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Morphotectonic Properties Of Young Active Strike-slip Faults In Northern Vietnam

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The Red River (RR) and Dien Bien Phu (DBP) faults are conjugate strike-slip faults which in Pliocene-Quaternary times have shown, respectively, right-lateral and left-lateral sense of motion. The RR marks the boundary between the South China and Indochina blocks which has been shaped in two phases: during sinistral ductile shear active in 27–16 Ma, followed by exhumation and uplift from a depth of 20–25 km, and as dextral, predominantly brittle shear active in Plio-Quaternary times (Leloup et al., 1995 and references therein). This change of the sense of motion is related to collision between India and Eurasia. The pre-Pliocene history of the DBP is poorly known, although its recent sinistral character is obvious. Both these zones display different style of seismicity: RR is seldom accompanied by strong earthquakes, the strongest event recorded in historical times being 5.9, whereas DBP is the locus of frequent and relatively strong earthquakes of magnitudes 5–6 (max Ms 6.8). Geodetic (GPS) data are available for the RR only, showing 1–5 mm/yr of dextral slip (Cong and Feigl, 1999).

Indicators of recent strike-slip along the RR and DBP fault segments in Northern Vietnam include drainage offset and deflection (10–50 m to some 3.5 km along RR, and 6–50 m to 2–2.5 km along DBP), beheaded streams, shutter ridges, en echelon orientated minor fault and fault-line scarps, displaced terraces and alluvial fans, rectilinear fault valleys and long, rectilinear fault scarps. Moreover, the SE and northern portions of, respectively, RR and DBP faults, display increasing component of normal slip, as testified to by well-preserved triangular facets on fault scarps, highly elevated straths in river gorges, and overhanging valleys. The NW-SE – trending RR fault trace is accompanied by narrow pull-apart basins and grabens filled with thick Neogene terrestrial strata and relatively thin Quaternary sediments. Clasts in Neogene conglomerates are comonly fractured, indicating at least six phases of brittle deformation, alternately extensional and compressive ones. Clasts in Quaternary alluvium are, in turn, not fractured. On the other hand, the N to NNE trending DBP fault is accompanied by pull-apart basins whose size increases southwards and which are filled by Quaternary fluvial sediments, resting on Palaeozoic-Mesozoic bedrock. These sediments are frequently faulted and, at least in the Dien Bien Phu Basin, clasts composing alluvial fans are fractured parallel to the fault trace.

Our morphotectonic studies conducted in the medial segment of RR indicate 1–2 mm/yr of dextral slip and at least 0.1 mm/yr of uplift during the past 1–2 Ma (Cuong and Zuchiewicz, 2001). Morphotectonic indicators and displaced Quaternary alluvial sediments indicate that sinistral and sinistral-normal faults bounding pull-apart basins in the southern portion of the DBP appear to reveal minimum rates of sinistral strike-slip ranging from 0.6 to 2 mm/yr in Holocene and 2 to 4 mm/yr in middle-late Pleistocene times, whereas rates of Holocene uplift tend to increase northwards along the fault, from 0.4–0.6 to ca. 1 mm/yr. Long-term, average Quaternary uplift rates have certainly exceeded 0.05 mm/yr. Both the RR and DBP faults are capable of generating strong earthquakes in the future, particularly in the southern segment of DBP and SE segment of RR.

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