



# Implications of a 102 Ma Alabama Hills Granite for dextral offset in Owens Valley, CA, and the organization of Sierran magmatism

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## Abstract

The Alabama Hills (AH) of CA expose a Jurassic volcanic complex and a Cretaceous pluton (AH Granite; AHG) east of the Sierra Nevada batholith (SNB) near Lone Pine, CA. New U-Pb CA-TIMS zircon geochronology for the AHG yields ages from 102.8-102.2 Ma. These dates are older than the previously suggested age of 85 Ma, which implied a link between the AH and the adjacent 90-83 Ma Whitney Intrusive Suite (WIS). This connection is no longer tenable. Instead, the dates suggest a link to rocks tens of kilometers NW. Whole rock samples of the AHG yield  $^{87}\text{Sr}/^{86}\text{Sr}_i = 0.7058\text{-}0.7089$  and  $\epsilon\text{Nd}_i = -2.73$  to  $-3.03$  and extend the range of isotopic ratios for ~102 Ma plutons in the SNB.

Because there is no temporal connection between the AHG and the WIS, there is no requirement that the block be derived from the adjacent range front. Correlation of the highest density portion of the Independence Dike Swarm (IDS) between the AH and the SNB is consistent with 25-55 km of dextral offset between the Sierran range front and the AH (imprecise due to the obliquity with which the IDS intersects Owens Valley). However, the AH are not cut by the 83 Ma Golden Bear dike. This requires that the block be offset either <10 km or >28 km. We note that, if offset of the AH block is <10 km, the 102 Ma granite lies along a SE-NW trend of ~102 Ma plutons stretching from the AH NW to the ~102 Ma Dinkey Creek pluton in the central part of the SNB. Likewise, the Jurassic volcanic complex exposed in the AH is aligned with comparable rocks of the Oak Creek and Goddard pendants. Additional work is necessary to distinguish between the options of <10 km and >28 km offset, but because the offset estimate on the basis of density of the IDS is so imprecise, and the other features line up fairly well, we suggest that minimal dextral offset (<10 km) between the SNB and the AH is more likely than >28 km offset.

The new data for the AH suggest that Cretaceous magmatism in the SNB at ~102 Ma was organized obliquely to magmatism immediately before and after. Jurassic magmatism and the 98-83 Ma intrusive suites are elongated parallel to the batholith (N20°W) and have limited isotopic variability. In contrast, ~102 Ma rocks define a trend of N60°W and are isotopically diverse, ranging from juvenile isotopic ratios near the AH, to crustal values in the Shaver Intrusive Suite to the NW.

