Emplacement of the Santa Rita Flat pluton as a pluton-scale saddle reef: Comment and Reply

REPLY

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DATA REPOSITORY MATERIAL

WALL ROCK STRUCTURE

In Figure 1 of our Reply (Vines and Law, 2001) we illustrate the non-cylindrical nature of folding of metasedimentary rocks of the White-Inyo Range by showing a non-cylindrical anticline-syncline pair on the southwest-dipping limb of the Inyo Anticline before intrusion of Jurassic and Cretaceous plutons. In our model we propose that the early stage evolution of the Santa Rita Flat pluton was associated with flexural slip and dilation in the synclinal hinge zone of this fold pair. These non-cylindrical folds could plunge towards either the north-northwest or south-southeast. Because of the southward dips observed to the north of the pluton we are inclined to favor a dominant southerly plunge direction (Fig. 1), but caution must be exercised because local country rock structure to the north of the c. 165 Ma Santa Rita Flat pluton may well be influenced by later intrusion of the Cretaceous age Papoose Flat pluton (Morgan et al., 1998; Saint Blanquat et al., 2001).

DEPTH OF PLUTON EMPLACEMENT

We appreciate the reservations that Stevens et al. (2001) may have on mechanical grounds concerning space being made for intrusion of the Santa Rita Flat pluton by flexural slip and hinge zone dilation at depth in the crust, but point out that km-scale saddle reef formation has been well documented for many decades in the minerals industry, and is known to occur under both greenschist (e.g. Fowler and Winsor, 1996) and amphibolite (e.g. Mendelsohn, 1961) facies conditions. In contrast, we believe the Santa Rita Flat pluton would have formed at a much shallower crustal level. Based on available data (Dunne and Walker, 1993; Dunne et al., 1998) we estimate the pluton was emplaced beneath a maximum stratigraphic thickness of 2.1 km of uppermost Paleozoic and Mesozoic (> 165 Ma) rocks. Assuming a dip of between 25 and 40° for the western limb of the Inyo Anticline, this would correspond to an overburden of between 2.3 and 2.7 km; this crustal depth is similar to that at which well-documented laccoliths, such as those of the Henry Mountains of Utah (0.9-2.2 km depth; Cory, 1988), were emplaced.

PLUTON EMPLACEMENT RATES ASSOCIATED WITH SADDLE REEF MECHANISM

Stevens et al. (2001) question the likely ability of folding processes to operate at a sufficient rate to accommodate magma flux. In the case of the Santa Rita Flat pluton we concur with this view and specifically developed a two stage model to account for formation of the pluton in which cavity opening is only able to keep pace with the rate of magma influx during the first stage of pluton formation (Vines and Law, 2000) - see Point 4 of our Reply (Vines and Law, 2001). In a more general sense, however, we do not share Stevens et al.'s pessimism concerning the inability of folding processes to keep pace with magma influx, because injection of pressured fluids into dilating hinge zones may itself facilitate an increase in strain rate (cf. Hollister and Crawford, 1986). At present very little data is available on the rates at which natural folding processes actually occur. Estimated rates of present day and geologically recent uplift associated with folding range from 0.1-0.2 mm per year (e.g. Pinter et al., 2001) to 11-15 mm per year (e.g. Lees and Falcon, 1952; Lavé and Avouac, 2000), with uplift rates commonly falling in the 2-7 mm per year range (e.g. Vita-Finzi, 1979; Mann and Vita-Finzi, 1988; Rockwell et al., 1988; Keller et al., 1998; Sylvester, 2000). Depending on competency, ratio of bed thickness to limb length, interlimb angle, and variation in bed thickness (Ramsay and Huber, 1987, p. 422-424), maximum associated rates of vertical hinge zone dilation would be on the order of 10-20% of these uplift rates, and flexural slip could in 10,000 years, for example, accommodate a saddle reef (or phacolith) measuring 2-14 m in height.

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