Variable mantle and subduction components in the sources of Havre Trough backarc magmas

Erin Todd

US Geological Survey

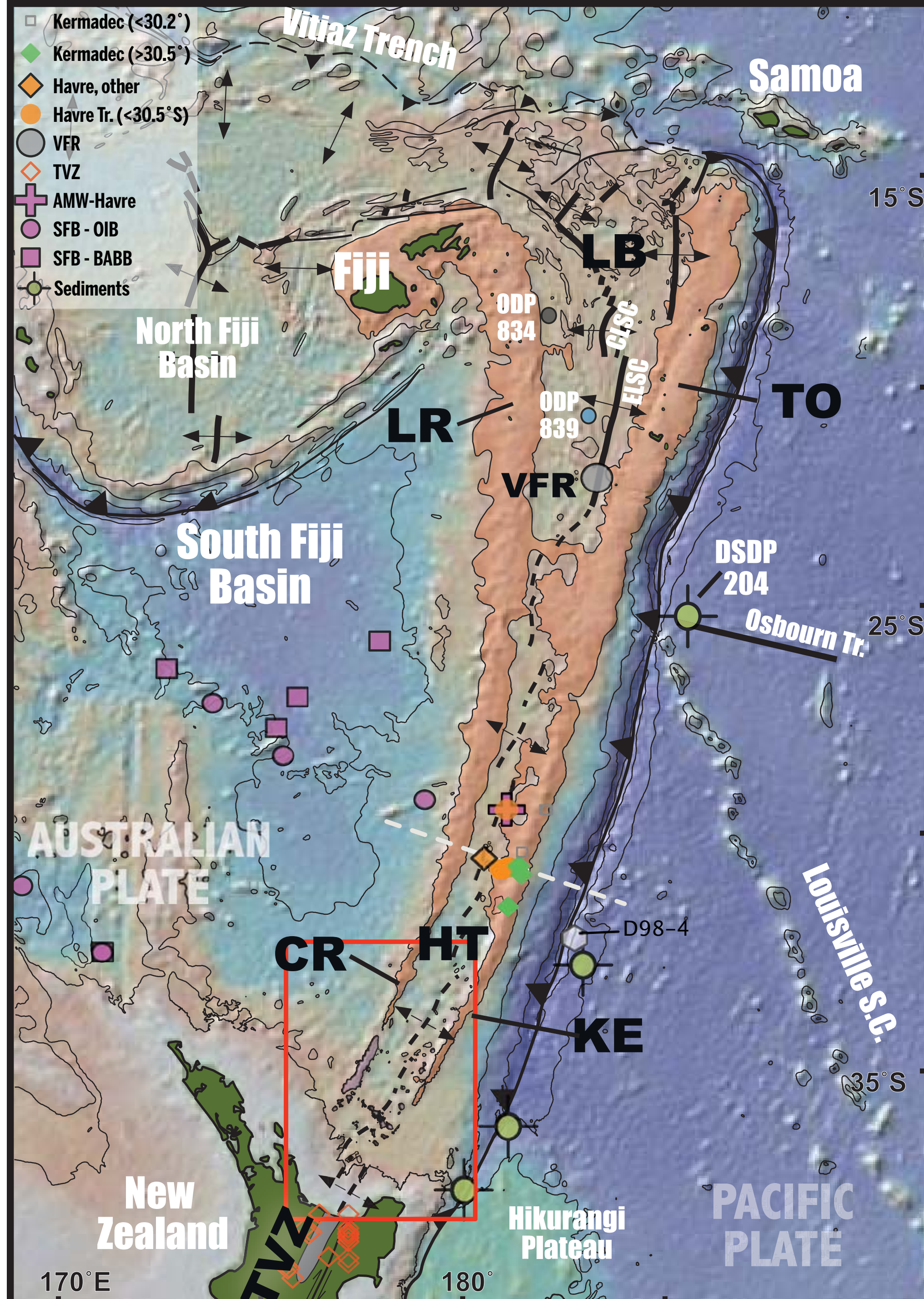
J. Gill, R. Wysoczanski, J. Hergt, M. Handler,

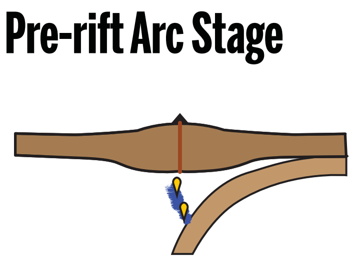
I. Wright, J. Gamble, N. Mortimer, M. Leybourne

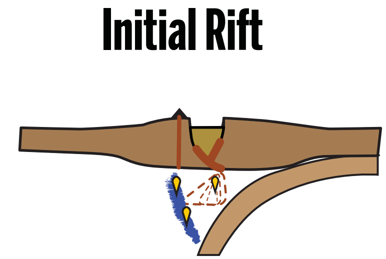
Kermadec Arc & Havre Trough:
Tectonics and Volcanism

- Havre BAB transitional "rifting" stage

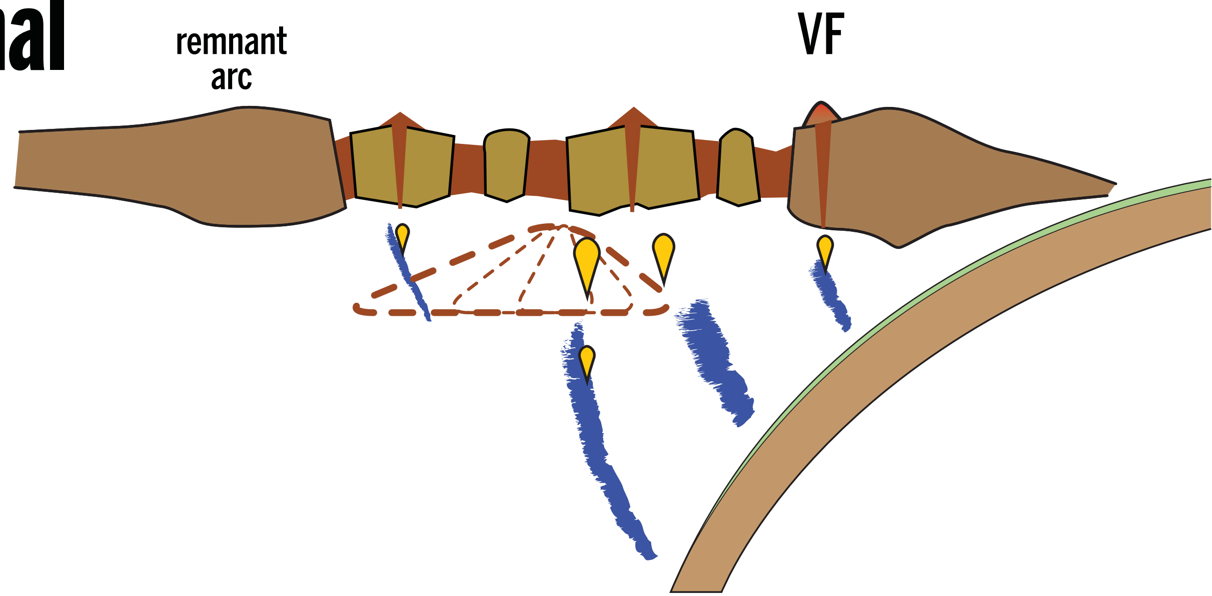
- Versus MOR-type BAB:
  - Lau Basin
  - South Fiji Basin
  - North Fiji Basin







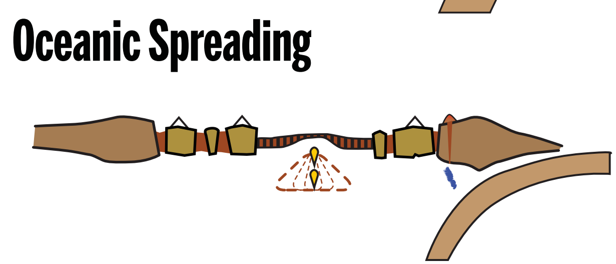
Transitional



Wysoczanski, Todd, et al., 2010 (JVGR) –

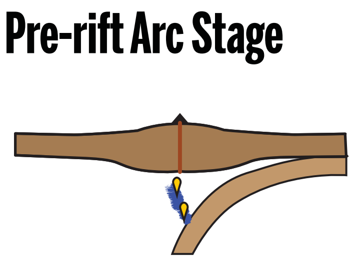
Havre Trough is a *transitional* backarc, characterized by **disorganized spreading**.

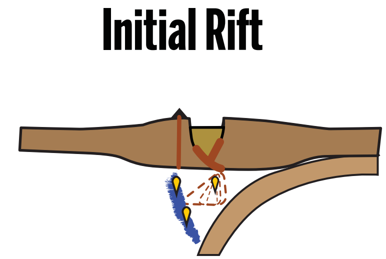
- Crustal accretion by diffuse intrusive volcanism



- Intersection of flux and decompression melting regimes
- Broad zone of melt production