## The Alabama Hills

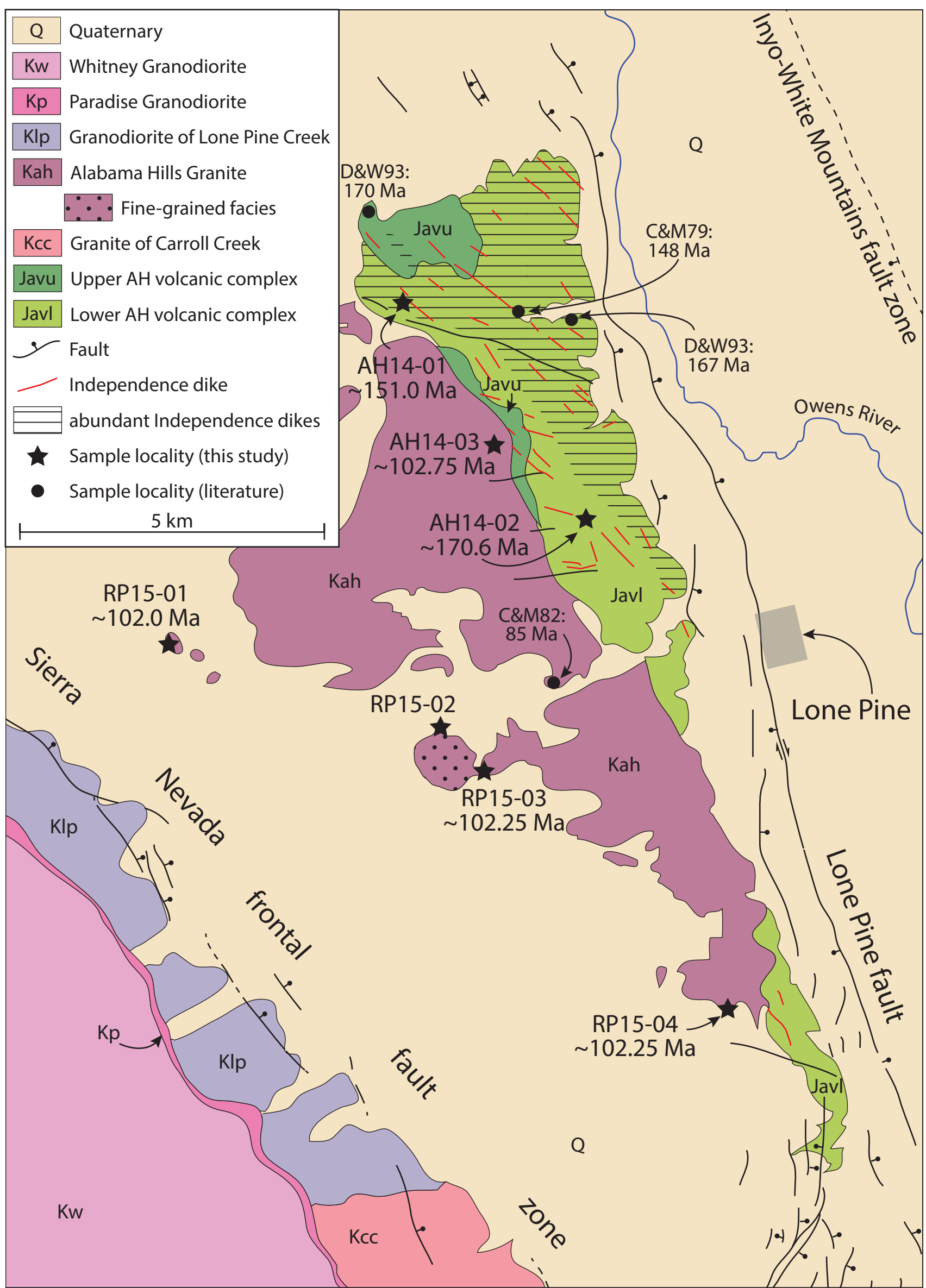


Fig. 1. Simplified geologic map of the Alabama Hills and adjacent 90-83 Ma Whitney Intrusive Suite. See map at right for location. modified after ref. 6.



Alabama Hills Granite in foreground; Whitney Intrusive Suite in background.

- Previous zircon U-Pb dating indicates metavolcanic complex is ~170-167 Ma<sup>1</sup>

- Chen and Moore<sup>2</sup> dated the Alabama Hills Granite at ~85 Ma

- (U-Th)/He data suggest the Hills block dropped ~2.6 km from elevation of Whitney suite<sup>3</sup>

- Multiple spatial and temporal links to adjacent 90-83 Ma Whitney Intrusive Suite<sup>4</sup>

- ~148 Ma Independence dike swarm highly dilates Jurassic rocks in Alabama Hills block; suggests it may be dextrally offset by up to 75 km relative to Coso Range<sup>5</sup>

