地理学报(英文版) 2002年第12卷第3期

A new conception on the formation of the first bend of Yangtze River: its relations with Eocene magmatic activities

作者: ZENG Pusheng

Based on field observations, the author proposes a new understanding on the formation of the first bend of the Yangtze River. The relationship between the formation of the first bend of the Yangtze River and Eocene magmatic activity is expounded, suggesting that the first bend of the Yangtze River is the result from choking of the strong magmatic activity in Eocene. As a result, the upstream became a natural reservoir, whose riverside between Mt. Yulong and Mt. Haba was burst, guiding Jinshajiang River running eastward. At the same time, the drastic uplift of the Qinghai-Tibet Plateau led to the deep dissection of the river cut down the channel, resulting in the formation of the Tiger Leaping Gorge. The magnitude of uplift in the study area (located in the eastern of the Tibetan Plateau) is calculated. Taking Mt. Yulong as a base, the magnitude of lift is 3,300 m from Eocene to Pliocene, adding 700 m since Pleistocene, totaling up to 4,000 m or so.

A new conception on the formation of the first bend of Yangtze River: its relations with Eocene magmatic activities ZENG Pusheng (Inst. of Mineral Resources, Chinese Academy of Geological Sciences, Beijing 100037, China) Abstract: Based on field observations, the author proposes a new understanding on the formation of the first bend of the Yangtze River. The relationship between the formation of the first bend of the Yangtze River and Eocene magmatic activity is expounded, suggesting that the first bend of the Yangtze River is the result from choking of the strong magmatic activity in Eocene. As a result, the upstream became a natural reservoir, whose riverside between Mt. Yulong and Mt. Haba was burst, guiding Jinshajiang River running eastward. At the same time, the drastic uplift of the Qinghai-Tibet Plateau led to the deep dissection of the river cut down the channel, resulting in the formation of the Tiger Leaping Gorge. The magnitude of uplift in the study area (located in the eastern of the Tibetan Plateau) is calculated. Taking Mt. Yulong as a base, the magnitude of lift is 3,300 m from Eocene to Pliocene, adding 700 m since Pleistocene, totaling up to 4,000 m or so. Key words: magmatic activity; choking channel; bursting; Laojunshan Mt.; Yunnan; the first bend of the Yangtze River CLC number: P931.2 1 Introduction The first bend of the Yangtze River is located in Shigu town, Lijiang City, northwestern Yunnan, including the sharp bend zone of the Jinshajiang River extending from Shigu to Sanjiangkou. The Jinshajiang River, runs from north to south to Shigu facing Laojunshan Mt., composed of trachytes and syenites, abruptly turns eastwards to cut through the hard and integrated, non-fractured Paleozoic metamorphic rocks between the Haba Snow Mt. and Yulong Snow Mt., both over 5,000 m above sea level, and flushes down along the Tiger Leaping Gorge (Figure 1). The first bend of the Yangtze River has been extensively studied by many predecessors (Deprat, 1912; Gregory, 1923; Credner, 1932; Ding Wenjiang, 1933; Li Chunyi, 1933; Li Chengsan, 1933; Barbour G B, 1935; Lin Wenying, 1942; Li Shijin, 1945; Misch, 1947; Yuan Fuli, 1957; Ren Mei´e, 1959; Shen Yuchang, 1963; Xu Zhonglu et al., 1982; He Kezhao, 1983; He Haosheng et al., 1983, 1989, 1991; He Kezhao et al., 1991; Zeng Pusheng, 2002). It was generally thought that the first bend of the Yangtze River is a consequence of river piracy of the Yangtze from the Jinshajiang River before the 1950s, and regarded the valley from Baihanchang to Jiuhe to Jianchuan as the paleo-course of Jinshajiang reaching Honghe River (Red River). Nevertheless, from then on, Li Chengsan (1956), Yuan Fuli (1957), Shen Yuchang (1963) and Xu Zhonglu et al. (1982) made suggestions different from "piracy" mentioned above. Li, Shen and Xu all thought that the Baihanchang valley is the result of a glacial denudation, not the paleo-course of Jinshajiang River. Moreover, Professor Li regarded the big bend of the river as an inland river course. On the other hand, after a detailed study on the river and the valley, Professor Ren (1959) made conclusions as follows: the piracy o