Modified from Parson and Wright, 1996
& Martinez et al., 2006





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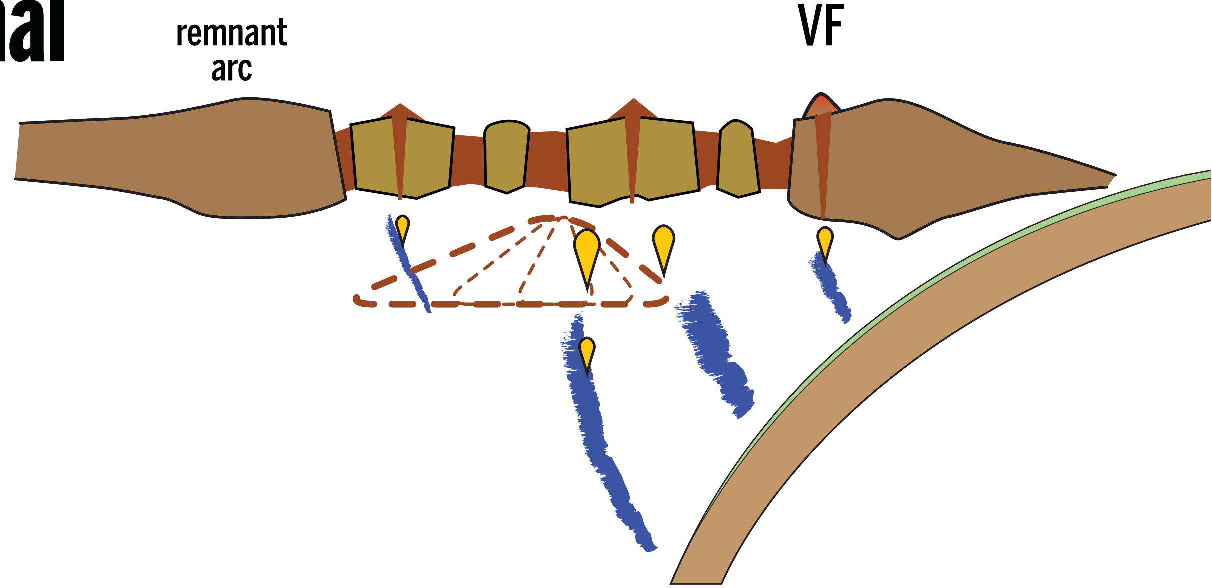
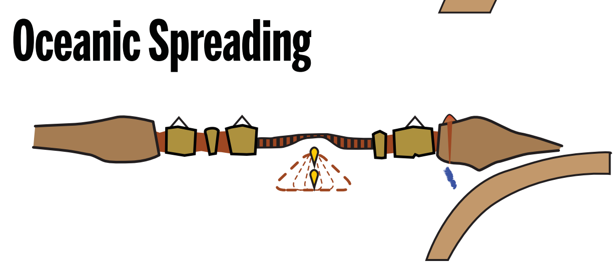


Compared to volcanic front:

- Far greater melt productivity

  ~150 vs. ~10 km^3/km *My^{-1}

- Overlie far more variable range of slab-surface conditions **and fluxes**
- Undifferentiated, un-homogenized by axial magma chambers
  - Better preservation of mantle- & slab-component signatures



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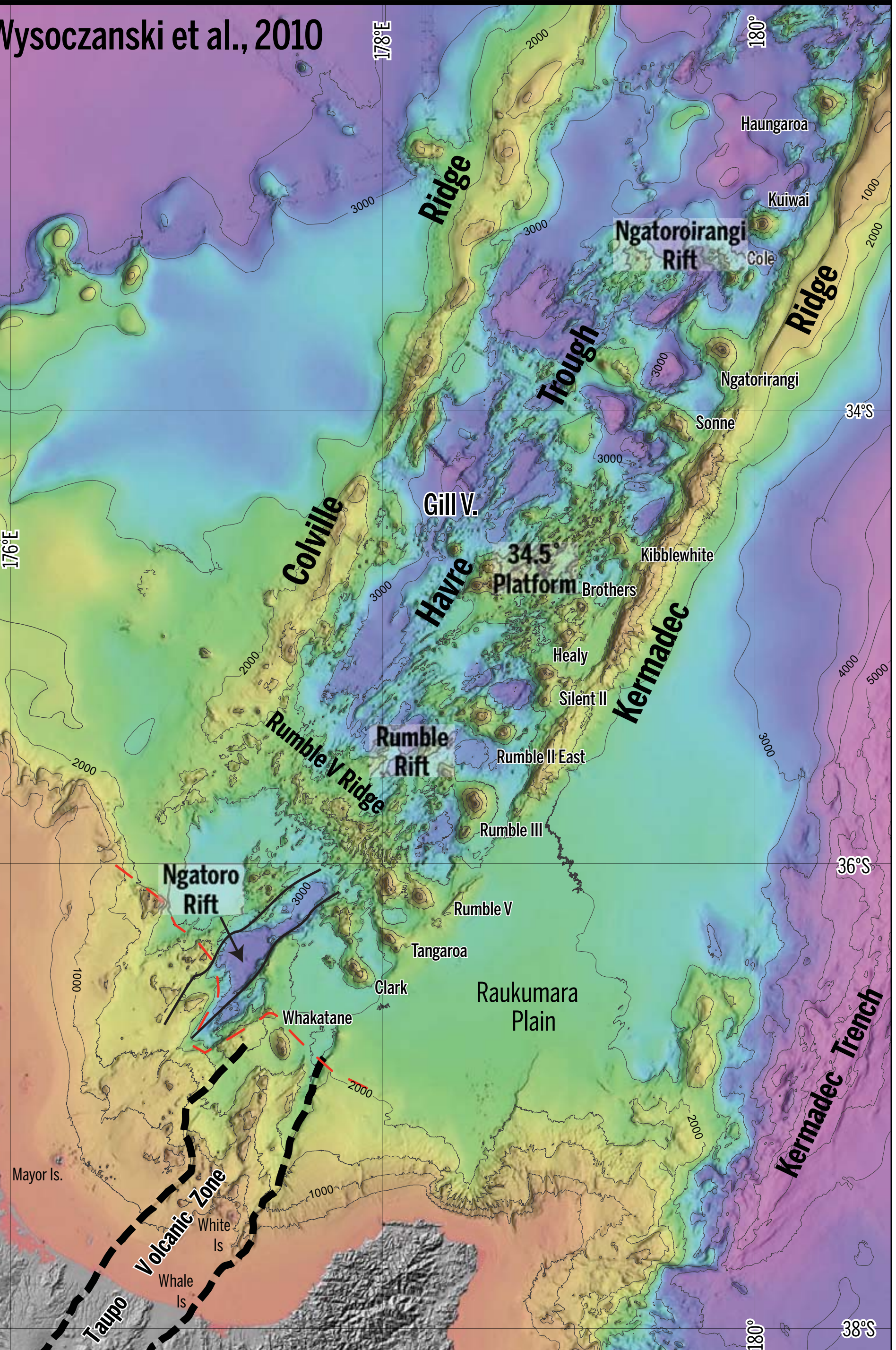


Wysoczanski, Todd, et al., 2010 (JVGR)

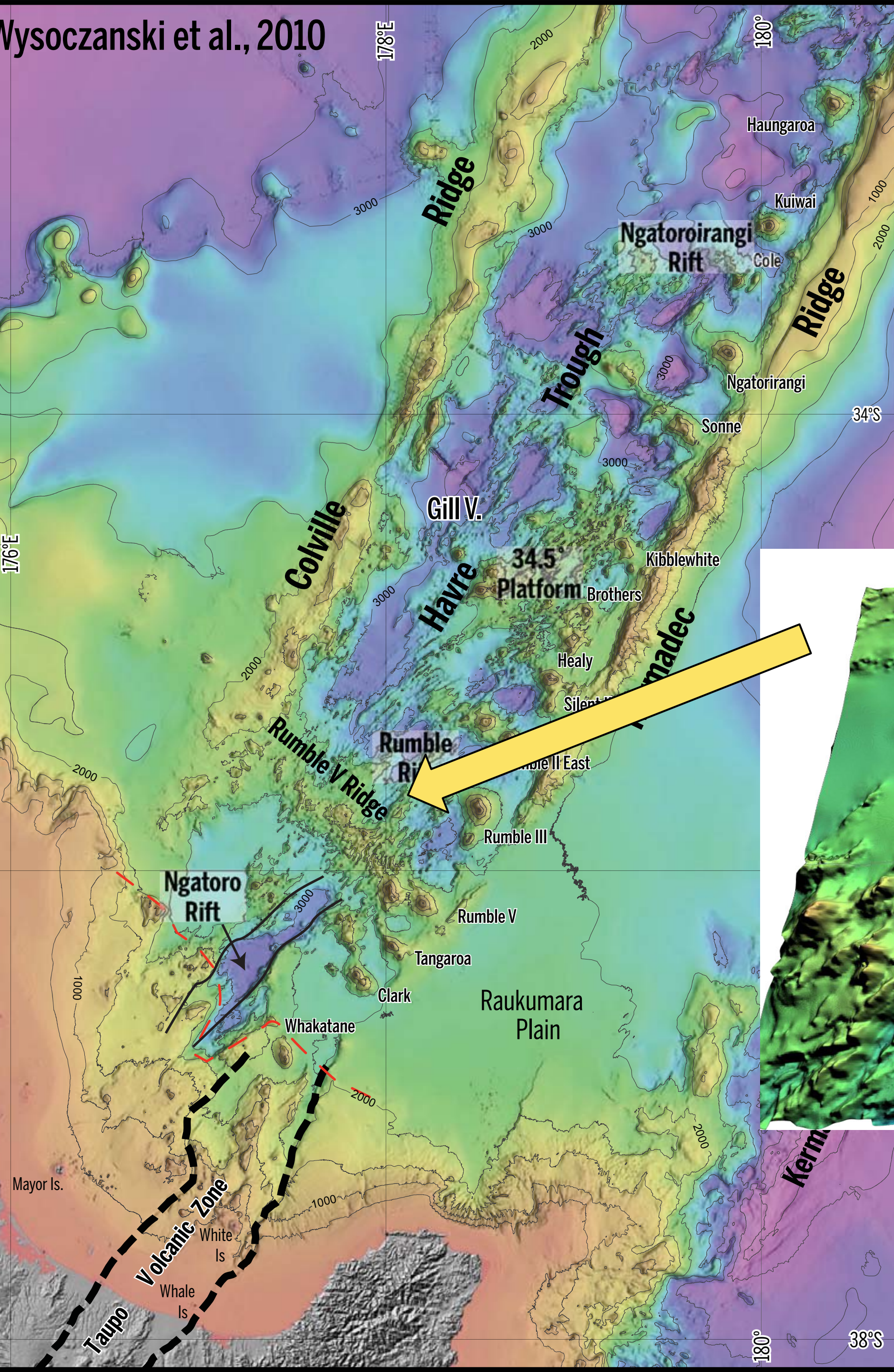
- Havre Trough is a transitional backarc, characterized by disorganized spreading.
  - Crustal accretion by diffuse intrusive volcanism
- "Arc" and "Rift" regime morphology contrasts represent variability in melt productivity