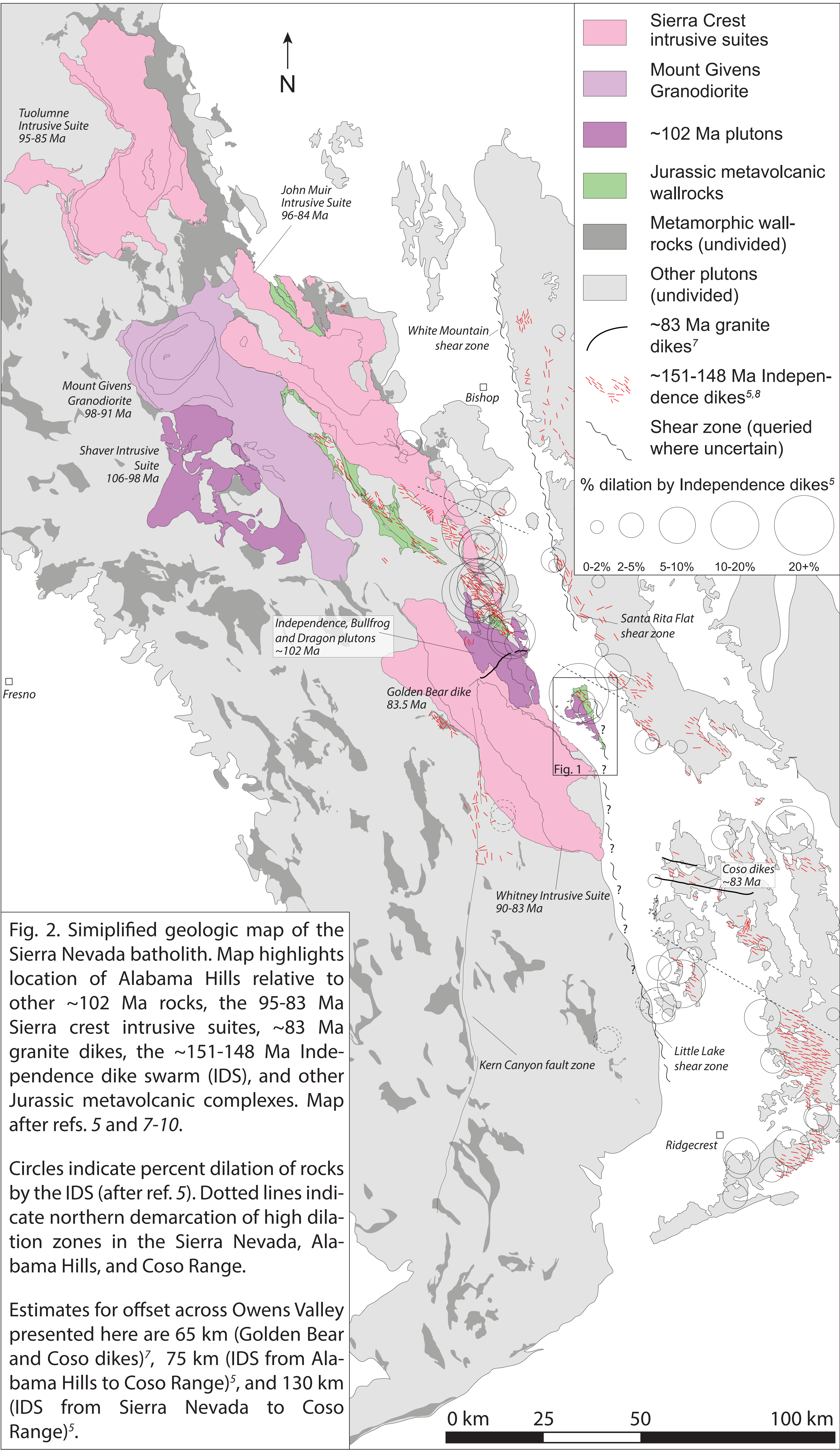
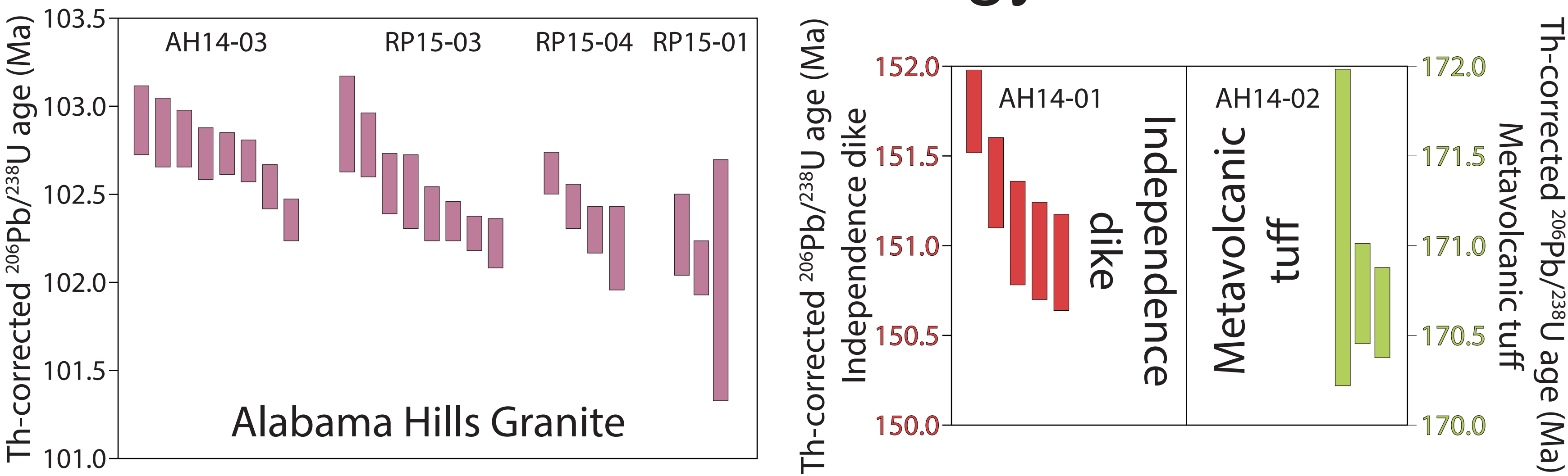