f the Jinshajiang River did not happen at Shigu but at downstreams between Xionggu and Hongwen; the valley from Hongwen→Baihanchang→Jiuhe to Jianchuan is the paleo-course of the Jinshajiang River, for it is almost impossible for a small river to produce such a wide course of river, and on both sides of the valley three erosional terraces are found, an old fluvial gravel bed and a series of depressions and lakes remained; piracy of the river occurred in Early Pleistocene or Middle Pleistocene; the big bend of the river is controlled by two sets of faults trending SN and NE respectively. He Haosheng et al. (1991) showed a research conclusion that no piracy occurred in Quaternary whether at Shigu or at Hongwen. By recent field observations in a larger scope, it is found that piracy of the Jinshajiang River does exist, but the mode is special. A uniformitarian process of piracy is difficult to explain some facts existing in this region, e.g. the reason why the Jinshajiang River is able to cut through the integrated and hard rock beds between the Haba Snow Mountain and the Yulong Snow Mountain uplifting just like Laojunshan Mt., and so on. This kind of marvelous spectacle may be derived from the asymmetrical uplift of the plateau in the Southwest Tri-rivers (Jinshajiang, Lancangjiang and Nujiang rivers) region. However, the Lancangjiang River and the Nujiang River have no piracy phenomenon regardless they exist in the same uplifting circumstance with the Jinshajiang River. The direct reason may be attributed to the choked of the course of river by the violent magmatic activity, a kind of catastrophe, in Laojunshan Mt., Jianchuan during Eocene. 2 Geological setting and magmatic activities Laojunshan Mt. region is located at the eastern end of the Qinghai-Tibet Plateau with a sudden turn southwards, and wedged between the Jinshajiang Fault trending near SN and the Hongwen Fault trending NE whose northern part is connected with the Gezahe Fault (Figure 1). Take Shigu as a rough boundary, the western strata are composed of the Proterozoic metamorphic rocks covered by the formation of purple-red melange deposits of Eogene (of which the Eocene is dominated) within Liming to Baoxiangsi, more than 3,500 m above sea level, even the main peak of Laojunshan Mt. up to 4,247 m; the eastern one is comprised of a series of the Paleozoic strata trending near SN or NNE, most of which are superposed as nappe (Wu Genyao, 2000), distributed on the two sides of Jinshajiang River from Shigu to Tiger Leaping Gorge, are also the main part uplifting rapidly, among which the main peaks of the Yulong Snow Mountain and of the Haba Snow Mountain are 5,596 m and 5,396 m respectively. Magmatic activities are distributed in Laojunshan Mt. region and its vicinity, most of them are hypabyssal or super-hypabyssal facies syenite porphyry, quartz syenite, quartz monzonite, granite porphyry, while there is trachyte erupted in the north urban of Jianchuan town. The alkali porphyries, distributing along the Jinshajiang-Red River Fault Zone, are intimately closed to the uplifting of the Qinghai-Tibet Plateau (Chung S L et al., 1998; Deng Wanming et al., 1997, 1998; Lu Boxi et al., 1993; Mo Xuanxue et al., 1993; Zeng Pusheng et al., 1999; Zhang Liansheng et al., 1991; Zhang Yuquan et al., 1987, 1997, 2000), the magmatic activities and corresponding rapid uplift in Laojunshan Mt. is a part of the uplift within the Jinshajiang-Red River Fault Zone. What is directly related to the formation of the first bend of the Yangtze River should be a series of syenite and trachyte around Laojunshan Mt. Duration of the magmatic activities is relatively long, but concentrated at 36.7-31.3 Ma (Table 1). Regionally, along the line of Laojunshan-Taohua-Liming-Xiarou, there exist magmatic activities in the same period, among which the strongest activity is in Laojunshan, Jianchuan, located in the convergence of the two groups of faults, near SN and NNE, may be the center of the magmatic activities at that time. The activities were gradually weakened northward. 