Basin Regime:

e.g. *Ngatoro Rift; ~36°30'S*

Ngatoroirangi Rift Graben; ~ 33°30'S

Includes sediment-poor basins on or near VF axis up to 4000mbsl



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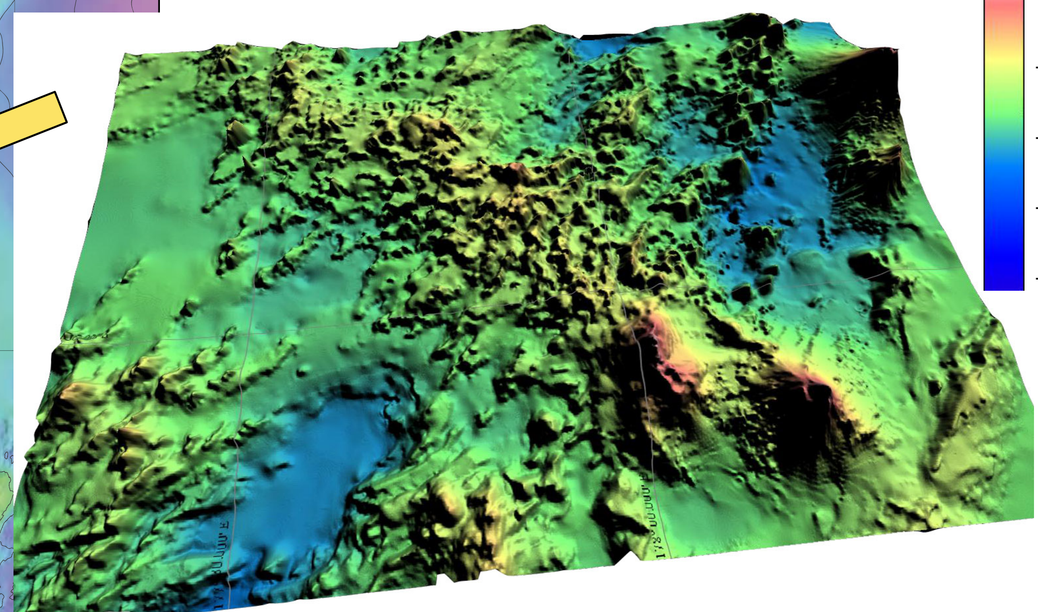
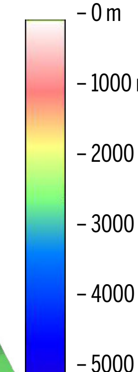




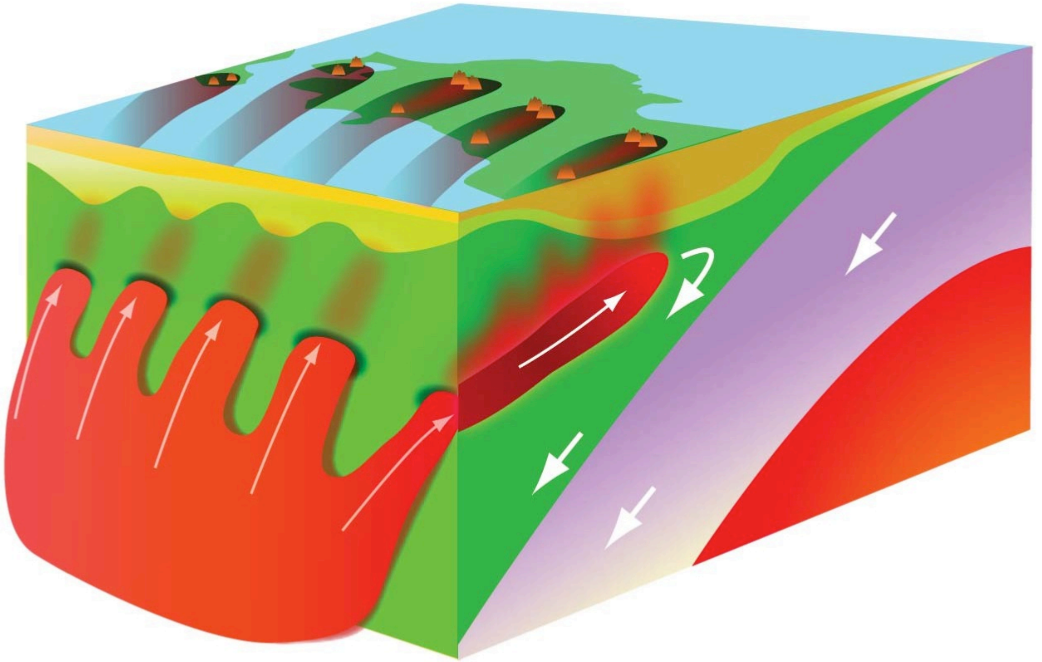
Arc-Regime:

e.g. Rumble V Ridge Cross-chain; ~ 36°S
34.5˚S Platform + Gill Volcano

Tamura et al., 2002

- NE Japan:
  Arc-transverse volcanic clusters (and inclined seismicity) result from locally fertile (+/- "hot") zones of inclined convecting mantle

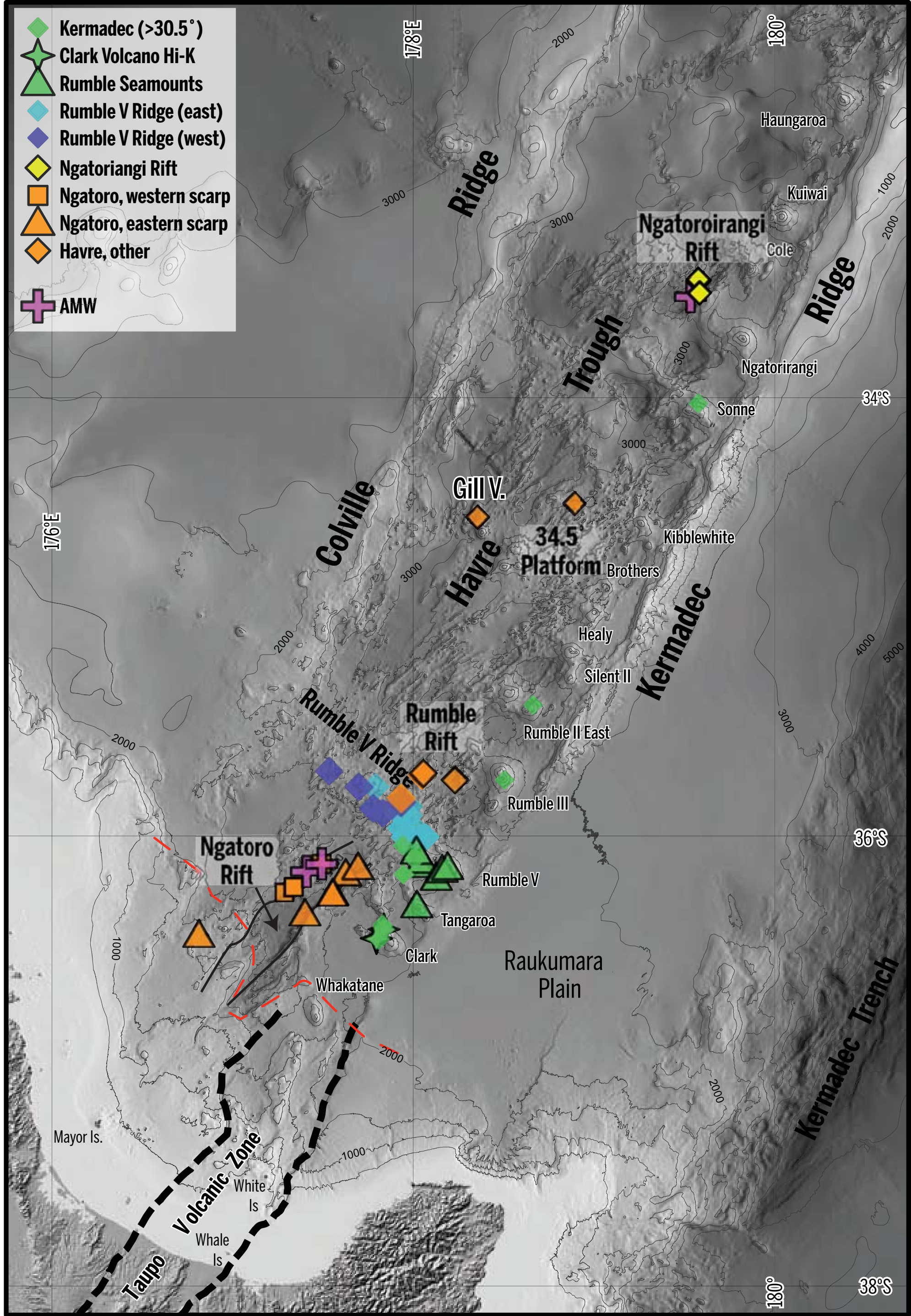
→ Locally higher melt productivity.



