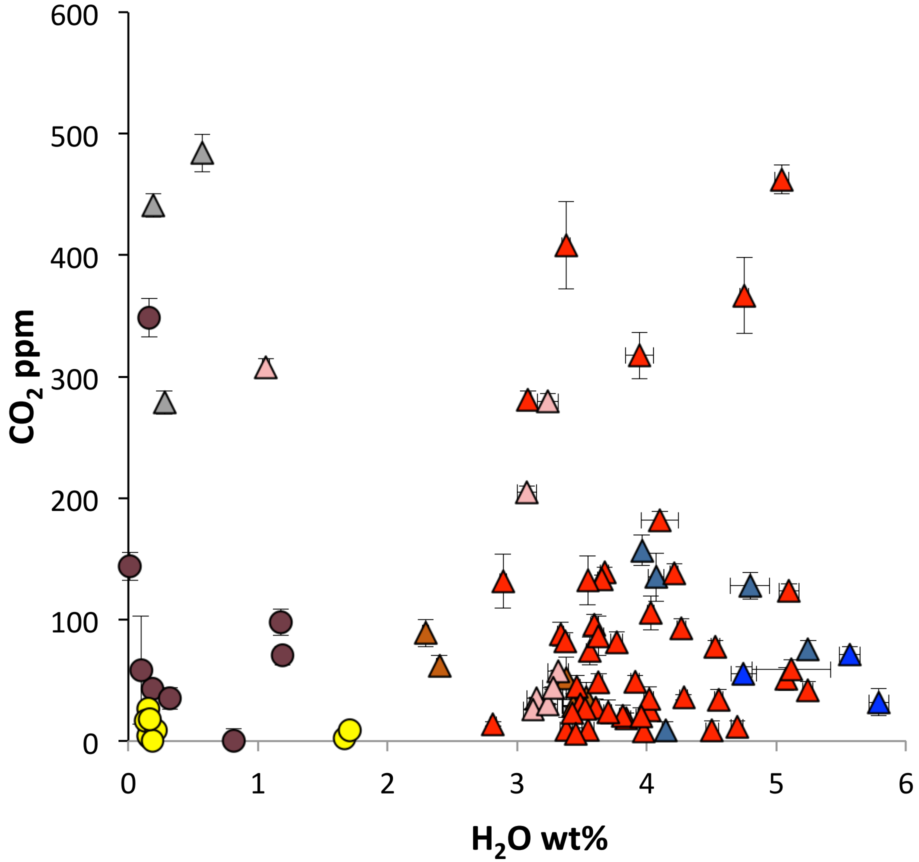


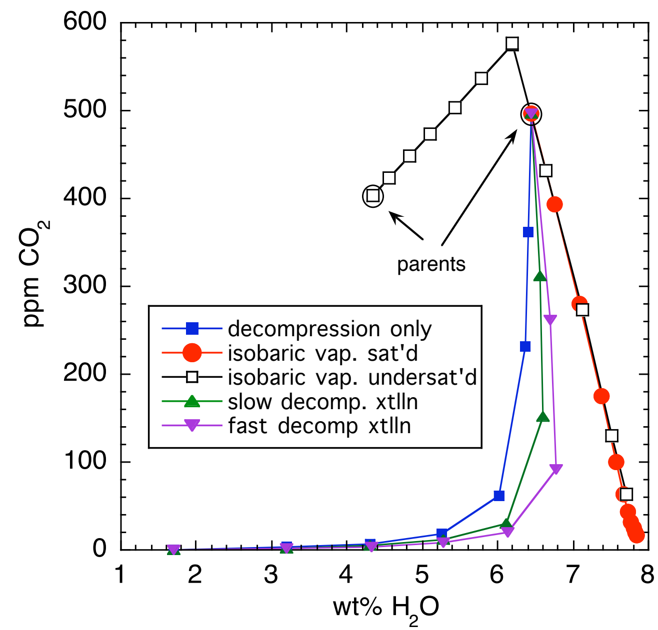


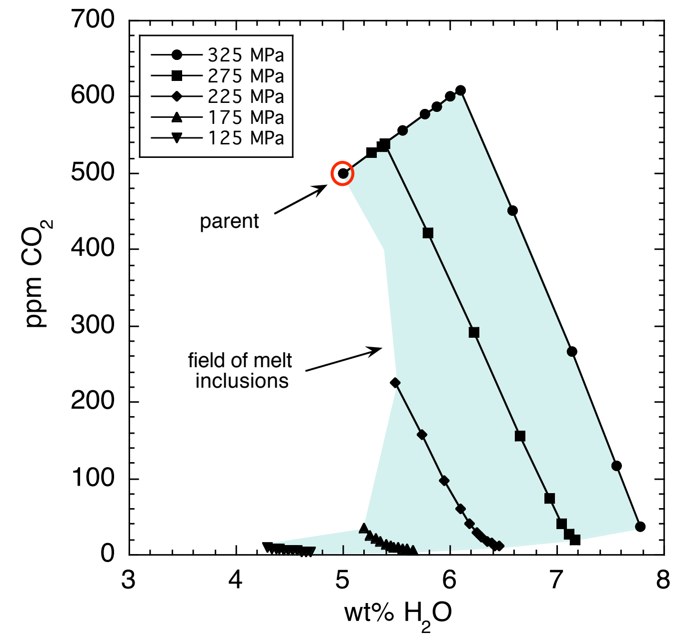




Volatiles in melt inclusions