3 Relationship between magmatic activities and river channel changes Some inspirations can be got from the characteristics of drainage distribution of the first bend of the Yangtze River. By comparison, the course of the Chongjianghe River (herein refers to the Chongjianghe River through the Tiger Leaping Gorge town, not the one in the west of Shigu), the course of the Jinshajiang River from Xiaqiaotou (the entrance of the Chongjianghe River into the Jinshajiang River) to Xionggu, and the paleo-course of the river from Xionggu, Baihanchang, Jiuhe, Jianchuan to Shaxi, these three parts the river course make up an integrated mass, striking NNE. It is inferred that each of the three sections of the river course shall be one part of the paleo-course of the Chongjianghe River, one of the reasons is that the composition of gravel, in the early stage in the course of river from Baihanchang, Jiuhe, Jianchuan to Shaxi, is very similar to that in the Chongjianghe River, both of them being mainly basalts and sandstones, obviously different from the composition of the gravels, limestone-marble-schist-granite, in the course of the Jinshajiang River. While the river course from Xiaqiaotou to Xionggu is "borrowed" by the Jinshajiang River, resulting in the composition of the gravels in this section of course is reformed by the Jinshajiang River and different from the one in the Chongjianghe River and the one in the river course from Xionggu to Shaxi. The Jinshajiang River runs, in near SN direction, to Shigu has a sharp turn in NNE to Xiaqiaotou; and then extremely disharmoniously takes a abrupt bend into the Tiger Leaping Gorge, between the Yulong Snow Mountain and the Haba Snow Mountain, both of which are primarily an integration, breaking a slot and escaping, forming a "Tiger being able to leap" gorge. The deep valley is about 4,000 m in depth, the cliffs of the gorge are steep, a part of which stands nearly erect, and the surface of the river is only about 4 m in width in low wa

ter season at Hutiaoshi (Tiger Leaping Stone). From Qiaotou to Daju, the gorge amounts to some 40 km long. By repeatedly observations, the strata of the two banks are a continuum; the rocks are integrated and hard, consisting of Paleozoic microcrystal schist, marbles and crystallized limestone, not being broken by faults in EW direction. It is impossible for such a steep, deep, long gorge to be formed by a normal piracy of the drainage system. In contrast, it must be the results of abrupt change of the drainage course, e.g. burst of a weired-lake, rapid uplift to keep the lower reaches of the river to have enough fall head of water to promote the river bed quick dissection. By the characteristics of Tertiary sediments, Paleocene (E1) sediments are outcropped extensively, while Eocene (E2) fluvial and lacustrine facies sediments are mainly concentrated on the south side of Laojunshan Mt. Although the scope of E2 sediments is much larger before erosion than the one at present, it can be seen that, in Eocene, paleo-Jinshajiang River ran southwards through Laojunshan Mt. In Laojunshan Mt. and its vicinity, Eocene (being about 33.1 Ma to 36.7 Ma) alkali porphyries and eruptive rocks (trachyte) are widely distributed, indicating that magmatic activities are intense at that time. According to the characteristics of sediments and magmatic activities, it is inferred that it is just this kind of sudden catastrophic intrusion and eruption of magma, para-synchronous with uplifting of strata, that led to the uplifting and blocking of the river channel, made the upper reaches of the river form a weired-lake, and bursted between the Yulong Snow Mountain and Haba Snow Mountain, dredging the Jinshajiang River flowing