Geochemical relationships between volcanic and plutonic upper to mid crustal exposures of the Rosario segment, Alisitos Arc (Baja California, Mexico): Petrologic processes behind the generation and evolution of arc crust

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INTRODUCTION

Exposed paleo-arcs, such as the Rosario segment of the Cretaceous Alisitos Arc in Baja California, Mexico, provide a unique opportunity to explore the evolution of arc crust through time. Remarkable 3-D exposures of the Rosario segment record crustal generation processes in the volcanic rocks and underlying plutonic rocks. In this study, we explore the physical and geochemical connection between the plutonic and volcanic sections of the extensional Alisitos Arc, and elucidate differentiation processes responsible for generating them. These results provide an outstanding analog for extensional active arc systems, such as the Izu-Bonin-Mariana (IBM) Arc.

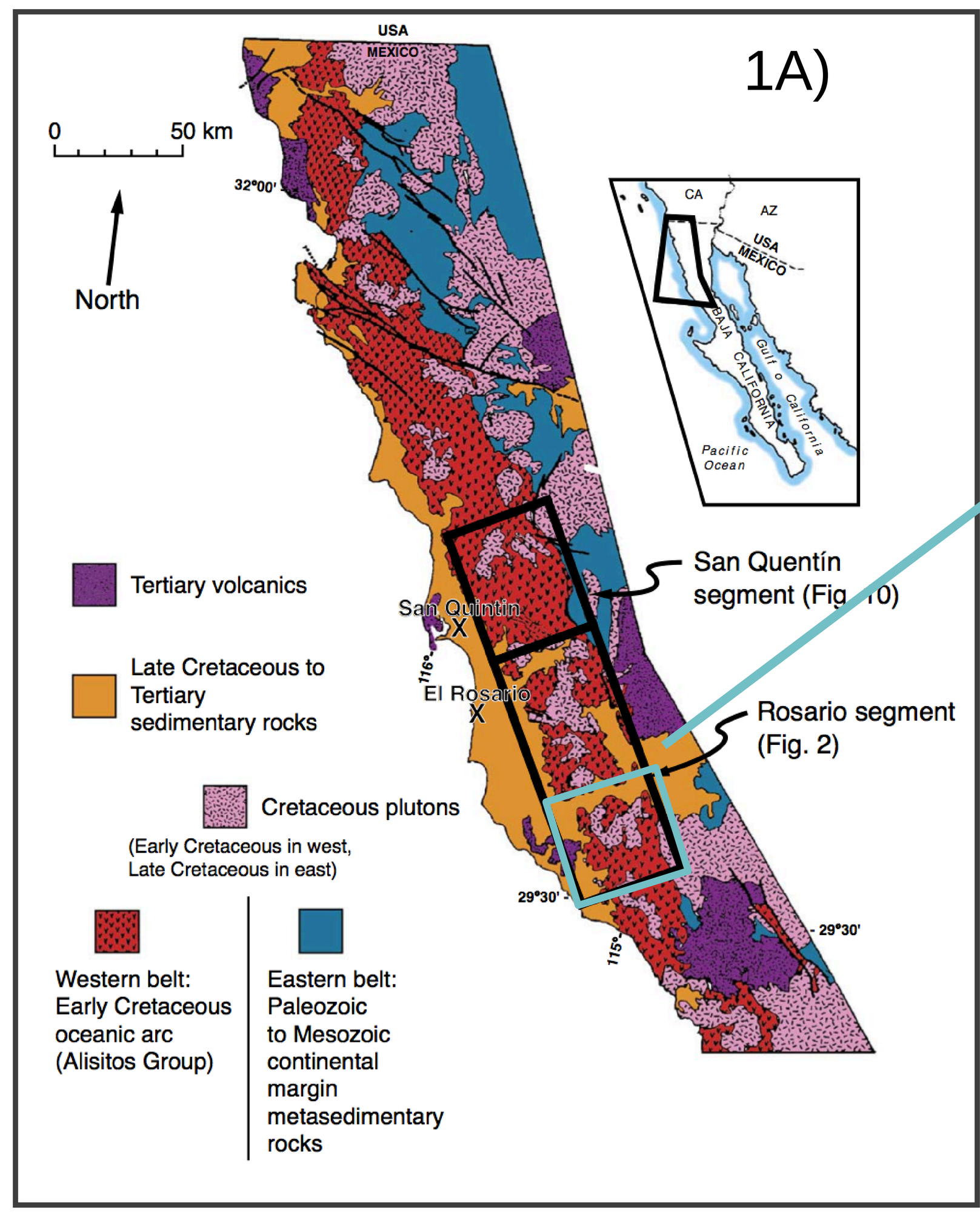


Figure 1A: Geologic setting of the Alisitos Arc (shown in Red), Baja California, Mexico. Figure from Busby et al., 2006.

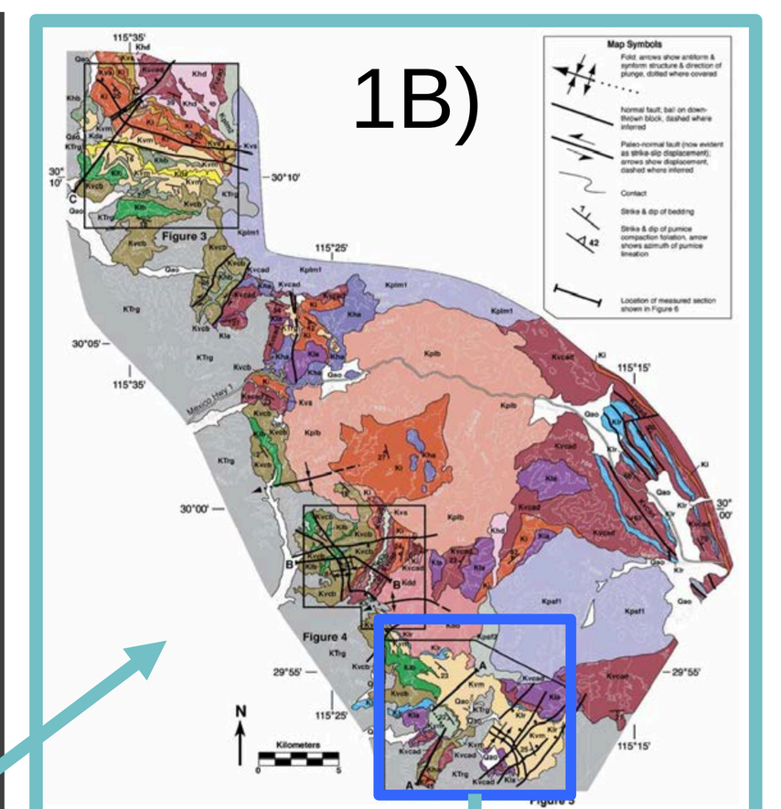
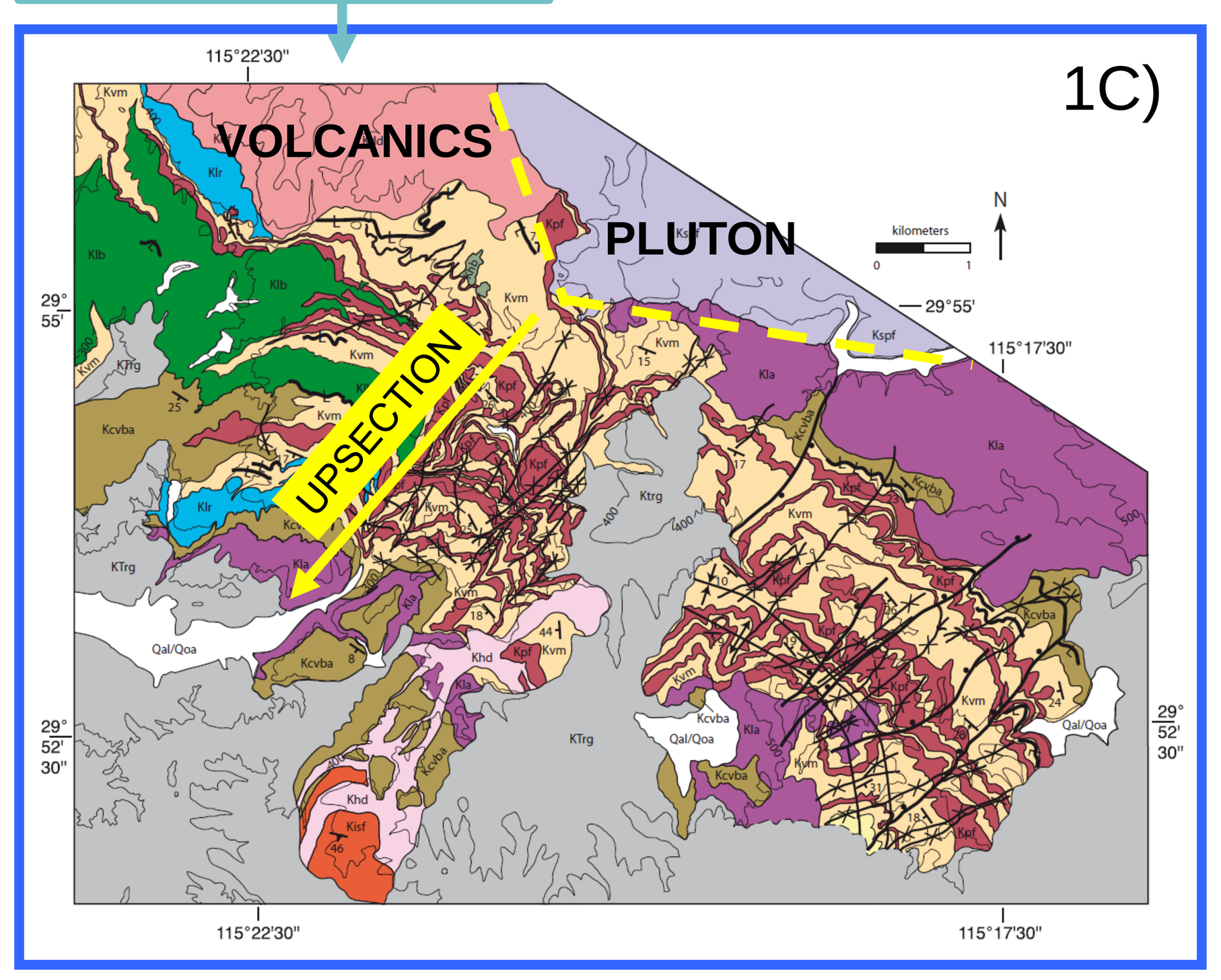


