Sedimentation of the Jianggalesayi basin and its response to the unroofing history of the Altyn Tagh, northern Tibetan Plateau

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The uplift of the Tibetan plateau is one of the most prominent geological event of the past 50 Ma. However, the timing and range of the uplift are still poorly constrained, and little attention has been given to the elevation history of mountains in northern plateau (Sobel and Trevor 1997, Zheng et al. 2000). In this study, we present new evidence from the sedimentation in the foreland basin to discuss the exhumation history of the Altyn Tagh in the northern Tibetan plateau.

Geological setting

The Jianggeleshayi basin is located on the northwestern edge of the Altyn Tagh, one of northwestern boundary mountains of the plateau. More than 3 km in thick Mesozoic to Cenozoic sedimentary rocks are continuously exposed in this foreland basin along the northwestern side of the northern Altyn Tagh fault (Cowgill et al. 2000). These Mesozoic to Cenozoic rocks can be divided into seven segments, including Jurassic Ye'erqiang Formation, Cretaceous Kezilesu Formation, Early Tertiary Kumugeliemu Formation, Oligocene to Miocene Wuqia Formation, Pliocene Atushi Formation, Early Pleistocene Xiyu Formation and Middle Pleistocene Wusu Formation according to the geological map of the Xinjiang BGMR (1993). A gently plunging anticline, the Jianggalesayi anticline is composed of these sedimentary units with Jurassic in the core, and is unconformably overlain by Middle Pleistocene Wusu conglomerate. Jianggeleshayi normal- and strike-slip fault cuts through the northwestern side of the fold (Cowgill et al. 2000). Field measurement of these sedimentary units in the northwestern side of the Jianggeleshayi normal fault was firstly completed in 2000 and about 200 samples were collected. More than 700 Cenozoic paleomagnetic samples were collected again to date the Cenozoic rocks in the summer of 2003.

Sedimentary features

The Jurassic Ye'erqiang Formation is composed of colorful fluvial and lacustrine coal-bearing sediments, which are mostly grey to dark, and brown sandstones interbedded with mudstones. The Cretaceous Kezilesu Formation is mainly composed of brown-grey sandstones with a few mudstones and conglomerates in bottom, full of calcite nodule, and mostly sand and mud as cement, showing alluvial fan and lacustrine sedimentary features. The Early Tertiary (Paleocene to Eocene) Kumugeliemu Formation is alluvial fan deposit, and composed of red to brown sandstones and conglomerates interbededd with mud-bearing sandstones and mudstones. The Wuqia Formation can be divided into two parts. The lower part is mainly composed of grey to red sandstones and siltstones. The upper one is mostly composed of gray conglomerates interbedded with mud-sandstones, behaving as a kind of fluvial deposits. The Atushi Formation is composed mainly of pluvial-circle sediments, having grey to brown conglomerates at the bottom and changing upwards into sandstones and mudstones. The Xiyu Formation is mainly composed of grey thick-bedded cobblestones with a few sandstone lenticular bodies, characterized by a rapid accumulated feature. The Wusu Formation is composed of fluvial terrace conglomerates.

Field measurements of ratio of conglomerate units in stratigraphic layer show a rapid increase of the ratio occurred in the lower part of the Wuqia Formation. The lower part of the section is dominated by fine-grain sandstone or siltstone, while the upper one is dominantly composed of coarse-grained conglomerates. If we suggest a stable sedimentary velocity in a geological time-period and take 35 Ma and 5 Ma as the beginning and end ages of the sedimentation of the Wuqia Formation (because the paleomagnetic data are still in the lab), the boundary age of the lower part with the upper should be ca. 25 Ma. And according to the thickness of the stratigraphic units, sedimentary velocities could be calculated out: 4.8m/Ma during the Cretaceous, 12m/Ma during the Paleocene to Eocene, 19.7m/Ma during the Oligocene to Miocene, 180.9m/Ma during the Pliocene, and 651.9m/Ma during the Early Pleistocene.

Composition of detritus in sandstone and conglomerate clast

44 samples are selected to analyze the composition of detritus in sandstone by point-counting of more than 300 grains per thin section. Overall, sandstone samples are quartzolithic arenites (Qm=55, F=20, Lt=25). However, lithic fragments (Lt) are less than 20% in sandstone from the Kezilesu(K) to Wuqia Formation and larger than 20% in sandstones from the uppermost part of the Wuqia Formation, while monocrystalline and polycrystalline quartz fragments (Qt=Qm+Qp) decrease from >50 into <50 at the same time. The rapid decrease of volcanic lithic fragments (Lv) occurred between the lower part and upper part of the Wuqia Formation (from 8 down to 5). The metamorphic lithic fragments (Lm), dominated by metamorphic-sedimentary lithic grains, increase from the bottom of the upper Wuqia Formation, and reach its peak at the uppermost part of the Quqia Formation(33). They are also major kind of detritus in sandstone of the Atushi Formation, but Lm is usually less than 5 in Xiyu Formation. Sedimentary lithic fragments (Ls) begin to increase in the uppermost part of the Wuqia Formation and become the dominant composition in Early Quaternary Xiyu conglomerate.

47 sites for point counting analysis of clast composition in conglomerate were completed in the field in 2003. The results show that clast composition in conglomerate is dominated by metamorphic rocks. The content is usually larger than 60%. sedimentary clast and is mainly composed of limestones. The rapid increase of its content occurred in the bottom of the Atushi Formation. The granitic clast is usually less than 10% in content and a few clast is sour or basic volcanic rocks in this section. The ecologite clasts can only be found in the Middle Pleistocene Wusu Formation.

Unroofing history of the Altyn Tagh

The sedimentary features in the Altyg Tagh basin together with point counting analyses of detritus in sandstone and conglomerate indicate the change of its paleogeomorgraphy as the main resource of sediments in this basin and thus the exhumation and uplifting history of the mountain. Paleozoic bimodal volcanic assemblage was firstly eroded during Cretaceous to Early Tertiary. During early Miocene, rapid uplift of mountains for the first time resulted in the exhumation of the Upper and Middle Proterozoic basement. Secondary rapid uplift began in the Late Miocene, while the fastest uplift of the mountains occurred since Late Pliocene. This has resulted in the exposition and erosion of the middle and lower part of the Proterozoic and Archean rocks. Deeply buried basement rocks such as ecologite began to be eroded till the Middle Pleistocene. This result is fairly consistent with our previous suggestions of the uplifting of the Altyn Tagh, especially the rapid uplift of the Altyn Tagh and rapid strike slip faulting of the Altyn Tagh fault at ca. 8 Ma, as has been indicated by fission track dating method of apatites, and the changes in values of $\delta^{18}O$ and $\delta^{13}C$ in carbonate cements from the same strata in this basin (Chen et al. 2002).

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