云南小江流域第四纪环境变迁与泥石流发育史

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前　言

中国是一个多山的国家，山地面积约占国土总面积的 2/3 以上，这些富饶美丽的山地环境历来就是我国人民赖以生存的主要地域之一。但是，由于我国山地所处的地理位置和所具有的山高坡陡，起伏剧烈的地貌特征，以及在季风气候驱使和人类活动的影响下，山区自然灾害频发，因灾损失严重。在众多的山地自然灾害中，泥石流乃是其中一种具有暴发突然、危害较大的灾害类型，已经成为我国山区防灾减灾的主要对象之一。自 20 世纪 90 年代启动的国际十年减灾行动以来，人类为解决面临的一系列重大而紧迫的全球问题进行了奋力探索，同时人类为减轻自然灾害、改善自己生存环境也做出了卓有成效的工作。不少实例表明，在山地形成演化过程和山区河谷地貌发育过程中，泥石流活动对地表的塑造和加积作用占有主要的地位，刻划下显著的烙印。为此，我们选择了小江流域这一我国泥石流活动的典型地区作为我们的研究区域，并将认识这一区域的泥石流灾害在山地演化过程中的形成与发育历史作为我们的研究目标，以期对了解我国南方山地泥石流的发生、发育过程有所裨益。

在本项目的研究过程中，得到了李吉均院士、杜榕桓教授的精

心指导。朱俊杰教授、张林源教授、崔之久教授给予了许多热情的帮助，提供了有益的意见；在云南小江流域野外考察期间，东川泥石流观测研究开放实验站的田连权研究员、张军副研究员以及站上的许多老师和同志的大量的支持和帮助；兰州大学分析测试中心的吴珍宜老师帮助作了 ESR 信号的分析测定；沙漠所孙忠同志测定了第四纪地层和山原红壤的化学元素含量；张宇田工程师、曹继秀高级工程师作了有机碳^{14}C 的年代测定；马玉贞讲师、潘安定博士作了孢粉的分析鉴定；陈发虎、周尚哲、潘保田和方小敏、陈怀录、王开学、王爱民以及张叶春、陈晔、王建民、马海洲、康世昌、杨咏春等同行和学友给予了不少的帮助。统志于此，特向他们表示诚挚的感谢！

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2002 年 1 月 28 日

云南小江流域第四纪环境变迁与泥石流发育史

摘　要

本文系统探讨了云南小江流域第四纪山地环境演化过程中泥石流灾害的发生与发展历史。根据该流域内第四纪地层、新构造运动、地貌发育过程的研究，结合 ESR 测年、山原红壤发育年龄的计算、孢粉分析、X 荧光光谱分析等第四纪环境研究的多种分析测试方法和手段，以及由此恢复重建的第四纪泥石流活动史的记录和其它古环境要素的系统信息，经综合分析得出以下基本认识。

(1)经过第四纪初的云南运动(青藏运动 B 幕)之后，新第三纪末期的云南准平原面发生一定程度的抬升。位于云南准平原东北部的小江流域地区内，断裂带上的局部地块出现明显的下陷形成湖盆，地面流水侵蚀作用逐渐活跃，地表物质迁移以流水侵蚀搬运过程为主，沉积作用较为缓慢，仅在新村盆地和云南准平原面上的洼地(拖布卡盆地等)内沉积有以河湖相为主的下早更新统地层。

(2)经过早更新世早期地表流水的长期侵蚀切割，至早更新世中期，小江流域内沟谷发育，地面起伏，1.6 Ma B. P. 的元谋运动

(青藏运动 C 幕)之后,地面高差进一步加大,坡面松散物质增多,流水侵蚀作用更加活跃,这时小江流域内开始了第一泥石流活动期。初期的泥石流活动强度较小,以稀性泥石流为主,泥石流沉积仅局限于沟谷上游的现在位于海拔约 1 900 m 高程的谷源盆地(多照盆地)之内,而地面的较细物质则主要汇集于流域中心的各断陷盆地(如新村盆地),并沉积发育形成河湖相地层。