Arc & Backarc Lavas

- Kermadec and Havre:
  - Basalt to basaltic andesite (this study)
  - Primarily low-K tholeiite
- Magmatism is diffuse, contemporaneous
  - Broad along-arc sampling above variable slab depths

- **Green** ⟹ Volcanic Front (VF)
- **Blue** ⟹ Arc Regime (**distal**/**proximal**)
- **Orange** (**+yellow**) ⟹ Rift Regime
- **Pink** ⟹ most MORB-like



Todd et al., 2011

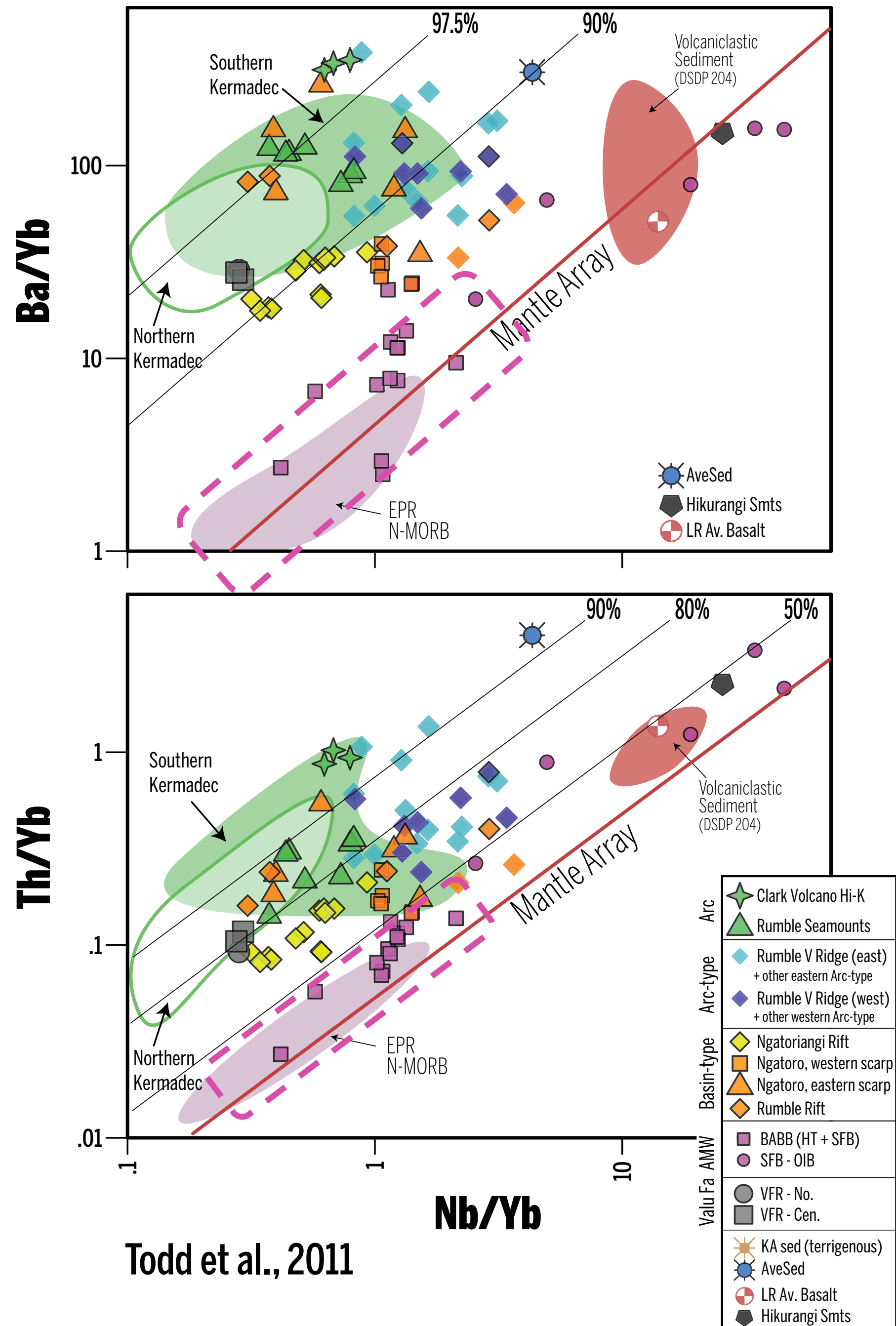
- **Pink = Least-subduction modified BABB**

  Ambient Mantle Wedge – "AMW"

  - On, or near, the global mantle array
  - Variably enriched (Nb/Yb)
    - MORB-like (depleted) to OIB-like (enriched)
    - Mixture of depleted and enriched components?

- **Greatest Ba, Th added by subduction (>90%):**
  - **VF**, and arc-proximal BABB (both **Arc** & **Basin** Regimes)
  - Even some distal **"Arc"**-regime samples have VF-like enrichment
  - Deep, or lateral migration of fluid flux?

- **Transitional, mostly distal BABB:**
  - **"Basin"** generally less Ba, similar Th to **"Arc"**
  - **"Arc"** generally higher Nb/Yb than **"Basin"**
    - Never as depleted as **VF**



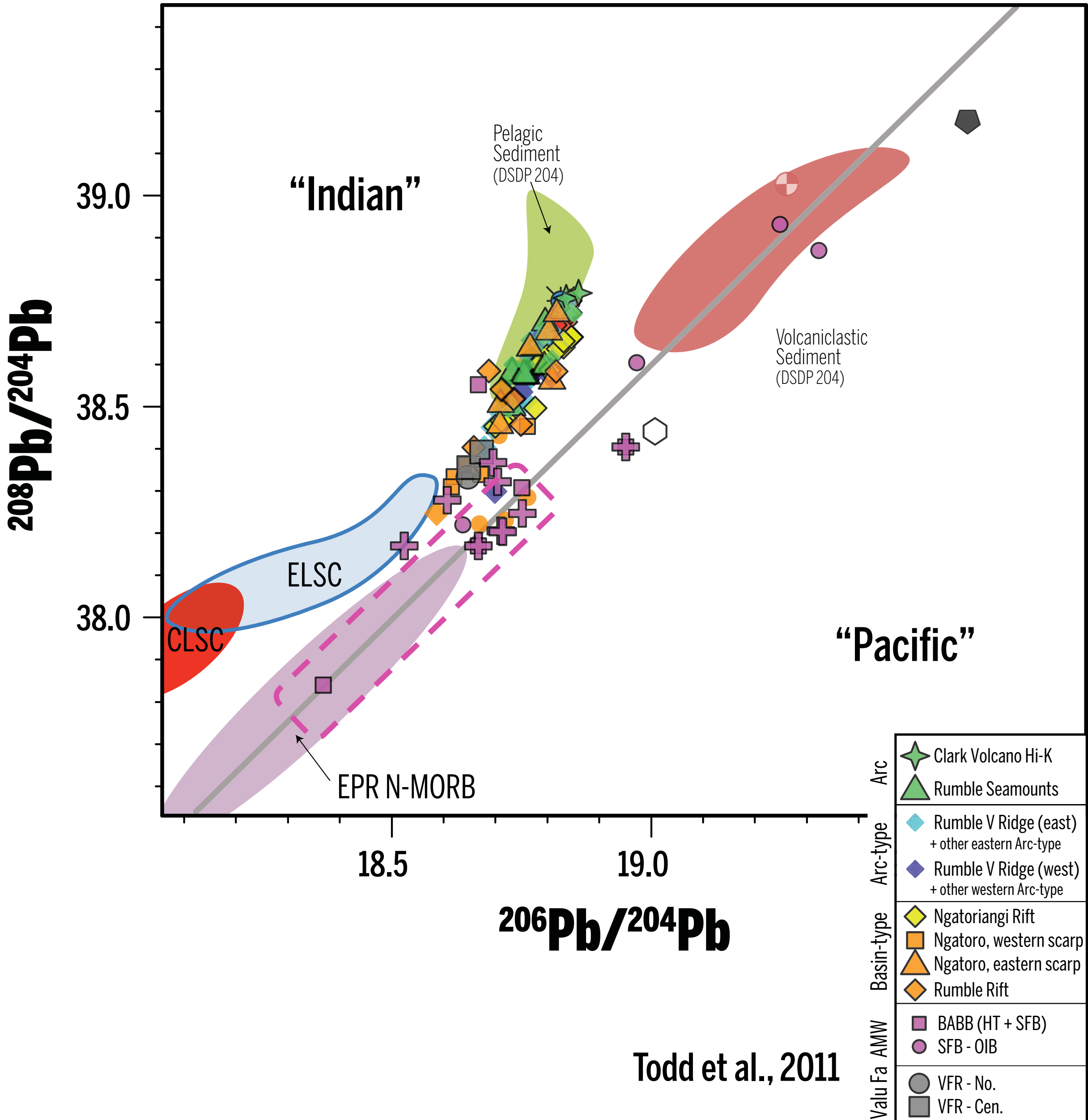
Todd et al., 2011

Pb isotope systematics

Ambient Mantle Wedge – "AMW"

- On, or near, the global mantle array
- Intermediate between depleted (EPR MORB) and enriched (~"C" or FOZO)

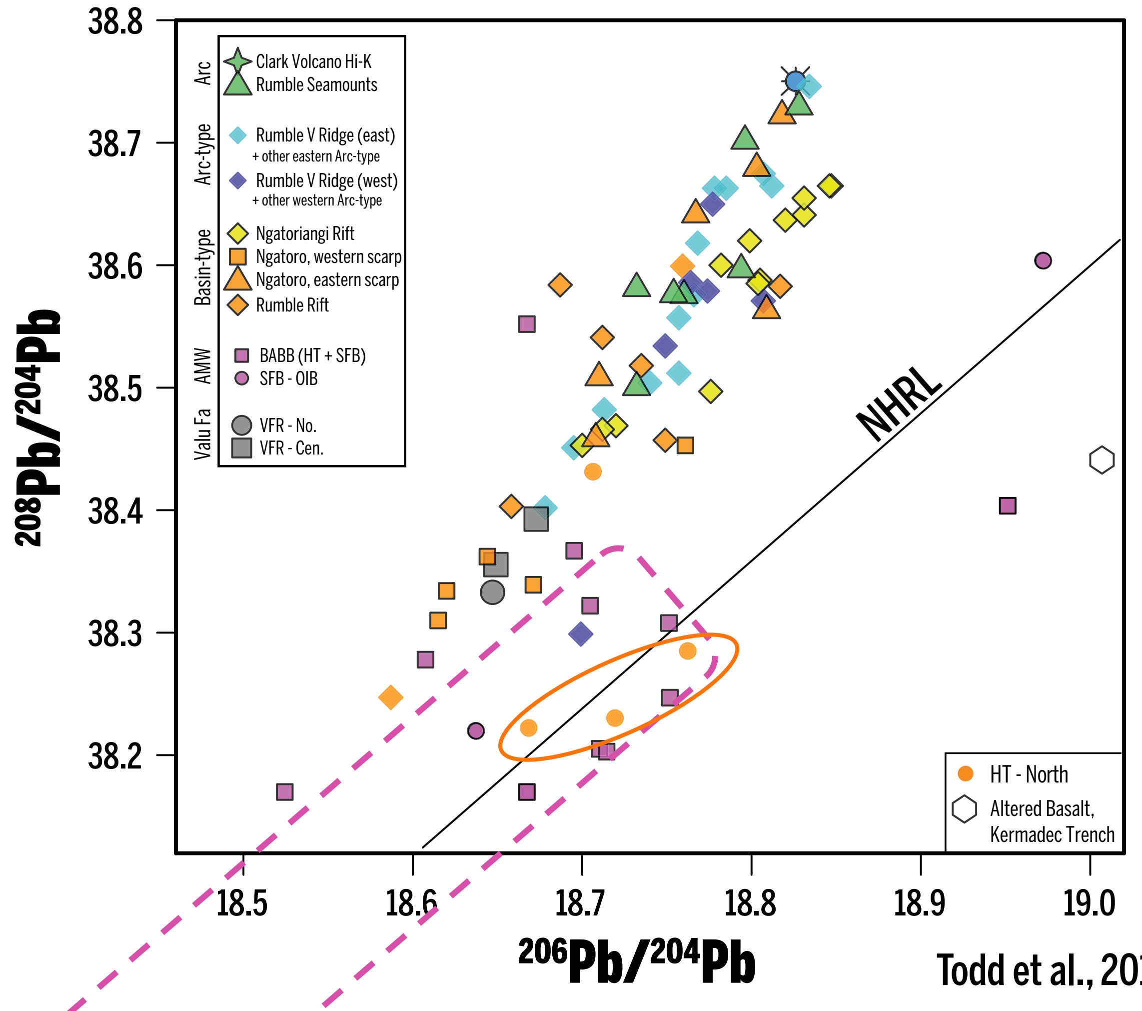
- Most Havre and Kermadec basalts define a mixing array to sediment
- Few **"Basin"** samples lie within AMW, all from northernmost Havre