Figure 1B: Southern section of the Rosario segment showing the southern volcano-bounded basin (Study Area). Figure from Busby et al., 2006. Previous mapping on the segment divides the plutonic from volcanic units (Busby et al., 2006).

Figure 1C: Southern volcano-bounded basin (Study Area) of the Rosario segment. Deeper units (mid crustal plutonics) are exposed in the eastern areas of the section and shallowest units (upper crustal volcanics) are exposed in the west due to the west-dipping nature of the segment. Figure from Busby et al., 2006.



STRATIGRAPHY AND PETROGRAPHY

Upper crustal volcanic rocks have a coherent stratigraphy that is 3-5 km thick and ranges in composition from basalt to dacite. The most felsic compositions (70.9% SiO_2) are from a welded ignimbrite unit. The most mafic compositions (51.5% SiO_2, 3.2% MgO) are found in basaltic sill-like units. Phenocrysts in the volcanic units include plagioclase +/- quartz, amphibole and clinopyroxene. The transition to deeper plutonic rocks is clearly an intrusive boundary, where plutonic units intrude the volcanic units. Plutonic rocks are dominantly a quartz diorite main phase with a more mafic, gabbroic margin. A transitional zone is observed along the contact between the plutonic and volcanic rocks, where volcanics have coarsely recrystallized textures. Mineral assemblages in the plutonic units include plagioclase +/- quartz, biotite, amphibole, clinopyroxene and orthopyroxene.

