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Thermochronologic constraints on the slip history of the South Tibetan detachment system in the Everest region, southern Tibet

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ABSTRACT

North-dipping, low-angle normal faults of the South Tibetan detachment system (STDS) are tectonically important features of the Himalayan–Tibetan orogenic system. The STDS is best exposed in the N–S-trending Rongbuk Valley in southern Tibet, where the primary strand of the system – the Qomolangma detachment – can be traced down dip from the summit of Everest for a distance of over 30 km. The metamorphic discontinuity across this detachment implies a large net displacement, with previous studies suggesting >200 km of slip. Here we refine those estimates through thermal–kinematic modeling of new (U–Th)/He and ^{40}Ar/^{39}Ar data from deformed footwall leucogranites. While previous studies focused on the early ductile history of deformation along the detachment, our data provide new insights regarding the brittle–ductile to brittle slip history. Thermal modeling results generated with the program *QTQt* indicate rapid, monotonic cooling from muscovite ^{40}Ar/^{39}Ar closure (ca. 15.4–14.4 Ma at ca. 490 °C) to zircon (U–Th)/He closure (ca. 14.3–11.0 Ma at ca. 200 °C), followed by slower cooling to apatite (U–Th)/He closure at ca. 9–8 Ma (at ca. 70 °C). Although previous work has suggested that ductile slip on the detachment lasted only until ca. 15.6 Ma, thermal–kinematic modeling of our new data suggests that rapid (ca. 3–4 km/Ma) tectonic exhumation by brittle–ductile to brittle fault slip continued to at least ca. 13.0 Ma. Much lower modeled exhumation rates (≤0.5 km/Ma) after ca. 13 Ma are interpreted to reflect erosional denudation rather than tectonic exhumation. Projection of fault-related exhumation rates backward through time suggests total slip of ca. 61 to 289 km on the Qomolangma detachment, with slightly more than a third of that slip occurring under brittle–ductile to brittle conditions.

1. Introduction

Regional-scale, low-angle normal fault ('detachment') systems are common features of extensional tectonic regimes such as the Basin and Range province of the North American Cordillera, but similar features are also found in convergent settings and their significance has proved to be controversial. One of the most impressive confirmed structures of this type is the South Tibetan detachment system (STDS), which crops out near the crest of the Himalaya in Bhutan, India, and Nepal over a distance of well over 1000 km along strike (Burchfiel et al., 1992; Hodges, 2000). Some researchers have argued that normal-sense displacement along the STDS has been one of the defining structural events of Himalayan evolution, enabling the southward extrusion of a thick, mid-crustal channel, over distances of well over 100 km, during the Miocene (Nelson et al., 1996; Beaumont et al., 2001; Hodges et al., 2001; Grujic et al., 2002). Others have instead argued that this structure is comparatively minor and was initiated simply as the upper bounding thrust fault of a tectonic wedge that subsequently accommodated at most a few tens of kilometers of normal-sense offset (Yin, 2006; Webb et al., 2007; Webb, 2013).

One way to objectively evaluate these competing hypotheses is to establish robust constraints on the total normal-sense offset across the STDS. Here we report the results of a study designed to contribute to this effort through medium- and low-temperature thermochronometry and thermal–kinematic modeling of the results. Specifically, we present new ^{40}Ar/^{39}Ar muscovite (MsAr), (U–Th)/He zircon (ZrnHe), and (U–Th)/He apatite (ApHe) data for samples collected in the Rongbuk Valley, 28.063159°N 86.865197°E to 28.273212°N 86.805560°E, north of the Everest massif, in south-