eastwards. Blocking of the trachyte in Jianchuan and uplifting in this area make the paleo-Jinshajiang River form a huge natural wiered-lake. The anabranch of the lake shall include the paleo-Chongjianghe River, related to the Ganzi-Litang sutural line. The elevation and closure of the southern part made the surface of water increasingly heightening, leading to the wiered-lake to form a burst in Hutiaojian (Tiger Leaping Valley) between the Yulong Snow Mountain and the Haba Snow Mountain (Figure 2). From then on, water of the river has flowed eastward to converge into the paleo-Yalongjiang River. It seems that the elevation of the region from Haba to Yulong was not as high then as at present, all the same as the situation in Diancangshan Mt. of Dali or Longmenshan Mt. of west Sichuan, which gradually uplifted to form high and steep mountains till Eocene (E2) (Qin Gongjiong et al., 1994; Zeng Pusheng et al., 1999; Wu Genyao, 2000; Luo Yaonan et al., 2001). The bursting place between the Yulong Snow Mountain and the Haba Snow Mountain is not inosculated with so-called "a trench must be a fault". Investigations revealed there is no fault in EW or NE direction along this huge trench, where a set of integrated and hard Late Paleozoic shallow metamorphic rocks (mainly consisting of Devonian phyllites, slates and carboniferous crystallized limestones) formed a composite anticline. Why the Tiger Leaping Valley is so narrow is just attributed to the fact that the banks of the river are firm and the riverbed is rapidly cut down. In light of the features of the river channel, the rate of uplifting is very quick after bursting. The attribution and genesis of the longitudinal valley from Hongwen, Lijiang to Diannan, Jianchuan is one of the key problems about the piracy of the Jinshajiang River. After research, Xu Zhonglu et al. (1982) and He Haosheng et al. (1989, 1991) suggested that, in the valley of the Jinshajiang River, the continuity of the terraces shows the river channel had never been inversed whether in Shigu or in Hongwen in Quaternary; the component of gravels in the valley of the Jinshajiang River is different from that in the valley from Hongwen to Shaxi, with obvious localization, implying it is impossible that the gravels come from the same river; therefore, proposed that the Jinshajiang River is not a consequence of "piracy". Nevertheless, by observation in larger scope, this longitudinal valley is not the paleo-course of the Jinshajiang River indeed, but a paleo-course of the paleo-Chongjianghe River. The evidences and reasons are as follows: (1) The courses of the Chongjianghe River, of the Jinshajiang River between Qiaotou and Hongwen, and of the longitudinal valley from Hongwen to Diannan, make up an integrated mass, wholly appearing in near SN strike; and the widths of the river valleys are similar to one another. The components of gravels in the Chongjianghe River are similar to the ones in the river valley from Hongwen to Diannan, mainly comprised of basalts and sandstones. (2) The Hongwen-Shaxi Fault and the Chongjianghe Fault (whose north end connected with the Gezahe Fault) are different sections of the same fault that is a main boundary fault in the west margin of the Lijiang depression of margin of the Yangtze Platform (Wu Genyao, 2000). After interception by the Jinshajiang River, owing to the differences in hydraulic conditions, the Chongjianghe River in the north shall be different in the characteristics of physiognomy and erosion from the valley from Hongwen to Diannan in the south: the Chongjianghe River shows a V-shaped valley for the continuous cutting downward of flow; while the section of river channel from Hongwen to Diannan forms a U-shaped one under erosion including glacial process, due to the weakening of the hydraulics after the uplifting of the river channel, at the same time, this kind of process makes the early sediments deformed nearly up and be difficult to recognize. Moreover, different parts within the valley from Hongwen to Diannan have different features. Taking Baihanchang as a rough boundary, the north dips northward, belongs to the drainage system of the Jinshajiang River nowadays, with the highest rate of erosion; the section of river channel between the Baihanchang and Jiuhe is nearly levered, with the lowest rate o