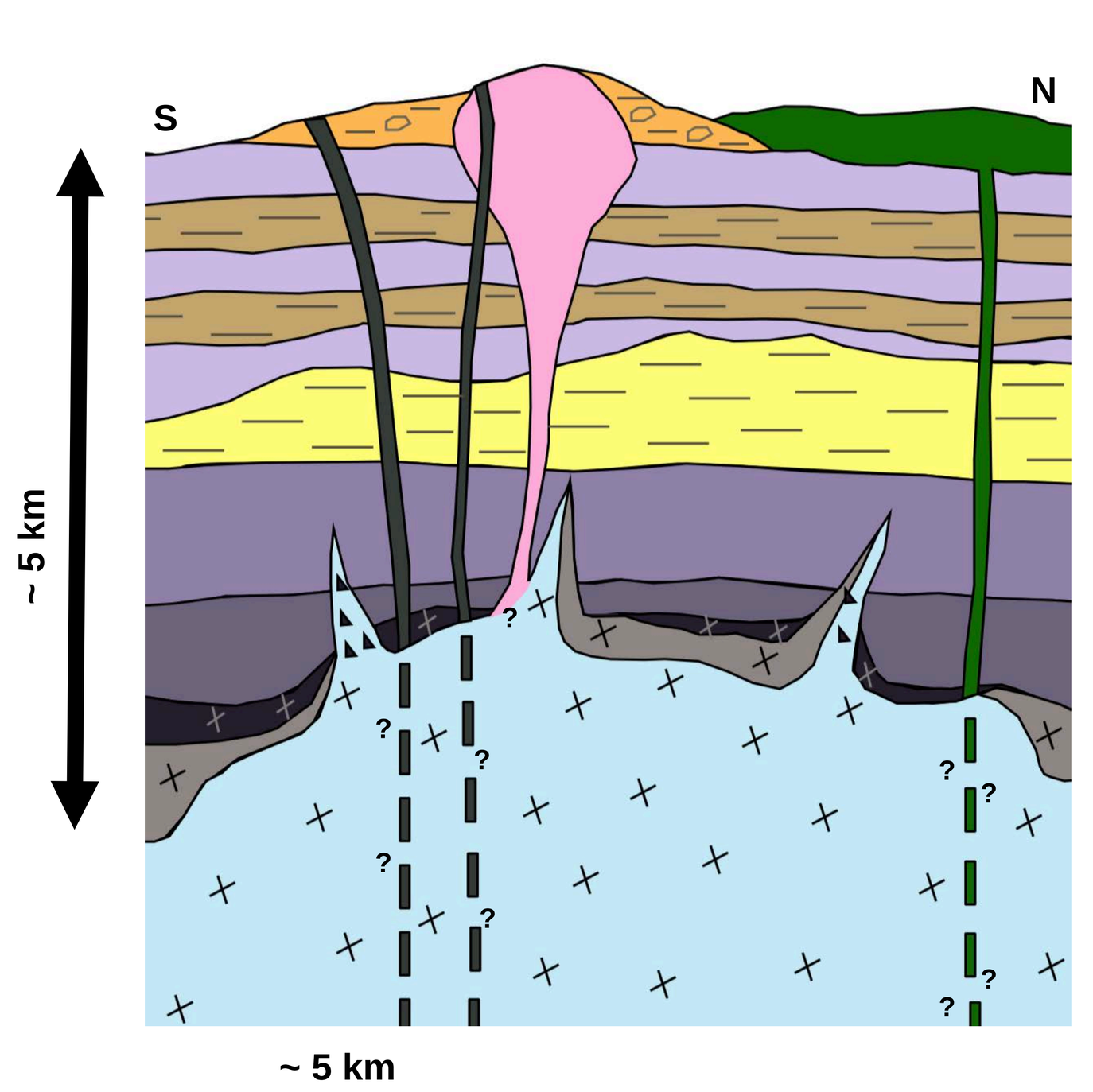


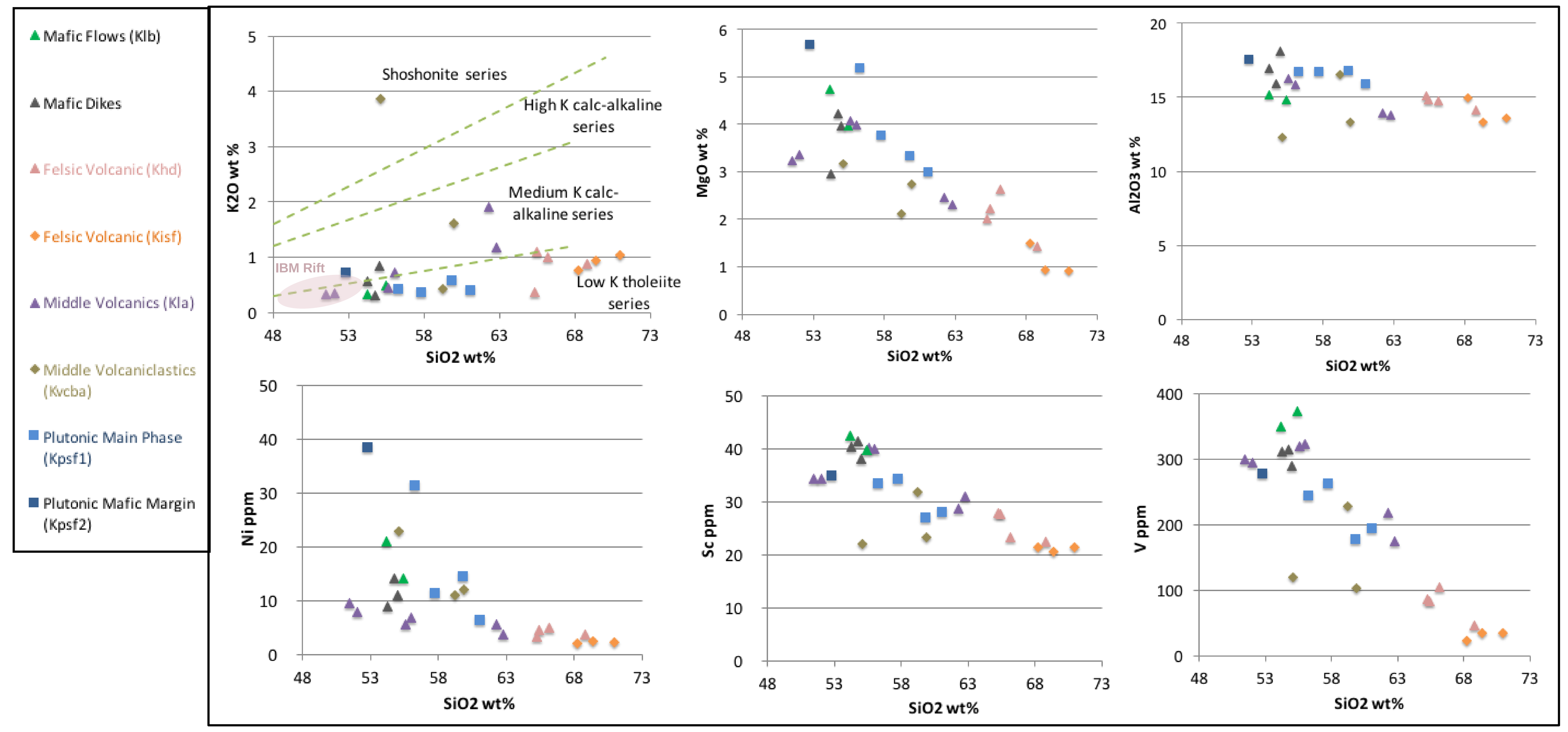
Figure 2: Cross-sectional schematic recording the rifting phase of the southern volcano-bounded basin of the Rosario segment of the Alisitos Arc. This time slice records volcanism, sedimentation, and intrusive activity, including abundant dikes within the crustal section. Units correspond to descriptions provided in legend.