Todd et al., 2011

Pb isotope systematics

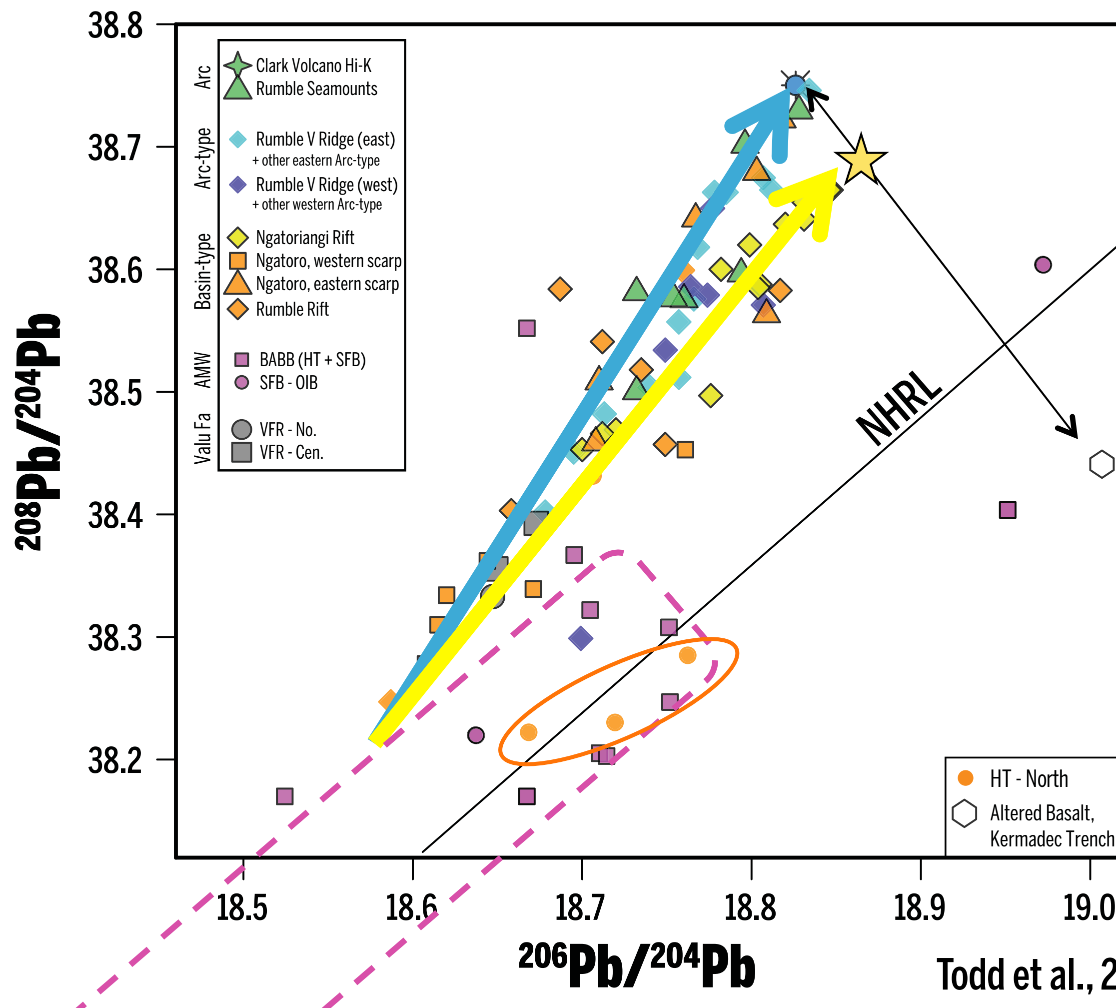
- Most of the northernmost **"Basin"** samples have little to no Pb from sediment sediment
- **VF**, **"Basin"** and **"Arc"** samples from southernmost Havre lie along an array terminating at locally subducting sediment



Todd et al., 2011

Pb isotope systematics

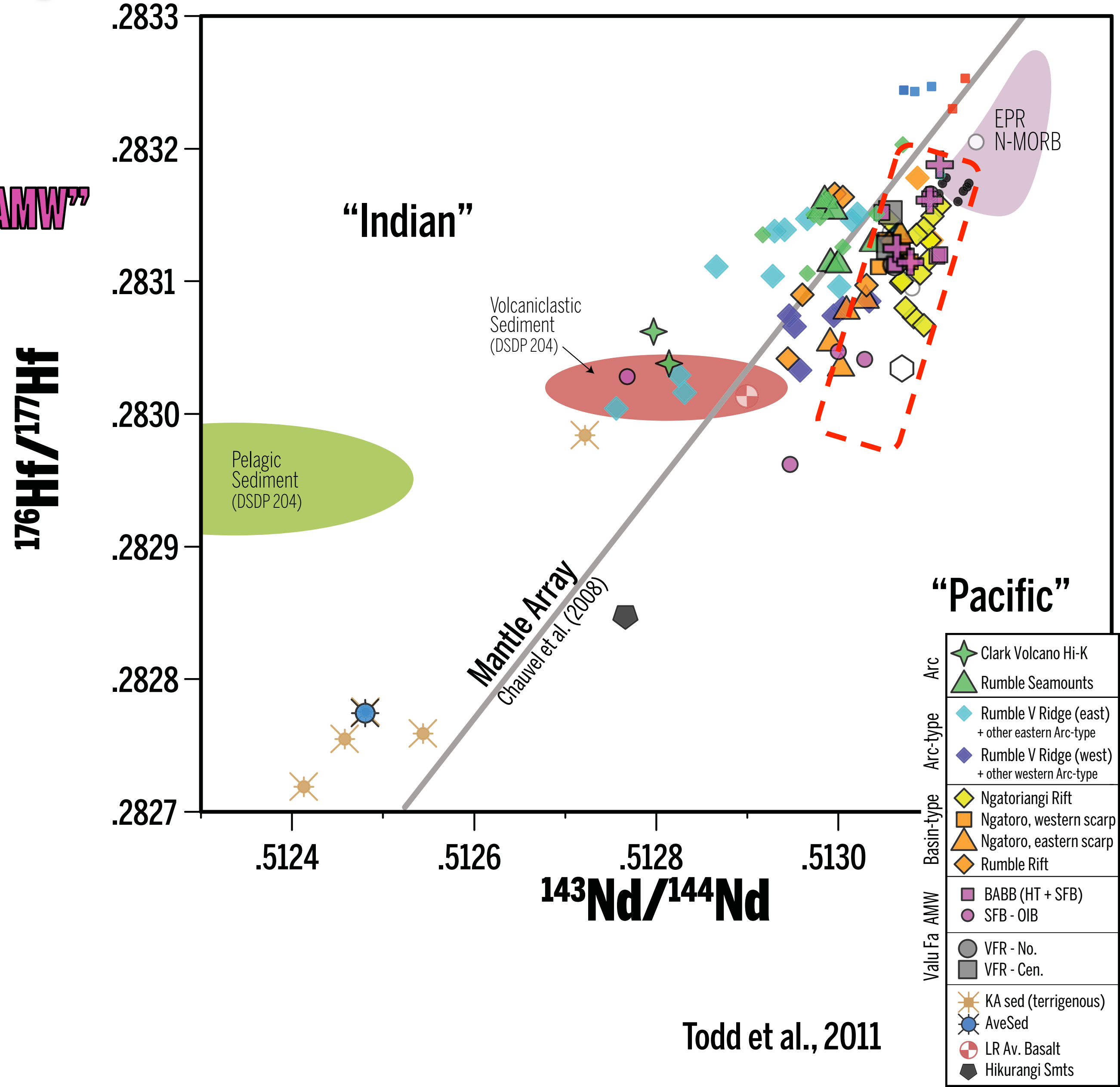
- Most of the northernmost **"Basin"** samples have little to no Pb from sediment sediment
- **VF**, **"Basin"** and **"Arc"** samples from southernmost Havre lie along an array terminating at locally subducting sediment
- Ngatorirangi Rift **"Basin"** samples *(transitional between northern and southern localities)* point to transitional Pb
  - Mixture of AOC and Sediment Pb?