(3)早更新世中期末,约 1.10 Ma B.P. 发生金沙江运动,云南高原进一步抬升,金沙江沿线各湖盆洼地间流水向源侵蚀加剧,各湖泊相继贯通,金沙江形成并出现迅速下切。伴随这一过程,位于小江流域北部的金沙江支流迅速南伸,逐渐将流域内的各断陷湖盆沟通,小江出现,流域内流水侵蚀由此更加活跃,地面坡度进一步加大,坡面物质运动增强,到晚早更新世初期,第二泥石流活动期出现。由于小江水系形成,断陷湖泊的湖水外泄,细粒物质随水输入金沙江,断陷盆地内河湖相沉积结束,泥石流堆积范围向流域中部扩张,第二泥石流活动期内的以稀性和粘性泥石流为主的泥砾沉积不但在各谷源盆地内继续进行,而且在流域中部的断陷盆地内也开始出现。

(4)至早更新世末期,位于云南高原西北方的青藏高原经过青藏运动之后,地壳厚度急剧增大,在印度板块继续北上的强大挤压力之下,巨厚的青藏地块东南侧的康滇菱型块体发生向东南方向的压扭性走滑。进入中更新世之后,当巨厚的青藏地块处于以均衡作用为主控制下出现迅速的上升期间,其强烈隆升波以脉动的形式通过向东南走滑的康滇菱型地块向云南高原传播,导致小江流域内各断陷盆地收缩,地面出现明显的间歇性抬升。与此过程相伴随,流域内的河谷流水多次快速下切,山地地貌明显升高扩展,地面高差进一步增大,以亚粘性、粘性为主的泥石流活动十分频繁,到中更新世末期,第三至第五泥石流活动期相继发生,并分

别在小江两侧海拔高程为 1 250～1 750 m 的阶梯状谷坡上沉积有三级泥石流堆积台地(上鸡冠石、下鸡冠石和泥得坪台地)。

(5)中更新世晚期,小江流域内雪岭周围山地已上升到海拔 3 300 m以上的高度。倒数第二次冰期期间,小江流域上空的冰川平衡线高度降至海拔 3 200 m 左右,小江流域内出现第四纪海洋性山岳冰斗冰川活动,形成海拔 3 150 m 地带上的侧碛堤地貌。晚更新世期间,山地高度进一步增大,大理冰期时的冰川活动范围有所扩大,形成以冰斗和侧碛堤为主的多种冰川地貌。由研究程度较高的末次冰期气候状况显示,冰期中北半球西风环流扩展南移,青藏高原南侧的南支西风常年存在。冬季,该气流强盛,气候少雨干旱;夏季,势力有所减弱的南支西风气流与北上的西南季风辐合形成锋面,在小江流域上空产生一定的降水,因此,冰期中小江河谷内的年降水量仍可达 250～450 mm。在这种气候状况下,山高坡陡、坡面物质运动强烈的小江河谷内仍有一定的泥石流活动。同时因冰期中河道径流减少,泥石流的大量泥沙难以输送,泥石流堆积十分旺盛,致使晚更新世期间第六泥石流活动期内以泥石流堆积过程为主形成的堆积台地(如达朵台地)高达 200 余米。

(6)进入全新世以后,随着气温回升,降水增多,地表径流逐渐活跃,至 7.0 ka B. P. 左右的气候最宜时期,小江河谷洪水高涨,沿江两岸的松散物质被搬运输移,厚达 10 余米的褐色淤泥层直接沉积于基岩之上。自此之后,气候在炎热湿润与温暖干旱的波状起伏中渐趋温热少雨,小江河谷内泥石流活动与堆积逐渐成为地表物质迁移过程中的最主要形式,以粘性、高粘性为主的泥石流堆积扇在小江两岸广泛发育,河谷内砾石成片,砂石化现象日益明显。历史时期以来,人类活动加剧,地表植被减少,坡面松散物质的迁移更加容易,泥石流活动逐渐增强,泥石流活动进入了全新世以来出现的第七泥石流活动期内的一个高潮期之中。近代历史时期以