LEGEND:	UNITS	UNIT DESCRIPTION	PRIMARY MINERALS	
UPPER CRUSTAL VOLCANICS	Klb	Basaltic lava, breccia and hypabyssal intrusions.	Plagioclase, Hbld, CPX.	4
	Dikes	Basaltic to basaltic andesite dikes.	Plagioclase, Hbld, CPX.	
	Khd	Dacitic hypabyssal intrusions.	Plagioclase, Hbld, CPX.	3
	Kisf	Dacitic to rhyolitic welded ignimbrite (silicic caldera).	N/A	
	Kla (Shallow)	Basaltic to andesitic lava, breccia and hypabyssal intrusions.	Plagioclase, Hbld, CPX.	2
	Kvcba	Basaltic andesite to andesitic volcaniclastic rocks.	N/A	
	Kla (Deep fine)*	Basaltic to basaltic andesite lava, breccia and hypabyssal intrusions.	Plagioclase, Quartz, Hbld, CPX.	
	Kla (Deep coarse)*	Basaltic to basaltic andesite lava, breccia and hypabyssal intrusions.	Plagioclase, Hbld, CPX.	
MID-CRUSTAL PLUTONICS	Kpsf1	Quartz diorite main phase +/- fine grained mafic enclaves.	Plagioclase, Quartz, Hbld, CPX.	1
	Kpsf-int*	Finer grained quartz diorite phase.	Plagioclase, Quartz, Hbld, CPX.	
	Kpsf2	Diorite to gabbroic diorite plutonic marginal phase.	Plagioclase, biotite, Hbld, CPX, OPX.	
CENTRAL EDIFICE VOLCANICS	Kvm, Kpf*	Volcaniclastics sourced from central (main) edifice.	N/A	

*Note: Geochemistry data not currently available.