Fig. 2. Simplified geologic map of the Sierra Nevada batholith. Map highlights location of Alabama Hills relative to other ~102 Ma rocks, the 95-83 Ma Sierra crest intrusive suites, ~83 Ma granite dikes, the ~151-148 Ma Independence dike swarm (IDS), and other Jurassic metavolcanic complexes. Map after refs. 5 and 7-10.

Circles indicate percent dilation of rocks by the IDS (after ref. 5). Dotted lines indicate northern demarcation of high dilation zones in the Sierra Nevada, Alabama Hills, and Coso Range.

Estimates for offset across Owens Valley presented here are 65 km (Golden Bear and Coso dikes)<sup>7</sup>, 75 km (IDS from Alabama Hills to Coso Range)<sup>5</sup>, and 130 km (IDS from Sierra Nevada to Coso Range)<sup>5</sup>.

## Geochronology



- New U-Pb zircon data from four spatially distributed samples indicate Alabama Hills pluton was emplaced ~103-102 Ma

- Independence dike (~151 Ma) and Jurassic volcanic sample (~170.6 Ma), agree with previous geochronology<sup>1,2</sup>

- Data indicate Alabama Hills Granite cannot be linked to Whitney Suite; likely linked to ~102 Ma Independence, Bullfrog and Dragon plutons<sup>7</sup>

## Sr-Nd Isotopic Analyses

- Initial  $^{87}\text{Sr}/^{86}\text{Sr}$  data for four samples show wide range, from 0.7058 to 0.7089

- $\epsilon\text{Nd}$  data for three samples are more restricted, from -2.7 to -3.0
  - RP15-02 (fine-grained Alabama Hills Granite) has no Sm data yet

- Data generally agree with O isotope data for 102 Ma rocks in area<sup>10</sup> suggesting mantle influence