f erosion, but the two ends of the valley are the same commodious; while the south of the Jianchuan Basin, dips south ward, belongs to the stream of the Yangbijiang River, with a moderate erosion rate. Consequently, the remnant of the original river course in each section of the channel is different from one another. Relatively, more remnants are sav ed within the plain section, but in Jiuhe, which is nearer to the Yulong Snow Mt and was more notably deformed by gla cier (around Xionggu the layer of moraine gravel can be found), the preserve of remnant of the paleo-course of the ri ver, including gravels, is worse than the Jianchuan Basin.Components of gravels preserved in Liyuan of Dongshan, Jian chuan, are similar to the ones in the Chongjianghe River, predominated by basalts and sandstones. (3) In this regio n, the characteristics of valley can not be explained by a down-faulted valley. By observation in Zhongnancu, Jiuhe, Dongshan, Shaxi, etc., the characteristics of the compressive faults are mainly thrusting or shearing, which is diffe rent from those in extensional basins in Dali or Midu. The same conclusion was suggested by Xu Zhonglu et al. (1982) according to the research in Jiuhe. Regionally, environment within Jianchuan and Lanping is generally strong compress ive, in Lanping, thrust structure leads to an altitude of shortening up to 40 km in EW direction (Qing Gongjiong et a l., 1994). Under such a strong compressive tectonic background, it is impossible to form a down-faulted valley as lar ge as the one from Hongwen to Diannan. In other words, it is impossible for the Hongwen-Diannan longitudinal valley t o be a down-faulted valley. According to the analysis mentioned above, the piracy of the stream does exist, but the m ode of piracy is different from that of traditional consideration, and the time of piracy is also different. The tim e of "piracy" should be earlier than Pleistocene. In fact, the main channel of the paleo-Jinshajiang River, once flow ed southward, is not located in the valley from Shaxi to Hongwen. It is shown by the distribution of strata that the main channel of the river may be more accessible to the west, passing through Laojunshan Mt. Therefore, it can be tho ught that the time of piracy should be earlier than that (Early Pleistocene or Middle Pleistocene) proposed by Profes sor Ren Mei´e (1959). There is no other record of piracy during Eocene to Pleistocene, then it seems to be reasonabl e to take the duration of Eocene magmatic activities as the duration of piracy (it is transient from being wiered of the river channel to bursting, and neglectable). It should be noted that, even though this speculation is correct, i t is difficult to preserve the track records of Eocene piracy of stream (including volcanic clastic sedimentation) be cause of a rapid uplifting and erosion in this region; therefore, during the field observation, it is difficult to fi nd a direct evidence supporting this speculation. Instead, what preserved more is record of the river channel since P leistocene. 4 Estimation of the magnitude of uplift in Laojunshan 4.1 Constraints for estimation Along the line from Shaxi (in the southwest of Jianchuan), through Laojunshan Mt., to Liming, there was ever a rapid depression at Eocen e (E2); then a rapid uplift after that time. Evidences are as follows: Baoxiangsi formation (E2b) red bed, being shor t of the strata from Cambrian to Cretaceous beneath it, directly covers above the metamorphic rocks of Late Proterozo ic Shigu Group (Pt3sh). E2b purplish red gypsum- and salt-bearing sandstone is large in thickness, over 1,000 m; wher eas no sediments occurred after E2b, accompanied by a strong