来，自 1833 年的强烈地震之后，小江流域的泥石流又转入了一个暴发频繁、活动剧烈的高峰期。此后，泥石流经历了百余年的活动高峰，泥石流活动逐渐平缓并趋近于全新世期间内泥石流活动高潮期的平均状况。目前，由于人类活动的影响，小江流域的泥石流又有所增强，至今的活动仍然较为强烈。

Research on Quaternary Ehvironmental Changes and Debris Flow Development in the Xiaojiang River Basin of Yunnan Province

Abstract

In the treatise, the process of forming and developing of debris flow disaster has been systematically researched on quaternary mountain environment changes in the Xiaojiang River Basin of Yunnan province. By the way of synthetical studying, the following knowledge has been achieved according to the resumed record of quaternary debris flow process and systematic informations of paleoenvironment essential factors on the basis of field investigations of quaternary layers marks of neotectonies, evolution of landforms, and indoor ESR dating, Counting age of quaternary red-soil growth, Spore-pollen analysis, Radio carbon (^{14}C) dating, X-ray spectroscope analysis and other measuring methods in studying paleoenvironment.

(1) The Xiaojiang river basin in the northeast part of the Yunnan Peneplain, subsequent to undergoing the Yunnan Movement (Tibet morphogenic movement B act, about 2. 5 Ma B. P.), was occured to a certain degree of uplift and some massifes

alongside fault zone were sunk clearly to form lake basins. Erosion of surface running water was gradually stimulated, erosion and transportation of running water were man in surface earth movement and sedimentation was comparatively slow. There were merely fluvial-lacustrine sedimentary strutumes, the lowest layers of early pleislocene series, to be deposited in the Xinchun fault basin and depressions on the Yunnan Peneplain.

(2) By the middle stage of early pleistorcene, the Xianjing river basin, through long times of erosion of suface running water during early stage of early pleistocene, there were many gullys and ground was rising and falling. After the Yuanmong Movement (Tibet morphogenic movement C act, about 1.6 Ma B. P.), ground was more rising and falling, loose earth on sloping land was more increasing and erosion of running water was more active. Then and there, the first debris flow act period took place. The debris flow of initial stage moved about in relatively poor intensity and watery debris flow merely in basins up gully, such as the Douzhao basin, whose altitude is about 1 900 m a. s. l. now and the fine earth on ground was mainly deposited in fault lake the middle part of the Xiaojiang river basin, such as the Xinchun basin, to form fluvial-lacustrine sidementary lagers.

(3) While the Jinshajiang Movement occurred about 1.1 Ma B. P., the Yunnan Peneplain was furtherly uplifted and running water among various lakes alongside paleo-Jinshajing eroded to the source to be intensified to link up these lakes, the Jinshajing river was formed to quickly cut down, slopes of ground were fur-

therly increased and movement of earth on sloping land was more active, the branch on the paleo-Jinshajiang river below the Xiaojiang valley quickly stretched to the south and gradually linked up various fault lakes to form the Xiaojiang river. Thereupon, erosion of running water was more active in the Xiaojiang river basin and the second debris flow act period appeared by dawn of the last stage of early pleistocene. Because the Xiaojiang river system had been constracted to drain water and earth into the Jinshajing river to bring debris fluvial-lacustrine sidementation finished in fault lakes, and in the second debris flow act period, quality of which was mainly watery and sticky, was not only deposited in basins up gullys and also in fault basins in the middle of the Xiaojiang river valley.

