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Active faulting in southern Bhutan Himalaya and its application for active tectonics

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Introduction

The on-going collision between Indian and Eurasia plates has caused uplift of the Himalayan range, appearance of dense distributed fault system and also outbreaks of mega earthquakes in the past 100 year along the Himalayan front. Because active faults generate large and shallow earthquakes (over M6.5), detailed information on distribution and sense of active faulting is fundamental data for not only study on active tectonics, but also planning for seismic mitigation. Geological and geomorphic knowledge about active faulting of Pakistan, northwestern India and Nepal is collected by numerous works, but limited works such as Nakata (1972) and Yagi et al. (1992) has only done to understand that of Bhutan and northeastern India at present. In this presentation we show the preliminary result regarding to distribution and sense of the active fault in southern Bhutan Himalaya and discuss about relationship between active faulting and structural tectonics, comparing with active faulting in southern Nepal Himalaya.

Method and material

We interpreted air photos by stereo-view to identify the typical tectonic landform such as a series of stream offset on same line and fault scarp on terrace or fan surfaces as geomorphic evidence for active faulting. We used air photos of both Bhutanese government institutions: Department of Geology and Mines (DGM), Ministry of Economic Affairs and Department of Survey and Land Record, Ministry of Home Affairs. The air photos are vertical, gray color scale with a scale of 1:12,500, 1:15.000 and 1:25,000 taken in 1989 and 1991. Information on the tectonic landforms and surface trace of active fault were mapped in topographical maps with a scale of 1:50,000. The air photos of some areas closing to the border to India are not available. We concentrated to interpret the area south of N27 in Bhutan where active faults may be distributed densely according to other Himalayan area.

Characteristics of active fault in southern Bhutan Himalaya

The result we interpreted are shown below:

1. There are many fault traces with E-W striking, parallel to the Himalayan range.
2. No single fault traces run from east to west entirely in the southern Bhutan, but the fault traces less than 30 km long are recognized generally, overlapped with five to six traces in part.
3. Regarding to vertical displacement on the E-W striking fault traces, that on the traces along the footwall of the Himalayan range shows north up-thrown, that inside the Himalayan range shows both directions between south up-thrown or north up-thrown.
4. The NE-SW and NW-SE striking fault traces are visible inside the range, oblique to the general trending of the range. We observed the left-lateral strike-slip along the NE-SW striking fault trace, the right-lateral strike-slip along the NW-SE striking fault trace. Some of those may run toward north out of mapping area.
5. Eastward from Tshoki, density of fault traces is less than other part, also the E-W trending traces concentrate within 1 km width.

Relationship between structural geology and distribution of fault

The active fault we identified in the southwestern Bhutan are almost distributed widely not only along the Main Boundary Thrust (MBT), but also over the Lower Himalaya between the MBT and the Main Central Thrust (MCT). However in south-eastern Bhutan east of Tshoki the traces of active fault is almost single along the MBT in map view. In Nepal the surface traces of active faults follow the main geological boundaries such as the MBT and MCT, and the density of active faults in the Lower Himalaya is very low. The difference reflects the difference of type of long-term collision tectonics. Principal axes of horizontal strain based on slip sense and striking of the faults is N-S, which is suitable for the direction of plate motion.

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