Todd et al., 2011

Hf – Nd Isotope systematics: Havre Mantle

- **Ambient Mantle Wedge – "AMW"**
  - "Pacific"
  - Steep Array
  - No sediment input



Todd et al., 2011

Hf – Nd Isotope systematics: Havre Mantle

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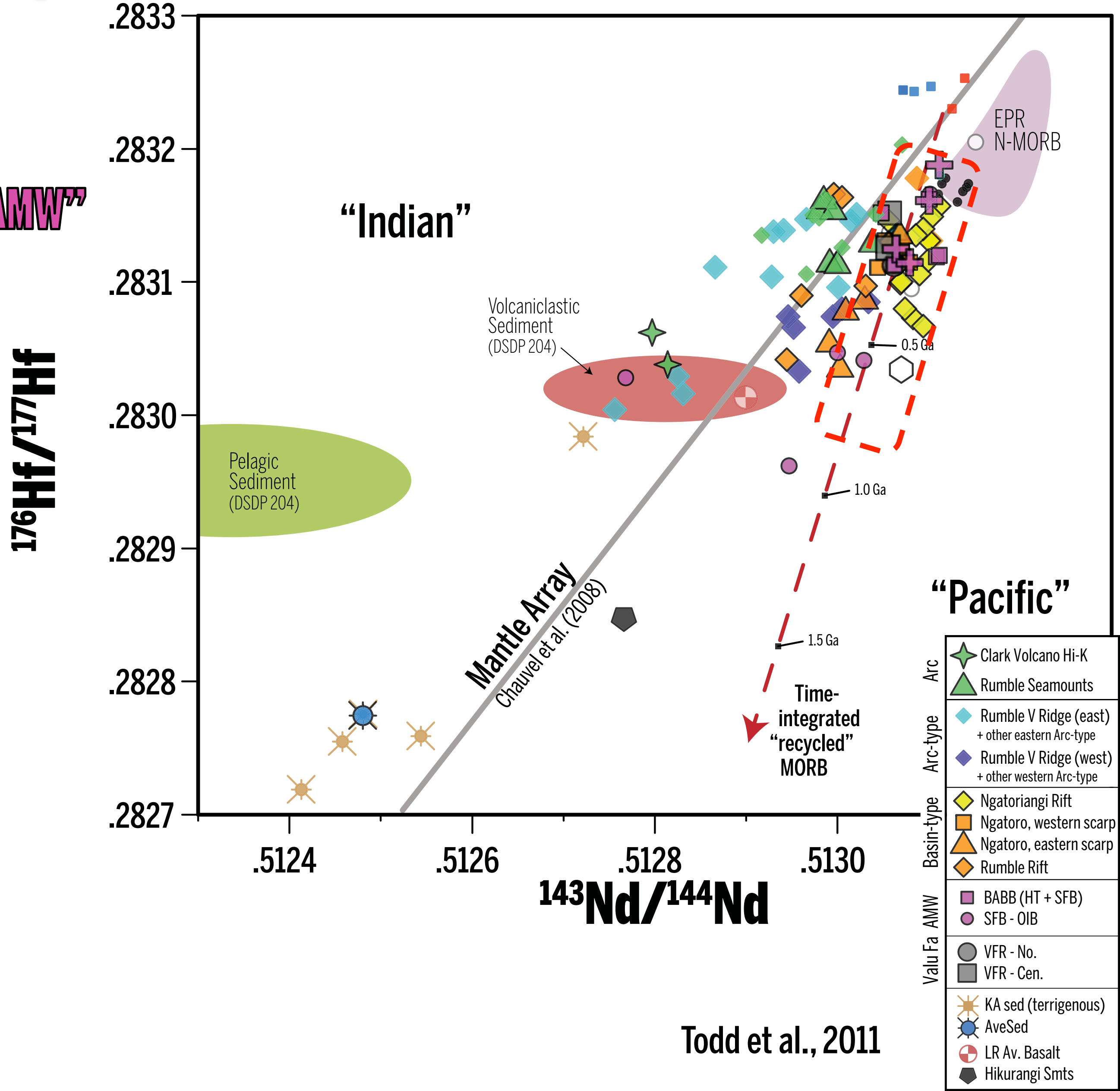
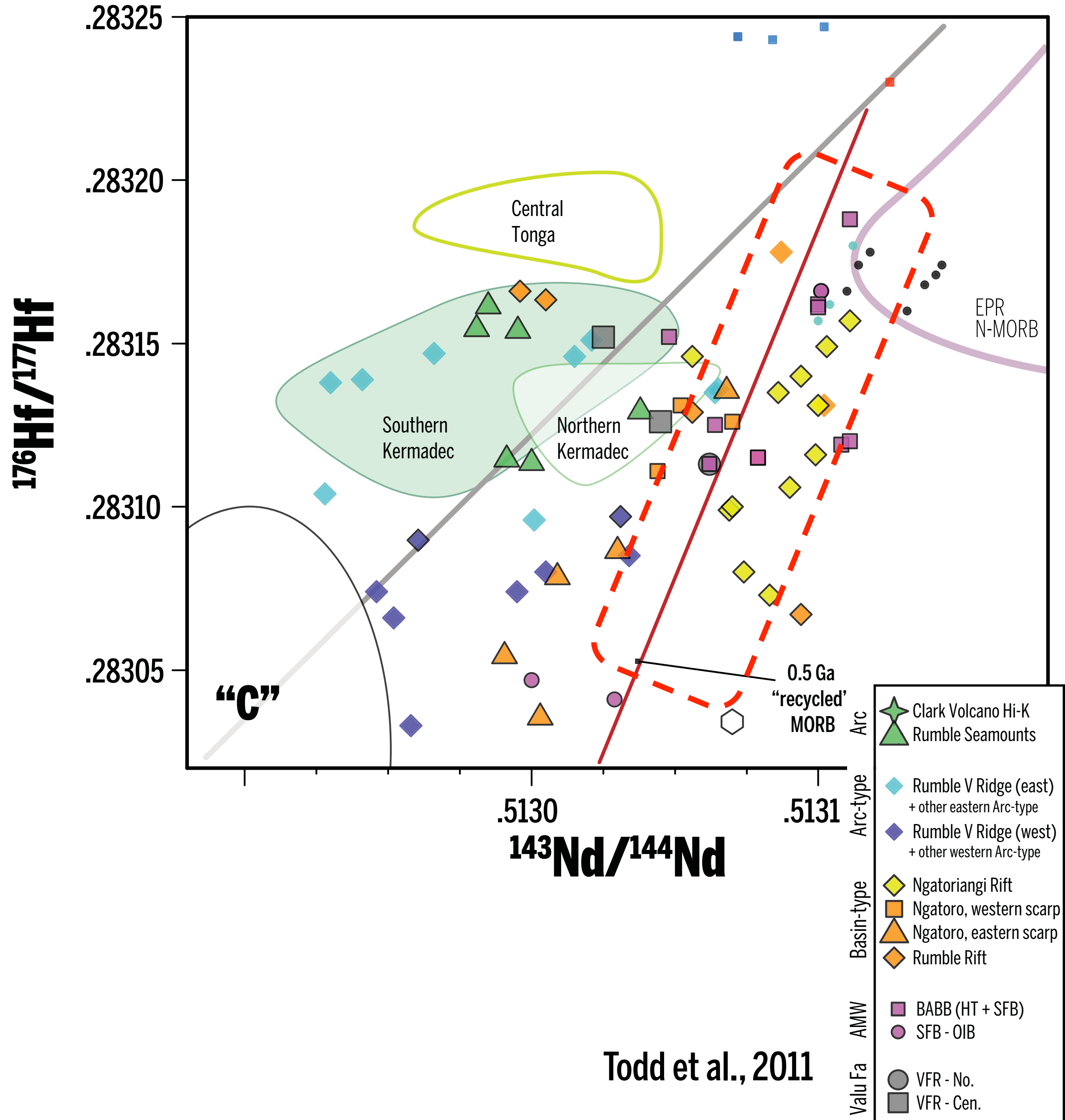
  - "Pacific"
  - Steep Array
  - No sediment input
  - HIMU enrichment?



Todd et al., 2011

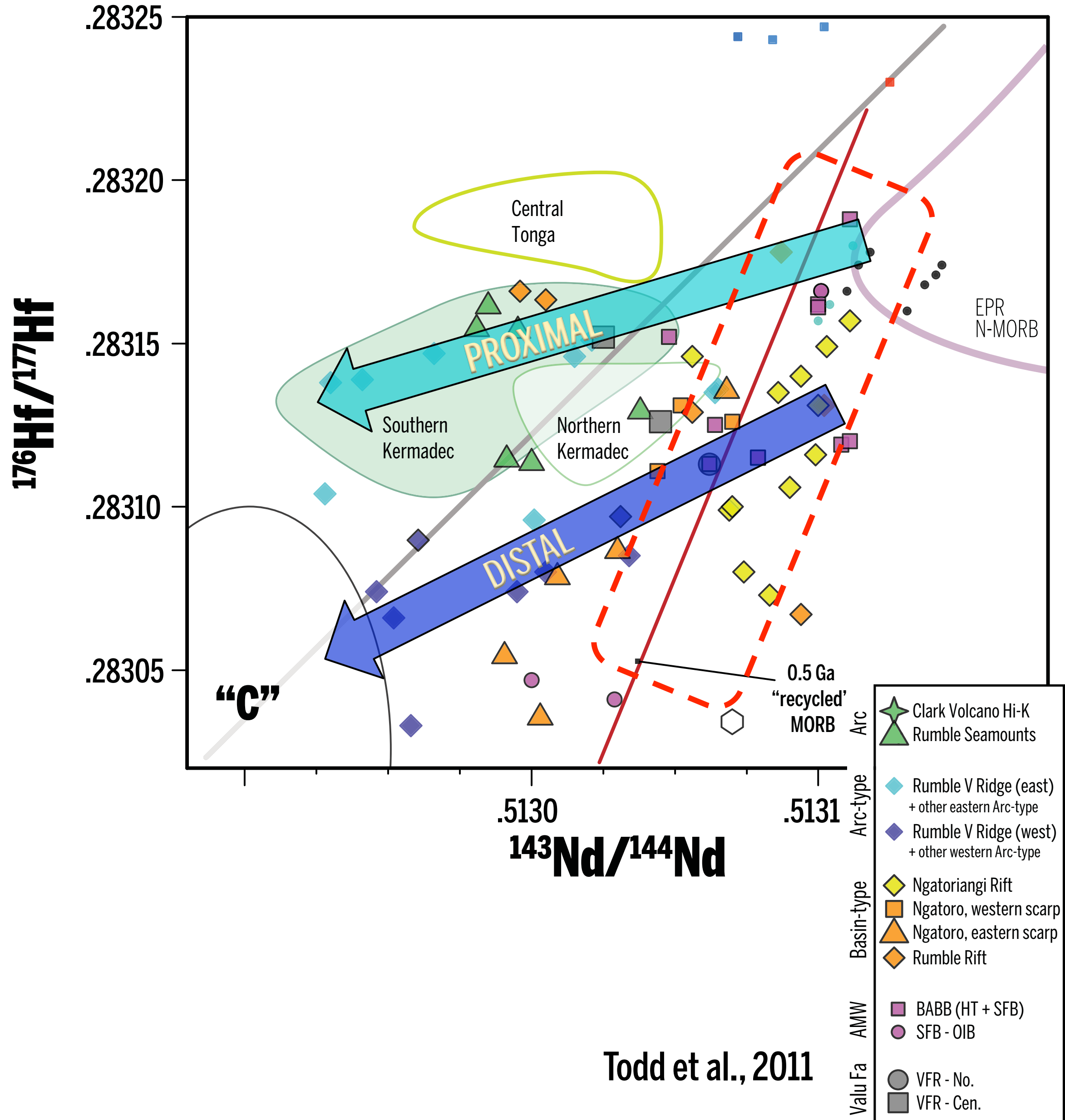
- **"Basin"** samples
  - follow the AMW array for all but the most arc-proximal samples.
- **VF** and **"Arc"** samples
  - Extend to lower, sediment-like Nd