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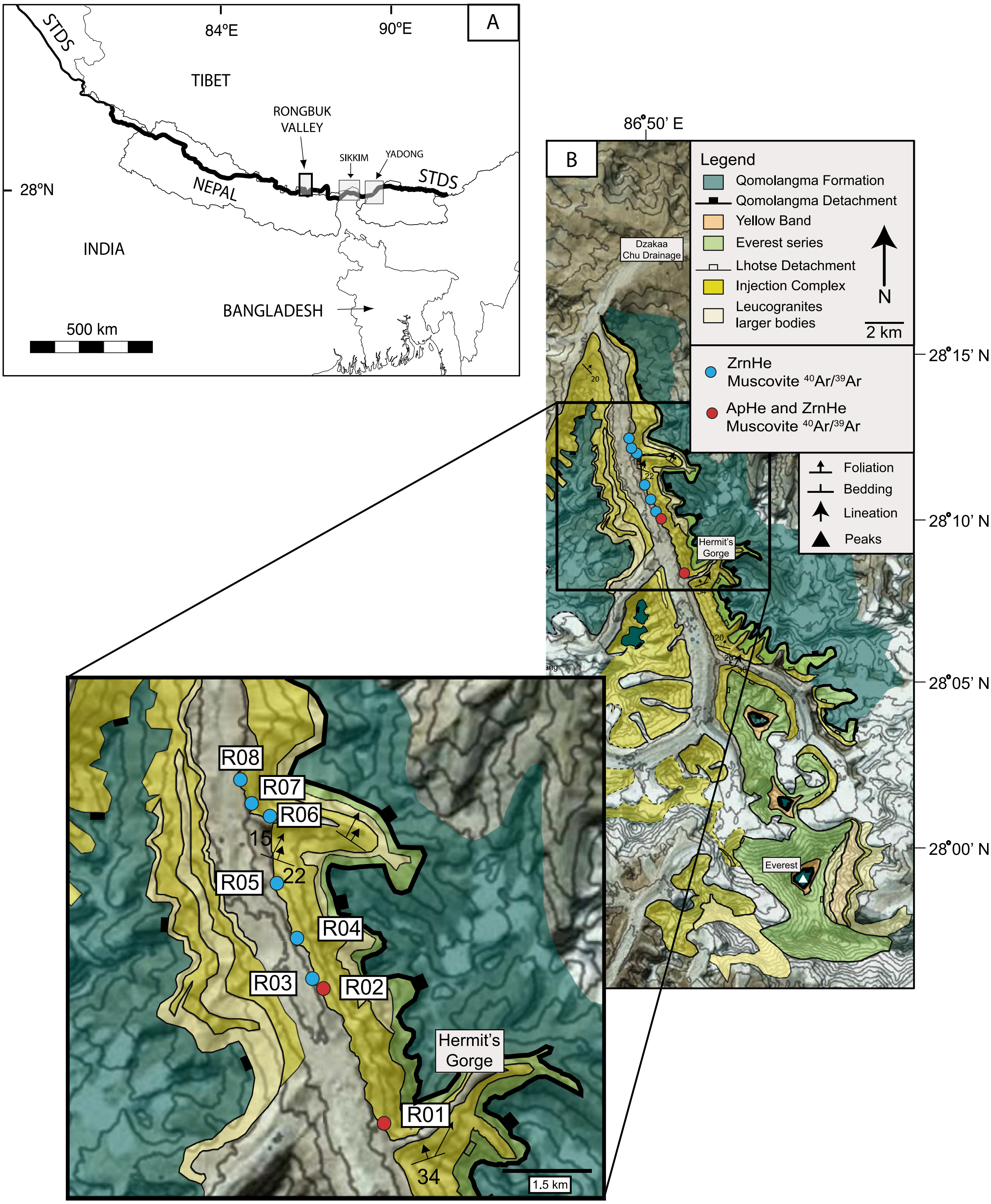

Fig. 1. A) Map showing the position of the STDS along the crest of the Himalaya. The bold shaded box indicates the location of Fig. 1B and the boxes to the east indicate regions where the STDS has been previously studied (Cottle et al., 2011; Cooper et al., 2012, 2013; Kellett et al., 2013). The map is based on Cooper et al. (2012). B) Regional map of the Rongbuk Valley in the Everest region of Tibet. Geologic units are mapped after Searle et al. (2003). Sample localities are shown with blue and red circles and the different colors represent different chronometric systems measured for each sample. See inset map for sample names. The base map is taken from the ArcGIS World Imagery catalogue.

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