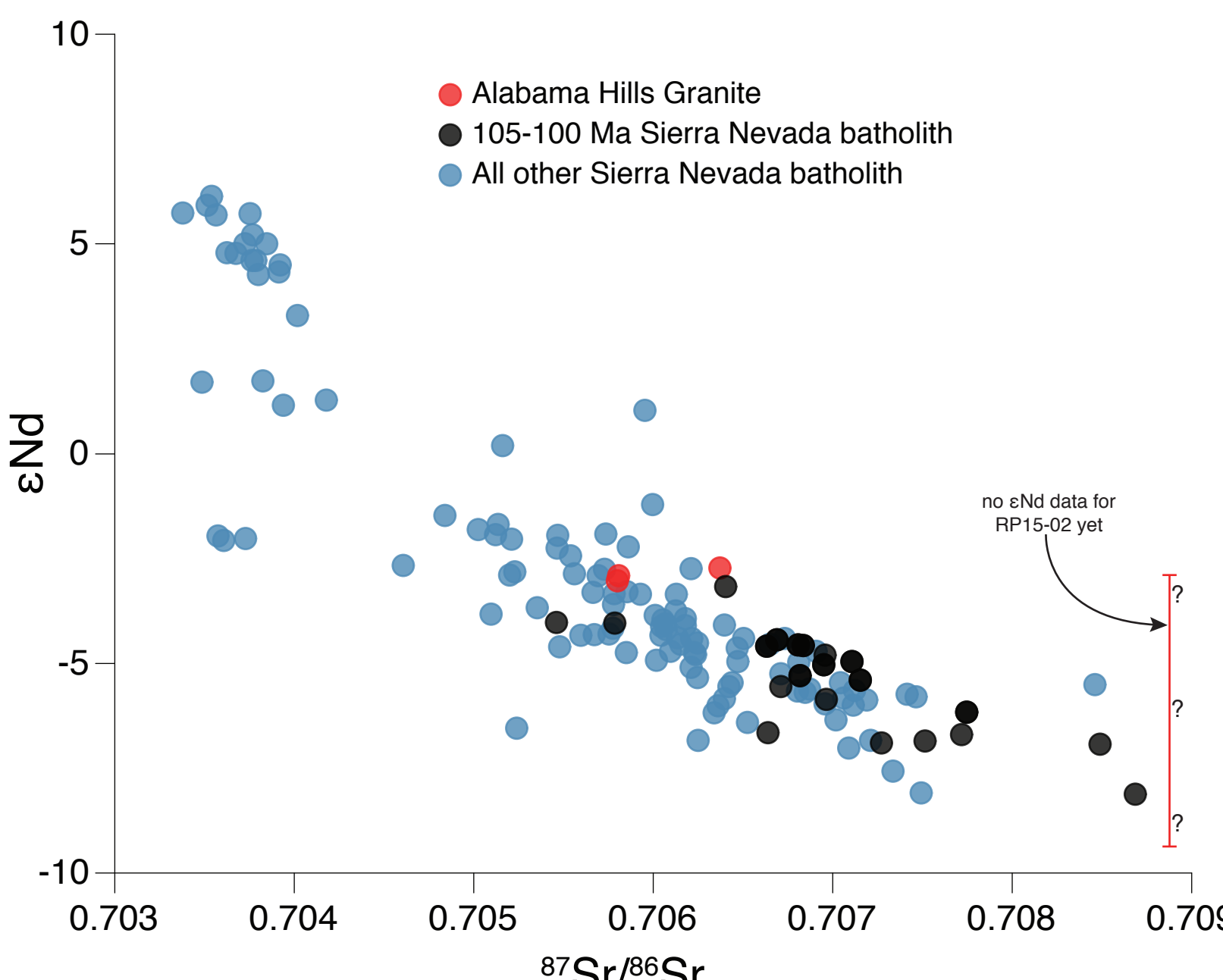


Fig. 3. Initial Sr and Nd isotopic data for the Sierra Nevada. Sources: NAVDAT, ref. 11; Frazer (unpub.).

## Implications

- Alabama Hills Granite cannot be part of Whitney Intrusive Suite temporally or isotopically

- Similar in age and isotopic characteristics to plutons to the NW

- Without link to Whitney Suite, block may be offset dextrally relative to main Sierra Nevada batholith
  - Not cut by vertical Golden Bear dike, so must be offset <10 km or up to 28-55 km

- Present location aligns block with plutons of similar age but diverse isotopic characteristics, from crustal (Shaver Suite) to mantle-like (this study)
  - Trend of ~102 Ma rocks is oblique to main batholith and younger suites

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