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Thermochronological Studies on Southeastern Tibetan Plateau Margin: A Case of Shangri-La Area

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1 Background

The southeastern Tibetan Plateau orogenesis margin, known as Sanjiang-Tethy Orogenesis, is a complex product of collisions, subductions and mantle-upwelling. Its formation in turn has played a significant role in reforming the mantle-crust structures and geodynamics, needless to say the ore deposits in this belt. Studies on the orogenesis processes, especially the uplift- denudation, can make the ambiguous relationships among plate motions, environment and climate to be clear in some extent and reveal the principles of ore deposits distributions.

The crust in Sanjiang Orogenisis becomes thinner from north to south (Zhang et al, 2007) and the material flows from Tibet Plateau main body (west) to southeast (Clark et al, 2000). Based on the thermochronological researches, Zhong et al, suggested that Sanjiang-Tethy Orogenisis experienced at least four tectonic stages, extrusion-folding-shorten deformation (45~38Ma), blocks strike-slip and rotation (25~17Ma), blocks heterogeneous uplift (13~7Ma) and extension-fast uplift (~3Ma).

As to the abnormal crustal thickness, many mechanisms have been proposed, including lithospheric mantle convection model (Molnar et al,1981), lithospheric subduction model (Tapponnier et al, 2001), lower crustal channel flow (Royden et al 1997 and Clark et al.,2000) and elastic lithospheric unloading effect (Beaumont et al., 2001 and Densmore et a., 2005l). Although many efforts have been put into, there are still critical questions to be answered. Large-scale strike-slip faults are the most remarkable geological characteristics, but these faults in fact do not contribute to the thick curst. While the crustal channel flow probably has the ability of causing the uplift, but it is not so confident to suggest that the intracontinental deformation are due to it.

Our research concerns on the thermochronology (AFT and ZFT) in Shangri-La County and tries to give a preliminary understanding on the responses between deep earth and its surfaces.

2 Sample Information

We sampled 11 hand spices, including seven sandstones, three intrusive rocks and one basalt (Table 1). As the fission track measurement techniques are well developed and elaborated, here the results are presented directly (Table 1 and Table 3).

Table1 Sampling information

Sample	Rock type	Ages	X	Y	Z
AD0526t1	diorite	T_3	99°53′12.5″	27°47′48.6″	3400m
AD0551t1		T_3	99°53′48.5″	27°45′46.3″	3790m
AD0566t1	sandstone	T_3ha^1	99°49′27.5″	27°47′53.6″	3480m
KDA03t1	syenite-porphyry	T_3	99°51′18.0″	27°40′51.3″	3920m
XD0508t1		T_1p	100°09′34.2″	27°47′01.1″	2167m
AD0562t1		T_3t^2	99°59′08.7″	27°48′03.3″	3700m
DD0550t1	sandstone	T_1q	100°00′39.3″	27°40′50.8″	3520m
ZD0571t1		T_1p	100°08′18.2″	27°46′26.1″	2200m
ZD0540t3		P_1ms^1	100°13′53.2″	27°49′05.7″	2120m
PM001-18t1	basalt	Plj	100°11′46.6″	27°48′13.7″	2080m
AD0591t1	sandstone	T_3t^1	99°59′21.1″	27°48′13.1″	3660m

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Table 2 Apatite fission track results

Sample	Grains (n)	ρ_s (10^5/cm^2) (Ns)	ρ_i (10^5/cm^2) (Ni)	ρ_d (10^5/cm^2) (N)	P(%)	Central age (Ma) (±1σ)	Pooled Age (Ma) (±1σ)	L(μm) (N)
AD0526t1	35	1.780 (602)	14.079 (4761)	15.227 (9722)	1.4	37 ±2	37 ±3	13.1±2.1 (117)
AD0551t1	28	1.575 (531)	21.574 (7274)	15.227 (9722)	0	21 ±2	22 ±2	12.8±2.3 (104)
AD0566t1	35	1.061 (232)	16.428 (3593)	15.363 (9722)	10.3	19 ±2	19 ±2	12.7±1.8 (15)
KDA03t1	36	0.809 (184)	9.501 (2162)	15.568 (9722)	96.7	26 ±2	26 ±2	13.2±2.1 (61)
XD0508t1	34	0.354 (58)	7.381 (1208)	15.910 (9722)	53.3	15 ±2	15 ±2	12.2±2.7 (35)
AD0562t1	27	2.445 (483)	18.423 (3640)	16.134 (9722)	0	39 ±4	42 ±3	13.1±1.9 (98)
DD0550t1	15	6.067 (668)	16.168 (1780)	16.321 (9722)	0	109 ±11	118 ±8	12.8±1.8 (78)
ZD0571t1	28	1.001 (123)	7.430 (913)	16.526 (9722)	61.2	43 ±5	43 ±5	12.2±1.9 (31)
ZD0540t3	31	3.336 (592)	29.121 (5167)	16.731 (9722)	44.0	37 ±3	37 ±3	12.1±2.2 (91)
PM001-18t1	31	3.162 (547)	23.8989 (4133)	16.869 (9722)	2.0	42 ±4	43 ±3	12.0±2.0 (104)
AD0591t1	33	0.740 (158)	4.676 (998)	17.075 (9722)	72.5	52 ±5	52 ±5	12.1±1.6 (103)