Todd et al., 2011

- **"Basin"** samples
  - follow the AMW array for all but the most arc-proximal samples.
- **VF** and **"Arc"** samples
  - Extend to lower, sediment-like Nd
  - **VF** and (proximal) **"Arc"** project to more depleted mantle
  - Distal **"Arc"** and most **"Basin"** samples project to more enriched mantle

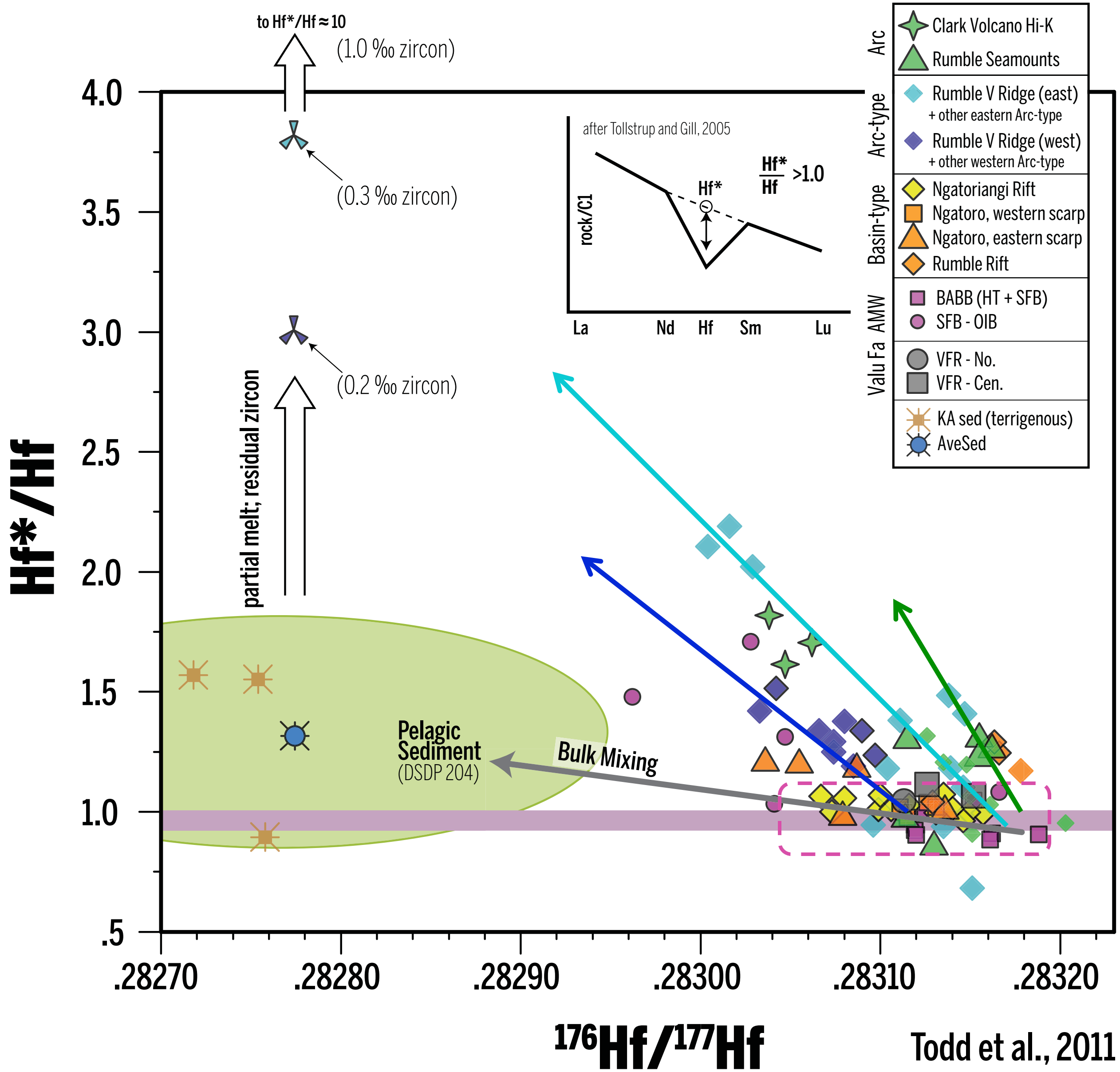
⟹ **Across-arc change in degree of mantle enrichment**



Todd et al., 2011

Can variable subduction components account for the range of "modified" back-arc lavas?

- Most **"Basin"** magmas lie within **AMW** field
- **"Arc"** and extreme enriched **VF** samples
  - Lie above the binary **AMW** + sed mixing line
- Negative correlation indicates sed Hf addition accompanies Hf/REE fractionation
- Variable slope consistent with effect of partial melting with residual zircon (+/- rutile, monazite)
  - Magnitude decreases with distance from the trench
  - Decreasing residual zircon with slab depth



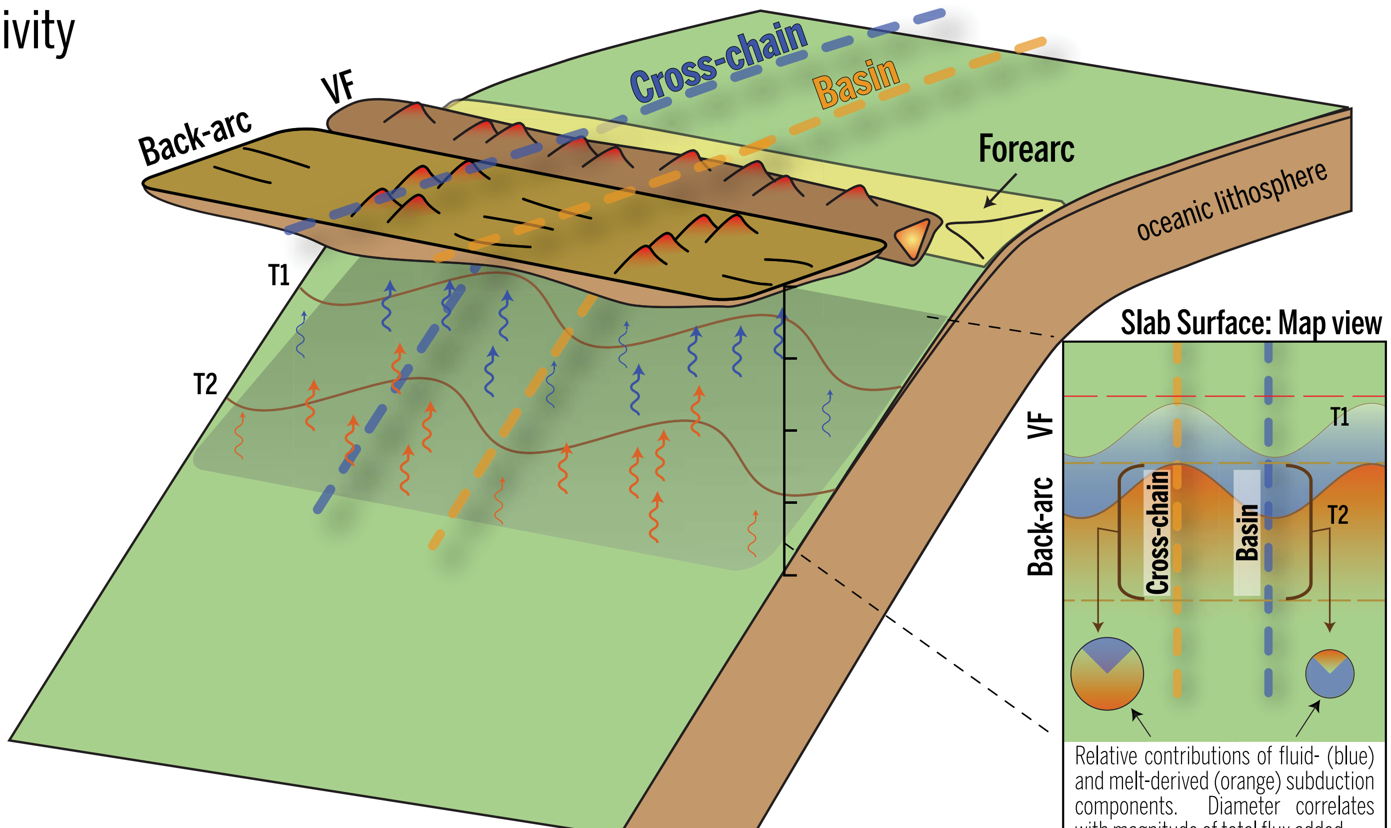
Todd et al., 2011

- Mantle component:
  - Variably enriched
  - Degree corresponds with distance to the trench, melt extraction
- Subduction component:
  - Variable Sed:AOC
    - Tracks thickness of sediment column
  - Variable fluid:melt
    - Tracks presence of thermal anomalies
  - Variable D_{HFSE}
    - Tracks buffering by residual trace phases during melting