magmatic activity. It is indicated that at Eocene the Sh igu Group metamorphic rocks, with a long term erosion since Paleozoic, were subjected to a rapid depression, and wer e uplifted after Eocene. The occurrence of the strata is nearly level in a large scope (from Liming to Baoxiangsi), i ndicating that a vertical ascend is dominated in this region since Eocene, while the tilt of the strata for lateral c ompression or thrust is little (Figure 3). Therefore, the difference, between the elevation of strata (E2b) and of th e surface of river at present, can be approximately regarded as the altitude of uplifting. Laojunshan alkalic rocks i ntruded E2b strata; and xenoliths of purplish red sandstone (E2b), some of which have decolored to be yellowish gree n, can be seen in the boundary of intrusive rocks. Age of the magmatic activities is 33.1-36.7 Ma, herein uplifting m ay be roughly regarded as commencing at the end of Eocene (35 Ma BP). 4.2 Result of estimation Based on the understan ding above, the altitude of uplifting in this region can be roughly estimated. The terraces of the Jinshajiang River have as many as 7 levels (He Haosheng et al., 1991), of which the highest one (situated in Jinjiang, Sanxiangu, with an elevation of 2,300 m) is higher than the surface of the Jinshajiang River for 700 m, which can be regarded as the lower limit of Early Pleistocene, about 2 Ma (He Haosheng et al., 1991). The highest peak in the Yulong Snow Mt is wi th an elevation of 5,596 m. It is conservatively estimated that the Yulong Snow Mt should be uplifted for at least 3,300 m (herein the main peak descended by erosion is not considered). Adding 700 m since Pleistocene, it is amount t o at least 4,000 m of uplifting from Eocene on. The rate of uplifting is not estimated here, and further work needs t o be done. 5 Conclusions Based on the above study, it is concluded that: (1) The first bend of the Yangtze River is t he result of a "catastrophic event" of strong magmatic activities in Laojunshan Mt. at Eocene (about 35 Ma BP), just like a strobe making the paleo-Jinshajiang River, including the paleo-Chongjianghe River, be choked to form a wiered-lake, and having a burst between the Yulong Snow Mt. and the Haba Snow Mt. (2) The section of longitudinal valley fro m Hongwen, Lijiang to Diannan, Jianchuan (adding the channel of the Jinshajiang River) was ever the paleo-course of t

he Chongjianghe River. (3) The altitude of the Yulong Snow Mt. was at least 3,300 m from Eocene to Early Pleistocene, adding 700 m since Early Pleistocene, the total amount of uplift is at least 4,000 m since Eocene. References Chung S L, Lo C H, Lee T Y et al., 1998. Diachronous uplift of the Tibetan Plateau starting 40 Myr ago. Nature, 394: 769-773. Deng Wanming, Huang Xuan, Zhong Dalai, 1997. Alkali porphyries in the west of Yunnan and its relationship to intracontinental deformation. Science in China (D), 28(2): 111-117. (in Chinese) Deng Wanming, Huang Xuan, Zhong Dalai, 1998. Petrologic characteristics and genesis of Cenozoic alkali porphyries in the west of Yunnan. Chinese Journal of Geology, 33(4): 412-425. (in Chinese) He Haosheng, He Kezhao, Jiang Fuchu et al., 1991. On the piracy of the Jinsha River in northwestern Yunnan. In: Chen Huahui et al. (eds.), Collected Papers on Quaternary Geology in Some Regions of China. Beijing: Geological Publishing House, 25-35. He Haosheng, He Kezhao, Zhu Xiangmin et al., 1989. Study on the piracy of the Jinshajiang River. Modern Geology, 3(2): 319-330. (in Chinese) He Kezhao, He Haosheng, Zhu Zhaoyu et al., 1991. The establishment of the Holocene sequence of the Jianchuan basin, Yunnan. In: Chen Huahui et al. (eds.), Collected Papers on Quaternary Geology in Some Regions of China. Beijing: Geological Publishing House, 45-52. Li Chengsan, 1956. History of the Yangtze River. Yangtze River, 10. (in Chinese) Li Chunyi, 1933. Development of the upper Yangtze River Valley. Bulletin of Geological Society of China, 13. (in Chinese) Lu Boxi, Wang Zeng, Zhang