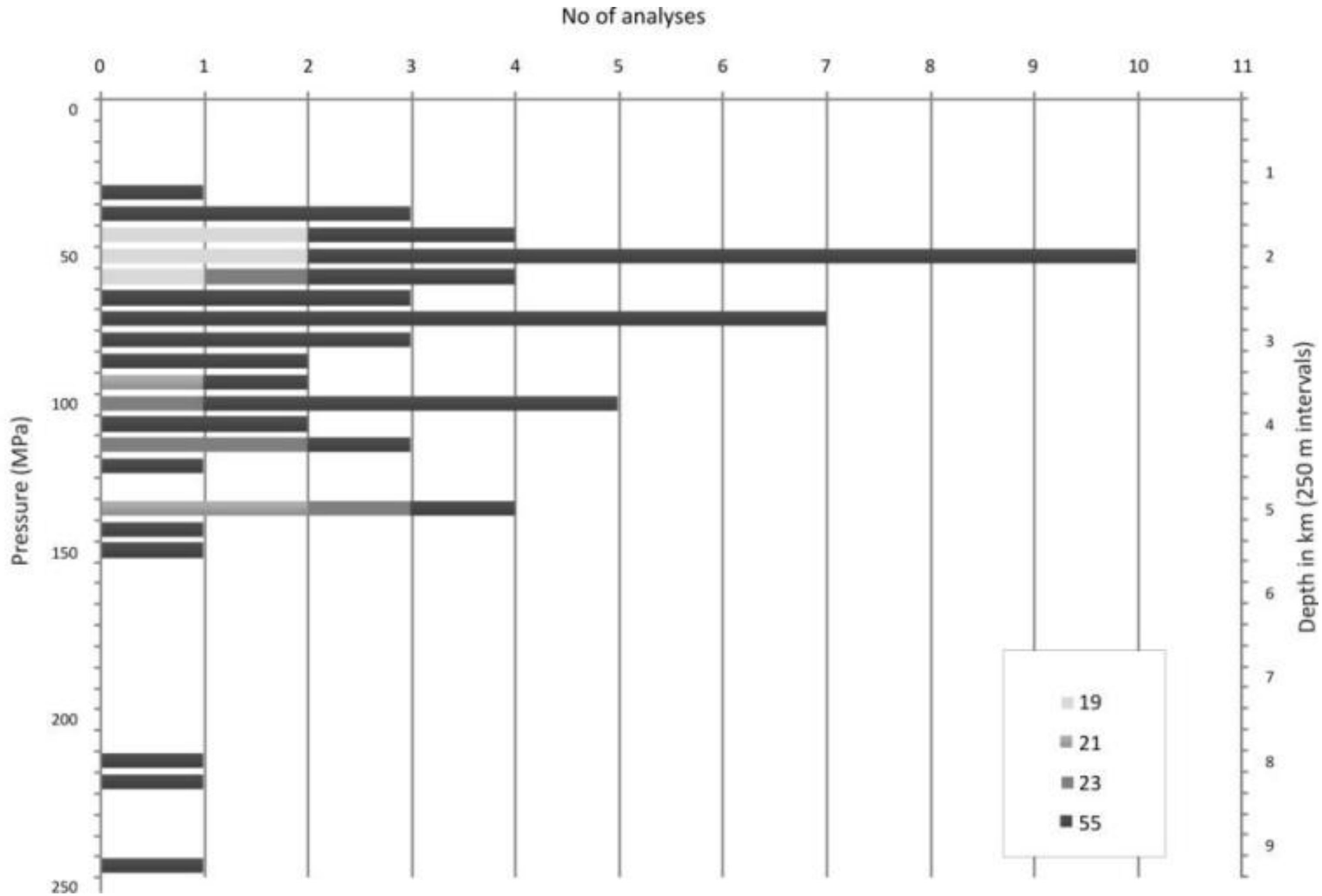






- Data do not describe simple degassing trends
- Some high CO_2 inclusions – gas fluxing?
- Crystallisation of small magma batches over range of pressures