Table 3 Zircon fission track results

Sample	Grains （n）	ρ_s (10^5/cm^2) （Ns）	ρ_i (10^5/cm^2) （Ni）	ρ_d (10^5/cm^2) （N）	P（%）	Central age (Ma) （±1σ）	Pooled Age (Ma) （±1σ）
AD0526t1	7	137.335 (837)	56.443 (344)	9.238 (6822)	5.2	96 ±10	95 ±8
AD0551t1	17	197.155 (3159)	83.193 (1333)	9.409 (6822)	14.9	95 ±6	95 ±6
XD0508t1	18	95.990 (2793)	33.406 (972)	10.309 (6822)	30.2	124 ±8	125 ±8
AD0562t1	6	157.446 (2012)	50.004 (639)	9.623 (6822)	0.3	128 ±12	128 ±9
ZD0540t3	27	235.270 (10014)	71.117 (3027)	9.709 (6822)	0	137 ±9	136 ±7
PM001-18t1	23	176.375 (6623)	35.525 (1334)	9.838 (6822)	0	210 ±17	205 ±12

The fission track length –length standard deviation of the AFT are consistent to the granite without thermal disturbance, which reveals that a slow and steady cooling history in this area. And the central ages do not change with the average lengths, indicating that the thermal histories among different blocks are almost the same. As the sampling elevations increase, part of the AFT central ages decrease, combining with the tectonics in this region, this can be owed to the nappes from east to west.

It is significant that no AFT central age is younger than 10Ma and this may be one discrepancy to previous researches (Zhong et al.), which implies that the uplift of Tibet main body might not exert a strong influence to its marginal mountains as thought previously.

While five ZFT central ages fall into the Cretaceous Era and three into Triassic Era, indicating that they may represent mantle upwelling-induced crustal uplift event. And this can be further confirmed by the geochemical and geochoronological researches on the intrusive rocks.

3 AFT Thermal History Modeling

Due to space limitations, the modeling figures are not presented here. Around 20Ma, the strike-slip faults in Zhongdian-Zhongzan Block may have the ability of uplift. Yidun Island Arc uplifted from north to south. The erosion of large rivers may play a role in the modeling age changes of Yangtz Block.

4 Conclusion

Fission tracks of apatite and zircon and temperature－time modeling exhibited two uplift processes. The first one was recorded by ZFT which happened in the Cretaceous Era and related to the mantle upwelling and thermal effect. The second one was recorded by AFT which happened in the Cenozoic Era and controlled by the compression－shorten deformation process and block slip and rotation process. Estimation of the erosion velocities indicate that the uplift velocities of Zhongzan－Zhongdian Block were fast than Yidun Island Arc and Yangtze Block, and furthermore, the Yidun Island Arc was uplifted gradually from northern to southern.

During the subduction of Indian Plate and Yangtze Plate, under the combined operations of northeastern tectonic shorten, mantle upwelling and lower crustal channel flow, the crust of research area was uplifted heterogeneously and in multistagse. We think that the lower crustal channel flow contributed more than the two others, while the stabilization of deep thermal structure was maintained by mantle upwelling. Although we do not estimate the degree of crustal thickening caused by tectonic compression process, the strong deformation of strata imply that tectonic compression may leads to superposition of the cortical crust or upper crust, and meanwhile the mantle upwelling and lower crustal channel flow mainly acted on the lower crust.

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