Spatial-temporal patterns of arc activity across the central Sierra Nevada, California

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MOTIVATION

- Continental arc systems are dynamic. Although subduction of oceanic lithosphere is a continuous process (Fig. 1), magma is added to the arc in episodic pulses, or flare-ups.
- Arcs can also sweep across the continents, and locally concentrate magma in inward-focusing zones.
- Whether these processes work in isolation or combination, they result in super-eruptions and super-pluton formation. Which process(es) primes the arc for this activity?
- It is important to differentiate the signals of each spatio-temporal process to distinguish the causes and the magma sources. Are there feedback processes that enable some arcs to operate more efficiently?

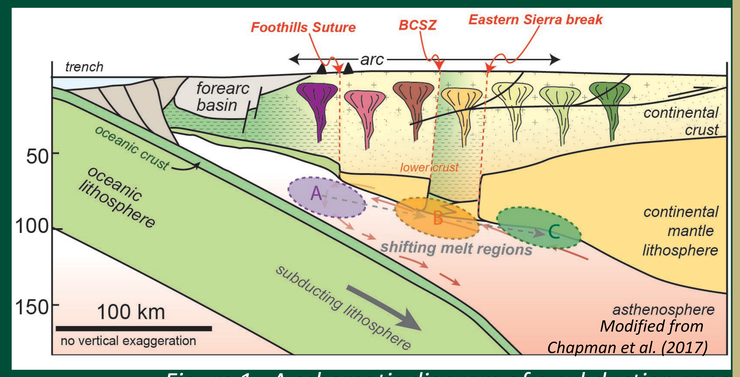

Figure 1: A schematic diagram of a subduction zone

BACKGROUND

The Sierra Nevada, California records ~150 million years of magmatism. Arc magmatism was episodic over three flare-ups in the Triassic, Jurassic, and Cretaceous (Armstrong and Ward, 1993; Ducea, 2001; Fig. 2). The arc migrated from west to east during the Cretaceous (Chen and Tilton, 1991), and doubled in thickness (Cao et al., 2016). During the peak of the Cretaceous flare-up, magma locally focused into a central zone, forming the voluminous granitic plutons that make up Yosemite National Park (Grunder et al., 2008; Ardill et al., 2018). Processes summarized in Figure 3.

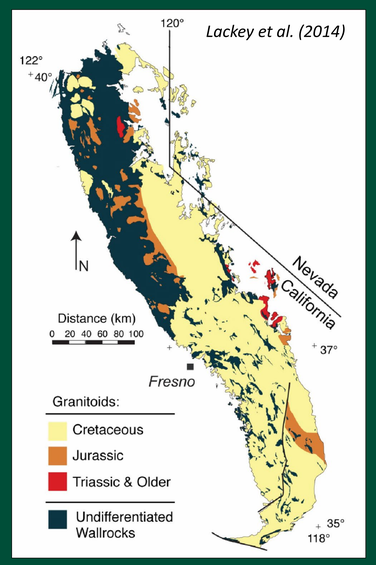

Figure 2: Simplified geologic map of the Sierra Nevada arc section, California

RESULTS

- Used rock ages (U-Pb in zircon), location, and isotopic composition ($^{87}Sr/^{86}Sr$ and $^{143}Nd/^{144}Nd$) to map the chemistry of magmatic rocks in space and time.
- Arc magmas inherit some chemical signature from the surrounding rocks (e.g., Kistler and Peterman, 1973) but within one domain, there are temporal patterns (Fig. 4). This indicates that the magma source is changing through time. This is potentially the flare-up signal (see also Attia et al., 2020).
- Focusing increased magma volumes in one location, forming long-lived magma chambers, and allowing magma mixing to occur, seen in averaged isotopic signatures. This potentially led to super-eruptions (volcanic rocks not exposed).

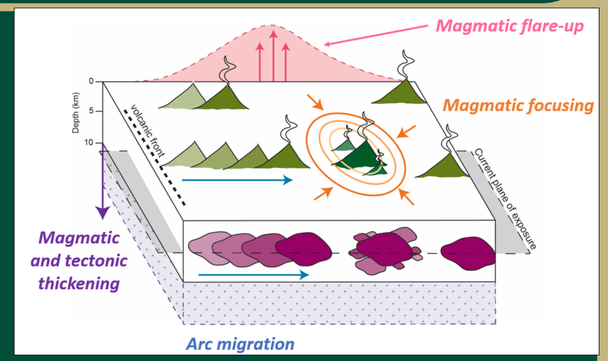

Figure 3: Summary of arc processes recorded in the Sierra Nevada between 140-85 Ma

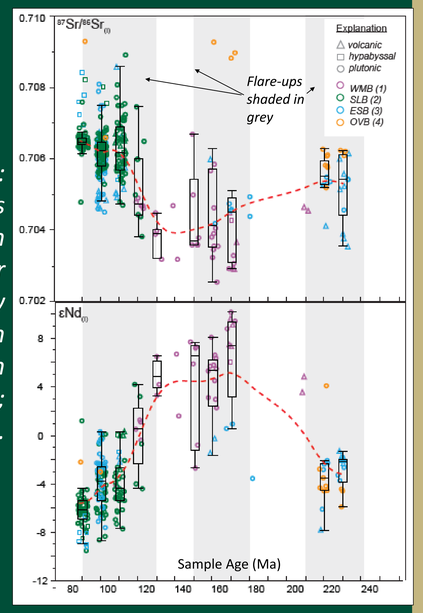

Figure 4: Isotopes through time, color coded by position in the arc (from west to east; 1 → 4).

IMPACT

The overlapping events in the Cretaceous Sierra Nevada demonstrate that it is not simple to attribute a chemical signal to one process. Models that consider the driving mechanisms for flare-ups, migration, or focusing need to evaluate the extent of interaction and connectivity between several dynamic aspects of arc activity.

FUTURE GOALS

Future work aims to map out the Jurassic and Triassic arcs to trace magma sources in the absence of migration and focusing patterns. Increased focus on the effects of crustal thickening on magma sources and vertical transitions in the crustal column.