Nengde et al., 1993. Granitoids in Sanjiang Region and Their Metallogenic Specialization. Beijing: Geological Publishing House. (in Chinese) Luo Yaonan, Yu Rulong, 2001. Major features and dynamic model of the Himalayan tectono-magmatism in the intracontinental orogenic belt in Longmenshan-Jingpingshan mountains. In: Chen Yuchuan et al. (ed.), Study on Himalayan Endogenic Mineralization. Beijing: Seismic Publishing House, 88-95. (in Chinese) Misch P, translated by Li Pu, 1947. Geology of Lijiang. Peking: National University of Peking. Mo Xuanxue, Lu Fengxiang, Shen Shangyue et al., 1993. Sanjiang Tethyan volcanism and related mineralization. Beijing: Geological Publishing House, 267. (in Chinese) Qin Gongjiong, Peng Sizhen, 1994. Equilibria Cross section of the thrust-detachment structure of Himalayan in Lanping district. Yunnan. Modern Geology, 8(2): 177-186. (in Chinese) Ren Mei´e, Bao Haosheng, Han Tongchun et al., 1959. The Jinsha River valley landforms and river-capture in northwestern Yunnan. Acta Geographica Sinica, 25(2): 135-155. (in Chinese) Shen Yuchang, Yang Yichou, 1963. New research on the problem of river-capture of Ching-Sha-Chiang (the upper Yangtze), western Yunnan, China. Acta Geographica Sinica, 29(2): 87-108. (in Chinese) Tu Guangchi, 1982. Preliminary study on the two alkali porphyry belts in the south of China. In: Annual Report of Guiyang Institute of Geochemistry, CAS. Guiyang: Guizhou People´s Publishing House, 127-129. (in Chinese) Wu Genyao, 2000. Stratigraphy of Orogengy. Chengdu: Sichuan Science and Technology Press. (in Chinese) Xie Yingwen, Zhang Yuquan, Tu Guangchi, 1984. Preliminary study on chemistry and metallogenic specialization of the Ailaoshan-Jinshajiang alkali intrusive rock belt. Journal of Kunming College of Technology, (4): 1-17. (in Chinese) Xu Zhonglu, Li Xingjian, 1982. On the origin of the longitudinal valley between Hongwen Village and Diannan Village, NW. Yunnan, and the discussion on the river capture of Jinshajiang. Acta Geographica Sinica, 37(3): 325-334. (in Chinese) Yang Jianmin, Xue Chunji, Xu Jue et al., 2001. Geological features and mineralization of the Himalayan alkalic porphyry in western Yunnan. In: Chen Yuchuan et al. (ed.), Study on Himalayan Endogenic Mineralization. Beijing: Seismic Publishing House, 57-68. (in Chinese) Yuan Fuli, 1957. A complementary study of evolution history of the Yangtze River. Yangtze River, (2). (in Chinese) Yunnan Bureau of Geology and Mineral Resources, 1990. Regional Geology of Yunnan Province. Beijing: Geological Publishing House. (in Chinese) Zeng Pusheng, Yang Weiguang, Yu Xuehui, 1999. Alkalic porphyry belt in western Yunnan and its relation to gold mineralization. Acta Geoscientia Sinica, 20(supp.): 367-372. (in Chinese) Zeng Pusheng, 2002. Relationship between the formation of the first bent of Changjiang River and the magmatic activity in Liaojunshan district. Acta Geographica Sinica, 57(3): 310-316. (in Chinese) Zhang Liansheng, Zhong Dalai, Liu Xiaohan, 1991. Tectonic relationship between Jinshajiang suture and Red River fault. In: Annual Report of Open Research Libratory of Tectonic Evolution of Lithosphere, Institute of Geology, CAS (1989-1990). Beijing: China Science and Technology Press. (in Chinese) Zhang Yuquan, Xie Yingwen, Li Xianhua et al., 2000. Isotope characteristics of magmatic rocks of shohsonitic series in the eastern of Tibetan Plateau: petrogenesis and tectonic significance. Science in China (D), 30(5): 493-498. (in Chinese) Zhang Yuquan, Xie Yingwen, Tu Guangchi, 1987. Preliminary study on alkalic porphyry belt in the Ailaoshan-Jinshajiang and its relation to the rift tectonics. Acta Petrologica Sinica, (1): 17-25. (in Chinese) Zhang Yuquan, Xie Yingwen, 1997. Geochronology of alkalic intrusive rocks in Ailaoshan-Jinshajiang region and its isotope characteristics of Nd, Sr. Science in China (D), 27(4): 289-293. (in Chinese)

关键词： magmatic activity; choking channel; bursting; Laojunshan Mt.; Yunnan; the first bend of the Yangtze River

