学位論文（要約）

Late Quaternary evolution of the Kumkol Basin at the northeastern margin of the Tibetan Plateau revealed by tectonic geomorphology and the analysis of in situ cosmogenic nuclides

（変動地形と宇宙線生成核種の分析に基づくチベット高原北東縁クムコル盆地における第四紀後期の地形発達過程の解明）

平成 26 年 12 月博士（理学）申請

東京大学大学院理学系研究科
地球惑星科学専攻

白濱　吉起

Abstract

The Tibetan Plateau is the biggest orogen in the world, formed by the collision between the Indian and Eurasian plates. The crust of the Indian lithosphere has been injected into the orogen, causing progressive increase of its volume. The maximum elevation (~5000 m) of the plateau is likely to be controlled by gravity-induced differential stress that is not to exceed the strength of crustal materials. Once the plateau has grown to this height limit, it was to expand its volume by growing not vertically but laterally. The lateral growth is most spectacular and is now ongoing along the northeastern margin of the plateau. However, the mechanism of lateral expansion at the northeastern margin of the plateau has been highly debated due to the scarcity of tectonic researches. We conducted tectonic geomorphological analyses in the Kumkol Basin at that margin. This basin encloses a large-scale active anticlinorium (Kumkol Anticlinorium), which would provide a quantitative constraint on the lateral growth of the plateau if we could properly date tectonically deformed landforms.

Our geomorphological mapping revealed 3 steps of terraces (H, L1, and L2) and 6 steps of terraces (T1, T2, T3, T4, T5, and T6) along the Sijiquan River and Pitileke River, respectively, in descending order. Topographic cross sections of river terraces indicate progressively larger deformation with increasing relative ages of the terraces, suggesting qualitatively that the KA has been evolving throughout at least late Quaternary time.

In this research, we conducted surface exposure dating to estimate the absolute ages of the Pitileke and Sijiquan terrace formations. Analyses of CRN data revealed that the present-day bed load of the Sijiquan River includes a large amount of reworked clasts. The results of the Pitileke River also indicate that the sediments at site 2-4 contains clastic grains with a variety of CRN inheritances. An important finding is that source areas of clastic sediments have changed dramatically during aggradation-degradation cycles.

The CRN concentrations of the subsurface samples at section 10D on the T1 surface and section 08D on the T3 surface in the Pitileke Terraces were analyzed by least-squares fitting. We estimated the emergence age of T1 surface by analyzing depth-profile data; we found that its emergence age falls into the range from 173 ka to 380 ka, and is most likely to be 252 $^{+24}/_{-25}$ ka or slightly younger. The age of T3 surface was found to be 103 ± 23 ka by the same procedure. Based on the some assumptions on inheritance and erosion rate, the true age at every sample site was calculated. The ages of T1, T2, T3, T4, and T6 on the Pitileke Terraces show 252 ± 24 ka, 140 –160 ka, 103 ± 23 ka, 98 ± 11 ka, and 0–23 ka, respectively. The ages of H, L2b, and L2a on the Sijiquan Terraces show 137 ± 10 ka, 47 ± 4.6 ka, and 23 ± 3.4 ka, respectively. The ages of T1, T2 and H, T3 and T4 surfaces thus determined fall into the Marine Isotope Stages (MISs) 8, 6, and 5, respectively. Our results make it clear quantitatively that debris supply is controlled by climate and therefore degradation-aggradation cycles are correlated to global climatic fluctuations.

We estimate the uplift rate from relative heights the Pitileke Terraces with respect to the present channel and their ages estimated by CRN analyses. Since we know the ages of some terraces such as T1 and T2, we can translate these relative height profiles into the uplift-rate profiles. The ages of T1 and T2 and terrace deformation on the Kumkol Anticlinorium show the maximum uplift rate of 1.05 ± 0.10 mm/yr and 0.96 ± 0.07 mm/yr, respectively.

In order to estimate the geometry of faults by which the Kumkol Anticlinolium has evolved, we used dislocation fault model in a semi-infinite elastic half-space. The overall surface deformation across the Kumkol Anticlinorium suggests that the Kumkol Anticlinorium is produced principally by slip on a flat-ramp-flat structure, in which the deep detachment fault in the south connects up-dip through a ramp fault to the shallow detachment fault in the north; two surface faults could be secondary back-thrusts associated with the kink zone behind the ramp. Then we searched the appropriate slip rates of all faults so that they could produce the distribution of the uplift rate. As a result, the horizontal shortening rate across the Kumkol Basin is found to be 2.5 ± 0.18 mm/yr and 3.2 ± 0.28 mm/yr based in the case of the 15 and 10-km-deep detachment, respectively. Interestingly, the depth is in or just above the depth range of the brittle-ductile transition zone in continental crust with a normal heat flow. This result suggests that there is a large-scale detachment fault below the basement-involved fold-and-thrust belt.

The horizontal shortening revealed by our study should be directly related to the northward migration of the Tibetan Plateau. The stress concentration would occur due to the abrupt southward decrease of effective elastic thickness, and due to gravity-induced stress caused by the abrupt southward increase of elevation. The stress concentration at the plateau margin would have facilitated the development of the crustal-scale deformation underlying the Kumkol Basin, which in turn would have accelerated the lateral growth of the topographically defined Tibetan Plateau.

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