<u>Hot Fingers</u> beneath the Arc Regime

Their "hand-print" on the slab could explains along-arc changes in morphology AND composition

- Compared with **"Basins"**,the **"Arc"** regime is characterized by:
  - <u>More</u>, and, <u>earlier</u> (trenchward), melt component
  - Higher melt productivity



Todd et al., 2011 (G-Cubed)

Conclusions:

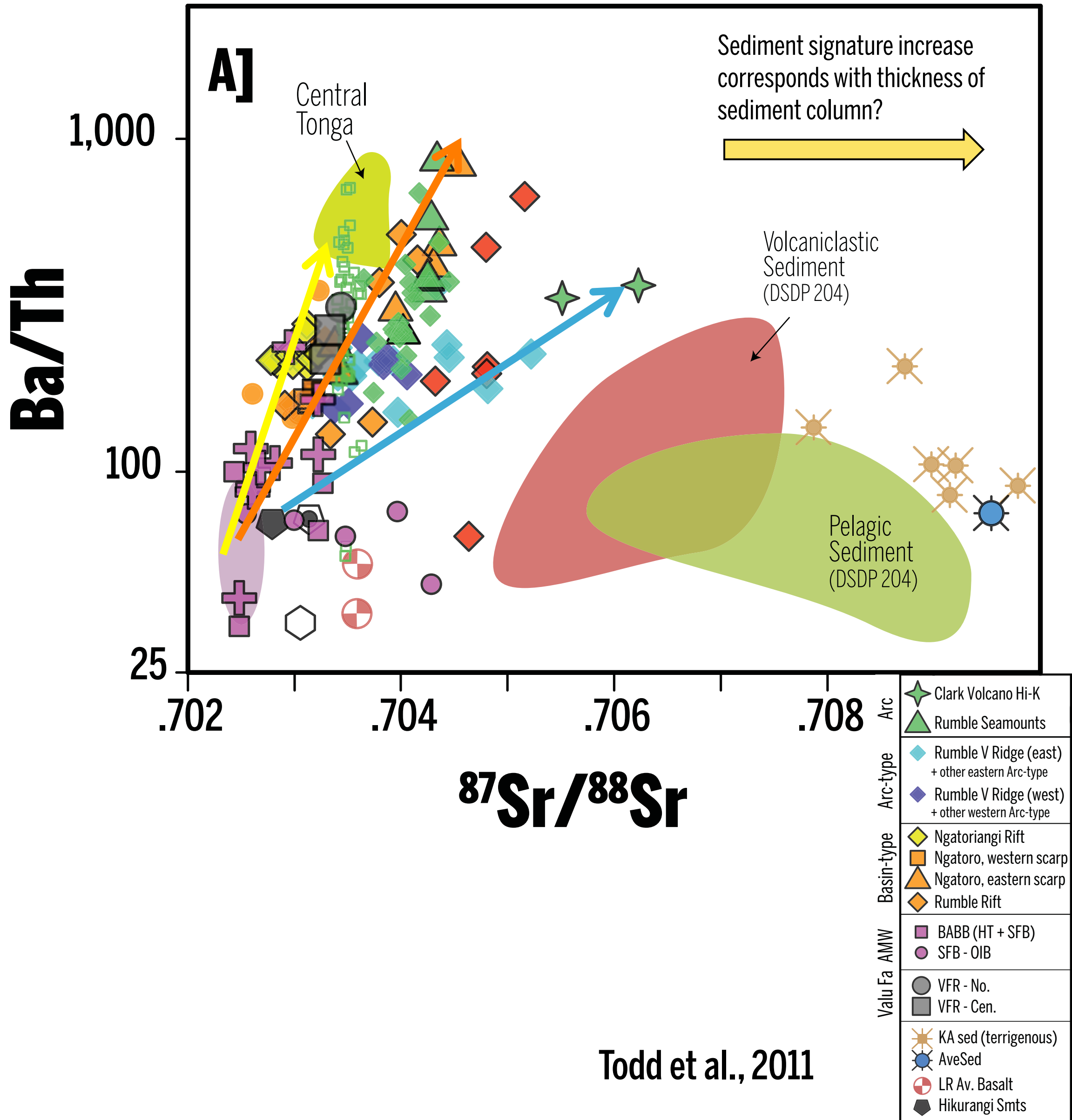
- The ambient mantle is heterogeneous
  - Fertile mantle is progressively depleted by partial melting during advection to the VF
- The top of the slab melts at some depth interval beneath arcs and back-arcs, and cross chains may track where this occurs.
- Sediment contribution decreases to the north
- The sediment-derived flux changes to more melt-like across the backarc
  - More abruptly in the basin regime, more gradually in the arc regime

Sr Isotopic Signal of Slab-derived Fluids

- **AMW**: MORB-like elemental ratios, little/no $^{87}Sr/^{86}Sr$ variation
  - Two at ~0.704, seawater alteration?

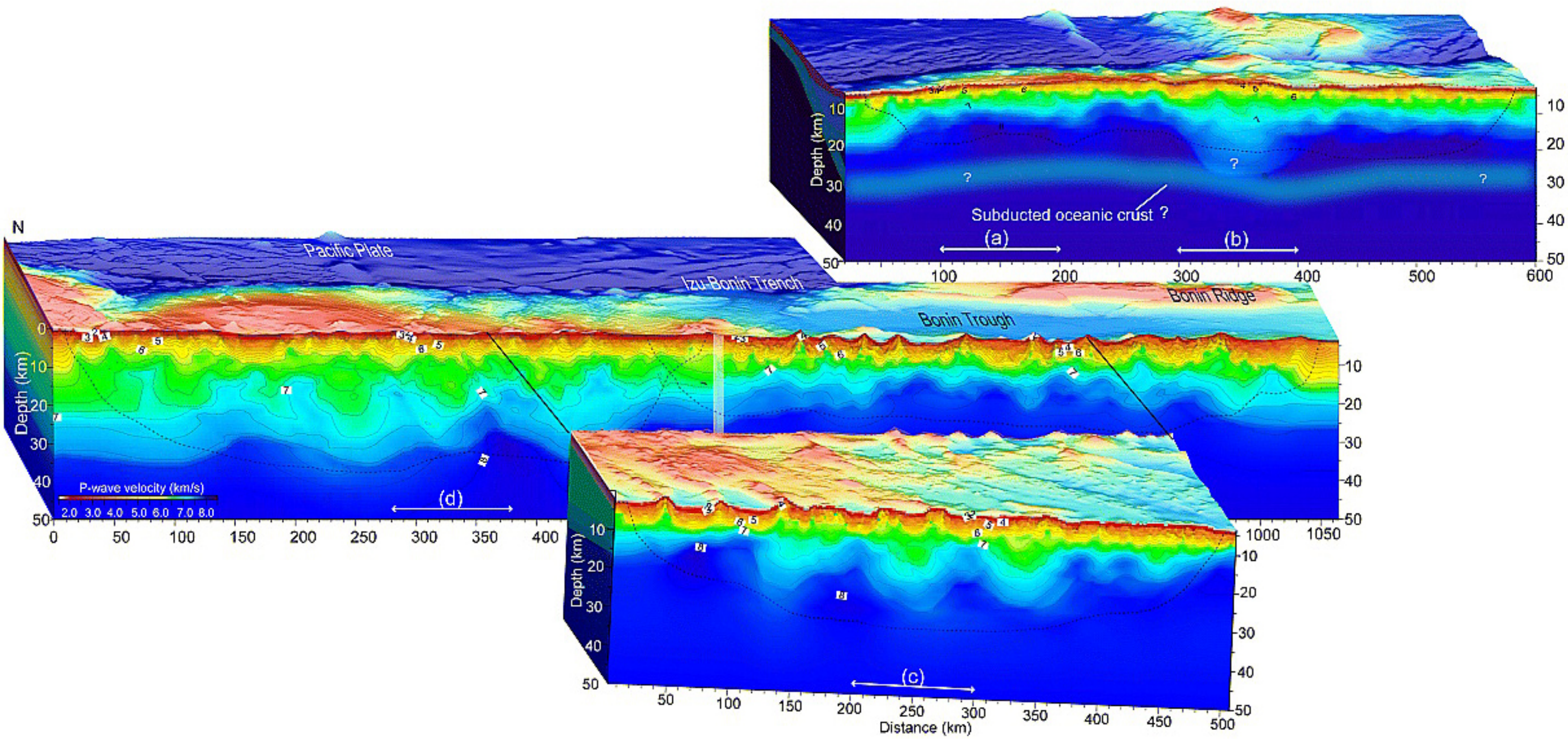
- $^{87}Sr/^{86}Sr$:
  - Most BABB point to Sr ratios intermediate between AOC and Sediment.
  - Some extreme **VF** and **"Arc"** (+ **TVZ**) indicate fluids with more continental Sr ratios
    - Fluids from higher Sed:AOC slab
  - Ngatorirangi **"Basin"** indicate fluids with less continental Sr ratios
    - Fluids from lower Sed:AOC slab

– Along-arc variation in fluid Sr:
  - Function of distance from continental sediment source



Todd et al., 2011

Evolution from fore–arc oceanic crust to island arc crust: A seismic study along the Izu–Bonin fore arc



Kodaira et al. 2010. Journal of Geophysical Research: Solid Earth
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