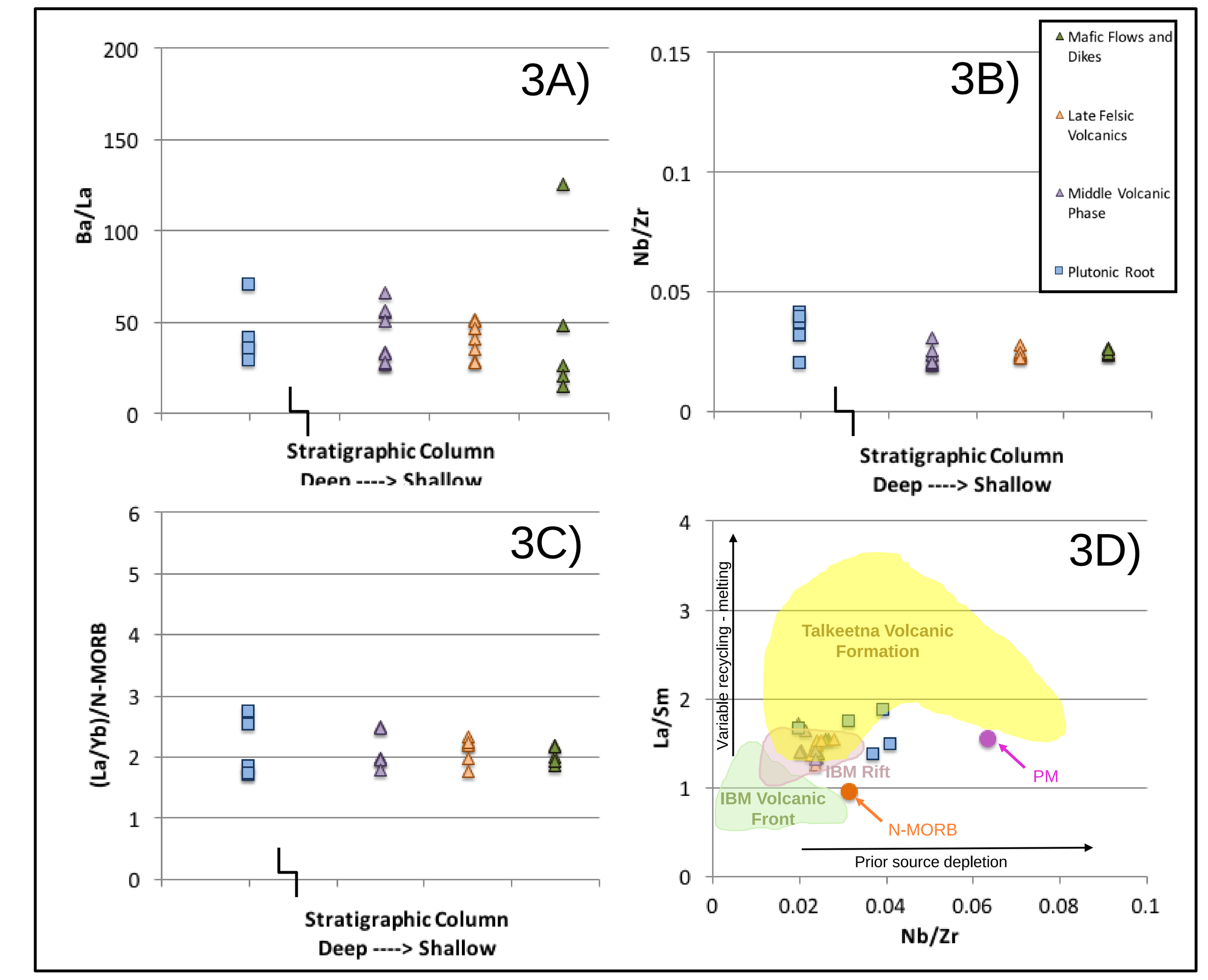
MAJOR AND TRACE ELEMENT CHEMISTY

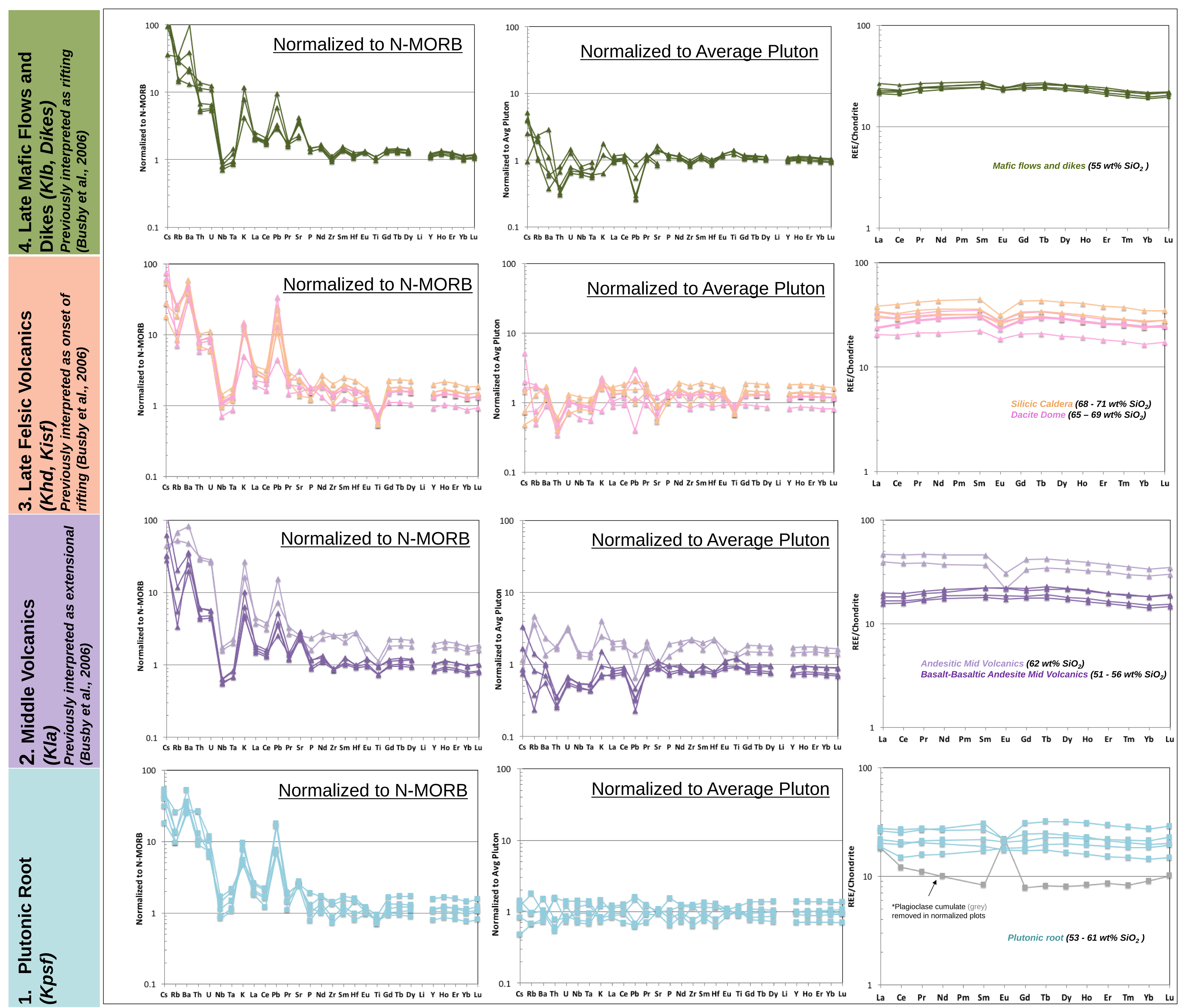
Most samples are low K series, with medium and higher K outliers. Whole rock compositions show linear trends in major and trace element bivariate plots, where decreasing and increasing trends are observed relative to SiO_2 wt%.