Depths of entrapment



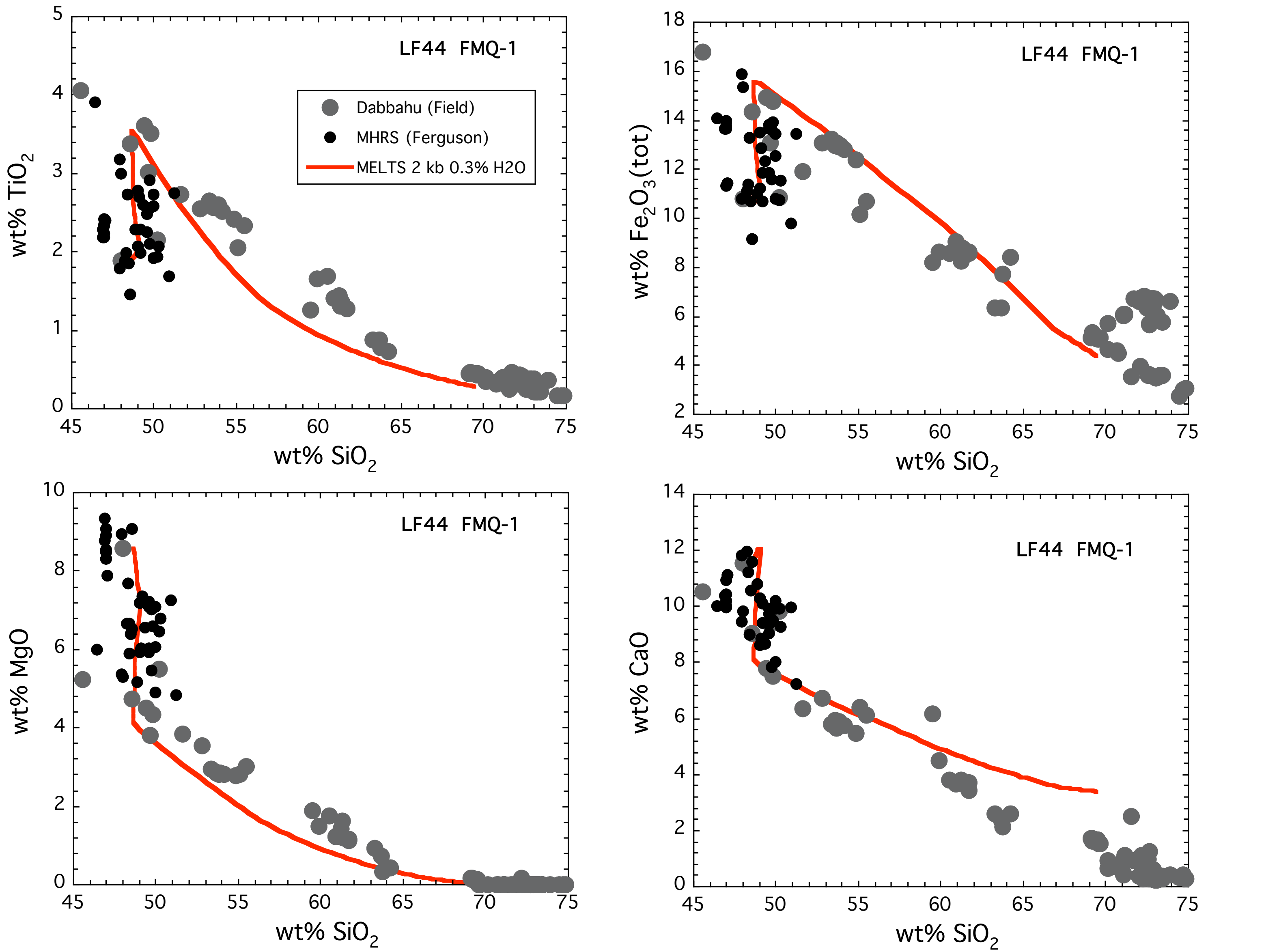
Stacked sills at 2-6 km depth gives good fit to INSAR data

Constraints on crystallisation conditions from MELTS and pMELTS modelling

Observation	**Constraint**
Basaltic parent has mg# = 0.6	Not in mantle equilibrium
Lack of opx	fO_2<FMQ
Ilmenite	fO_2≤FMQ-1
An_{80}, Fo_{80}	3 kb>P≥1 kb
Cotectic Ol+Plag+Cpx in basalts	3 kb>P≥1 kb, H_2O≤0.3 wt%
4±1 wt% H_2O in rhyolites	~0.4% H_2O in parent
Liquid line of descent (esp. CaO)	P≤3 kb
Max Al_2O_3 = 17 wt%	≤ 0.4 wt% H_2O in parent
Extreme mineral variation	≤90% fractional crystallisation

Run models to obtain best fit to whole-rock chemistry, phenocryst assemblage and mineral compositions

LF44 parent, FC, 2 kb, 0.3 wt% H_2O, FMQ-1



Similar results at 3 kb, 0.1 wt% H_2O

Conclusions

- Shallow differentiation in stacked sills (or dykes) – 2-6 km depth
- Low H_2O content of parent basalt (~0.4 wt%)
- <10% of basaltic input becomes rhyolite
- Shallow, dense cumulates
- Crustal contamination is not *required* by isotope data
- Thermal budget is critical – ~100 ka of silicic magma production
- Differentiation enabled by reduced magma supply at segment end