Arc-rift transition volcanism in the Volcanic Hills, Jacumba and Coyote mountains, imperial county, California

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Neogene volcanism associated with the subduction of the Farallon-Pacific spreading center and the transition from a subduction zone to a rift zone has been studied extensively in Baja, California, Mexico. One of the main goals of these studies was to find a geochemical correlation with slab windows that may have formed during that complicated transition. While workers have been able to find distinct geochemical signatures in samples from Baja California, none have shown statistically significant correlation with samples from southern California that are thought to be related to the same arc-rift transition events. All of the basaltic samples from this study of southern California rocks have prominent Nb depletions typical of island-arc subduction-related volcanism, in contrast to the chemistry of Baja California volcanics that have trace element patterns typical of synrift related volcanism. The work done by previous investigators has been additionally complicated due to each investigator's choice of important ratios or patterns, which bears little, if any, correlation with work done others working in the same area. For example, Martin-Barajas et al. (1995) use K/Rb ratios in their study of the Puertocitos Volcanic Province, while Castillo (2008) argues that Sr/Y vs. Y is a better indicator of petrogenetic processes.

Little petrologic work has been done on Neogene volcanic rocks in the Imperial Valley and eastern San Diego County region of Southern California. This thesis combines new research with that of previous workers and attempts to establish a better understanding of the processes involved with the transition volcanism. Prior work documents significant differences in the geochemistry between some of these areas, especially those in close proximity to each other (e.g. the Volcanic Hills and Coyote Mountains). These differences were thought to be largely the result different magmatic sources. The potential of finding two differing magma types in close proximity could possibly reflect the opening of a slab window produced by the collision of the spreading center and continued subduction of the Farallon plate beneath the North American continent. However, evidence presented here suggests that crustal contamination and metasomatic processes in the Coyote Mountains are the primary source of the geochemical variations. Trace-element signatures are similar in samples from all of the study regions, with pronounced Nb depletion typical of island-arc volcanism. The distinguishing features of samples from the Coyote Mountains are the high amount of alteration and their high levels of K_2O (4-5 wt%). This study will examine the possibility that these characteristics result from the interaction of the basalt with a highly alkaline body of water and/or sediments. Supporting data for such a model include pillow structures and spiracle formations within the basalt flows exposed in the Fossil Canyon and Butaca Canyon regions of the Coyote Mountains. Future studies of the olivine-basalt samples within the central region of the Coyote Mountains, away from the altered exposures, would provide a more complete understanding of their genesis.

While the geochemical data were initially analyzed using standard geochemical techniques, the data are also analyzed statistically using a relatively new multivariate analysis technique known as Compositional Data Analysis (CoDA). Using the CoDA techniques, a

clearer insight into the actual changes of the chemical composition can be seen. It also provides statistically valid correlation between the various regions in the study area. The CoDA processes, CLR BiPlots in particular, show which elements vary from one region to the next. It also differentiates elemental groups that correlate with typical rock-forming processes (e.g., fractional crystallization) from those that result from contamination from other sources or processes. Two examples illustrate the application: 1) In the Volcanic Hills, a pronounced negative correlation between MgO and K_2O is clearly observed. However, in the Table Mountain samples, there is less negative correlation observed between those same oxides, but a pronounced lack of correlation between MgO and P_2O_5, which may indicate magma mixing. 2) Samples from the Volcanic Hills show two distinct groups with similar variance values and strong correlation, but are negatively correlated with each other. The first group consists of those the elements that comprise the minerals that crystalize at high temperatures, such as, Mg, Fe and Ca. This is consistent with the formation of olivine, pyroxene and Ca-rich plagioclase, respectively. The second group shows the elements that comprise the lower temperature minerals such as more Na-rich plagioclase and orthoclase. These include, Na, Al, K, and Si.