RATIO PLOTS AND ARC COMPARISONS:

- Neither Ba/La, Nb/Zr, nor any other major geochemical indicators vary significantly from the bottom to the top of the stratigraphic section. This is in contrast to IBM, where rift related rocks have much lower Ba/La compared to arc front rocks (<20 compared to 100), and on average have higher Nb/Zr (see 3D).
- La/Sm vs. Nb/Zr show constant grouping through stratigraphic level (MORB like). Similar to depleted arcs like Talkeetna and rift phase of IBM.





NORMALIZED PLOTS AND REE DIAGRAMS:

N-MORB normalized plots:

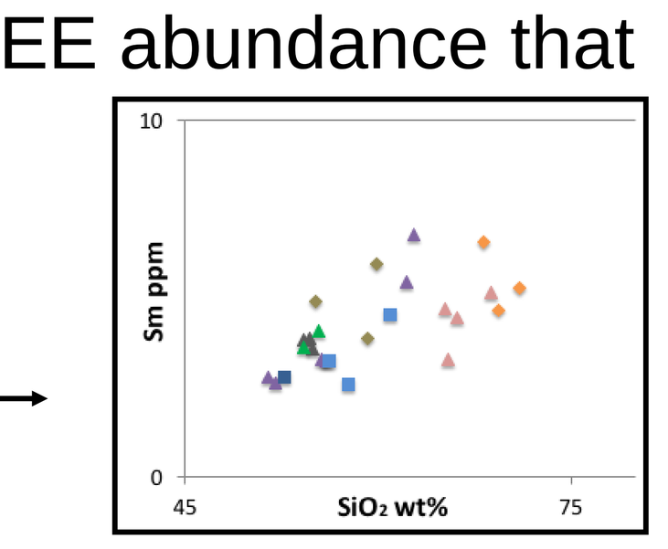
- LILE enrichment and HFSE depletion typical of arc rocks.
- Muted Nb and Ta anomaly

Pluton normalized plots:

- Volcanic rocks and plutonic rocks are generally similar patterns. Plutonic rocks therefore likely represent liquids (except for one distinct cumulate)
- Mid Volcanics appear to have two geochemically different groups: one enriched compared to average pluton, and one depleted compared to average pluton. Further work in progress.

REE diagrams:

- REE patterns are relatively flat.
- Mid Volcanics show two groups in REE abundance that correlate with Si content.
- Overall, REE patterns, no matter what the stratigraphic level, positively correlate with SiO2.



FIRST ORDER INTERPRETATIONS (still a work in progress):

This preliminary data does not demonstrate major geochemical differences through the stratigraphic section, therefore units are likely related by simple differentiation. Data suggests units are derived from a MORB-like mantle source, likely related to arc rifting.

Acknowledgements

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