(4) By the end of the early pleistocene after undergoing the Tibet morphogenic movement C act, the Tibet plateau which lies on the northwest of the Yunnan Plateau, plate thickness of which with powerful pressure in India plate being continually moved up had been maximumly extended and the rhomboidal Kandian mass in the southeast of the Tibet plateau occurred to slide toward the southeast in the nature of press and twist. Since the middle pleistocene, when the tremendous thick Tibet plate appeared to be quickly uplifted in a main state of isostasy controling, strong uplifting waves of which expanded to the Yunnan plateau in the course of that the rhomboidal Kandian mass was slided to the southeast in the form of pulsetion, various fault lakes in the Xiaojiang river basin were pressed to lead to contract and ground appeared obviously uplifting in the form of intermit-

tence and river quickly cut down many times and mountainal land went up and expanded, and degrees of sloping ground was more increasing and debris flow, nature of which was mainly watery and sticky, moved about very briskingly. By the end of the middly pleistocene, the third, fourth and fifth mud-rock flow act peroids continually took place and formed three steps of platform of debris deposited beside the Xiaojiang river on three steps of laddery sloping field of 1 250～1 750 m a. s. l. (upper shanjiguanshi, Under Xiajiguanshi and Lidiepin platform).

(5) In the last stage of the middle pleistocene, the mountains about the Xueling Peak in the Xiaojiang river basin had been uplifted above 3 300 m a. s. l. During the penultimate graciation, the snow line height dropped to 3 200 m a. s. l. about and there were some marine alpinecirque glacier appearing to move about and form flank moraine landform on sloping field about 3 150 m a. s. l. By the last plistocene, altitudes and areas of the mountains were increased. During the Dali glaciation (last glaciation), limits of glacier exersising were expanded to form Cirque and flank moraine which were mainly in varied grlaciatal landforms. According to showing of last glaciation climatic condition which is more clearly to be studied, In the glaciation the westerlies was expanded on the morthern hemisphere extensive in mean temparature falling of the globe, the southwest monsoon from southern sea advanced up to the middly belt of the Yunnan Plateau to form front with the southern jet stream which perennially existed and occurred process of precipitation in glaciational summer, and there was about 250～450 mm of annual precipita-

tion in the Xiaojiang river valley. In that climate condition, there were some debris flows moving about in the Xiaojiang river valley where the mountains were high, the sloping field was steep and surface earth moving on ground was intense. Meanwhile, runoff was decreased in river, vast amount of debris was difficulty to be transported and depesitation of debris flow was very vigorous and led to the height of deposited platform were about 200 m during the sixth debris flow act period in the last pleistocene (e. g. Dadou platform).

(6) After having entered the Holocene, along with temperature picking up and precipitation increasing, runoff of ground gradually activated again. By the Altithermal about 7. 0 ka B. P. flood was highly risen in the Xiaojiang river valley, loose earth on the banks of the river was transported and drab silt about 10 m thick was directly deposited on bedrock. Henceforth, climate in alternately waving of blazing-humid and warm-aired was gradually changed to warmhot-modicumal rain, debris flow acting was progressively truned into the most impontant form in process of surface earth transporting, deposited fans of debris flow which was mainly sticking and high sticking were widespreadly grown on banks of the river and there were many gravels to be formed gravel desert in bottom land of the Xianjiang river valley. Since history period, action of mankind is more intense, vegetation on ground is decreased, loose earth moving on sloping field is easier, brisking of debris flow is increased day by day, the spread of sandy-stoney land, as the humid-desertification phenomenon was increasingly obvious and exercise of debris

flow is in the stage of high tide of the seventh mud-rock flow act period which appeared during the Holocene. Since the modern history, debris flow, after the viotent earthquake in 1833, has entered a hight strung stage again, and involved a fierce action of which was more than a hundered years. Thenceforth, action of debris was gradually gently and tended to a average condition in high tide in the Holocene. Now debris flow in the Xiaojiang river basin are stengthened to be even stronger condition with the influence of human action again.

目　录