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三江并流区地貌与环境效应

The Landform Development and Environmental Effects of Three Parallel Rivers

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内 容 简 介

全球变化及其区域影响是当今地球系统科学等研究的热点问题。横断山纵向岭谷的三江并流区，是青藏高原和云贵高原的交界地带、世界生物多样性重要的典型代表区、长江第一弯成因和金沙江水系发育等研究的热点所在地、中国面积最大的世界自然遗产地和水电开发争议焦点地区等，也是我国地学研究十分关注的地区之一。

本书系作者多年来承担多个科研项目在三江并流区研究的部分成果总结，是一本较为系统阐明三江并流区地貌发育与环境效应的重要专著。全书分为七章，分别论述了三江并流区地貌与环境演化效应研究进展及意义、地貌发育与环境演化的地质基础、河谷地貌特征与主要类型、晚新生代以来的环境演化、西南季风与三江并流区气候环境演化、纵向岭谷地貌及其生态与环境效应、干热河谷的特征及成因。

本书内容丰富，资料翔实，有新观点和新进展，对研究横断山区地貌与环境问题具有重要的参考价值，可供地学及相关专业技术和研究人员参考。

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中文摘要

怒江、澜沧江、金沙江三条大河在云南西北部紧密相邻，并列南流，构成独特的横断山纵向岭谷区，被称之为三江并流区。该区地处我国青藏高原东南部及东南部边缘，是研究青藏高原东南部、云贵高原西北部自然环境演化及青藏高原隆升对云贵高原自然环境演化影响的关键地区。

纵向岭谷区北部的河谷地貌，具有如下特征：①突出的纵向岭谷，构成了绝无仅有的三江并流奇观；②地貌相对高差大，河谷深切；③河谷地貌受地质构造特别是断裂构造的控制；④流域内的地貌类型及地貌组合多样化特征突出；⑤河谷地质、地貌环境具有较强的生态脆弱性；⑥河谷支流水源多发源于高山湖泊，两岸支流河谷分布不均匀。该区群山高耸、河谷深切、峡谷群聚，是横断山区及我国峡谷地貌密集分布的典型代表区。作者对该区河流峡谷进行了广泛调查研究，并着重论述了金沙江虎跳峡的成因和形成时代。认为玉龙—哈巴雪山为一相对完整的块状山体。金沙江虎跳峡的发育非构造控制沿断裂发育的峡谷，仅用河流溯源侵蚀原因也难以取得合理的解释。虎跳峡上下段河谷层状地貌是连续分布的，说明虎跳峡上下游河谷发育是同时代的，它是先成河在构造抬升背景下河流下切叠置而成的。依据玉龙雪山冰川发育年代、丽江盆地湖相沉积年代、点苍山更新世沉积物分布及年代、河谷阶地或宽谷面哺乳动物化石的测年数据等，初步判断虎跳峡峡谷地貌形成于中更新世以来的河流深切时期。昆黄运动是该区地貌和水系发育的重要转型事件。

云南夷平面因受青藏高原隆升、本区活跃的新构造运动等的影响，在纵向岭谷区的北部发生了位移、解体，导致现今各地分布于不同海拔高度上，即便在同一地区，在断裂两侧其分布海拔高度也很不一致。虽然在总体分布上因受青藏高原隆升牵引带动作用而造成自西北向东南海拔高度降低的趋势，但仍呈现出纷繁杂乱的分布格局。根据夷平面的分布及其上有无残存的早第三纪红土状风化壳的状况分析，提出了本区晚新生代以来存在着与青藏高原相对应的山顶面、主夷平面两期夷平面的观点。依据本区的相关沉积和与邻区的对比分析，认为山顶面大约形成于 23Ma BP 的渐新世晚期，主夷平面大约形成于上新世初，即约在 3.4Ma BP 以前，后因横断运动而导致解体。现今夷平面、相关盆地沉积、各江河多级阶地的发育，均说明纵向岭谷区北部三江并流区地貌演化也是多阶段间歇抬升的结果。

长江第一弯成因向来都有河流袭夺说与非河流袭夺（构造适应）说之争。其实，长江第一弯的形成与纵向岭谷区北部及云南水系演化息息相

关。纵向岭谷区北部及云南地区水系，经历了上新世末期以前的外流水系、上新世末至早更新世早期的内陆河湖水系、早新世晚期以来的外流水系和现代水系发育等几个阶段。中更新世晚期，本区地应力发生了由北西向变为近南北向和北东向的转换调整，造就了青藏高原东南部 8 条近东西向展布的隆起，成为一些江河的分水岭，迫使原南流的金沙江流路被阻，沿着金沙江在三江口处被袭夺了的古水洛河废弃河道反向流动。长江第一弯是古水洛河、古冲江河、古金沙江上游等河流的汇流口。

纵向岭谷北部三江并流区新生代以来的地貌经历了晚始新世至渐新世末的挤压对冲、盆地反转，渐新世末至上新世的剥蚀夷平准平原化，上新世末至早更新世早期的强烈抬升形成高原，早更新世末至现代的差异隆升、纵向岭谷发育等几个阶段。受青藏高原隆起、亚洲季风系统形成演化、横断山脉发育等因素的影响，本区的气候环境经历了早第三纪的亚热带信风气候、晚第三纪古季风气候、第四纪现代季风气候等几个时期。

构造地貌、气候、水系等的演化，导致本区形成了独特的地-气-水-生等耦合自然系统，相应地在本区出现了早第三纪的亚热带干热植被、晚第三纪的湿润半湿润森林植被、第四纪以来的亚热带森林地带性和河谷-山地垂直自然带植被等景观。纵向岭谷的通道-阻隔、高梯度效应和局地环境的复杂性，使本区成为中国乃至世界最为丰富的生物多样性地区和亚洲大陆多种生物物种分化和起源的中心。在全球变化背景下，纵向岭谷北部三江并流区生态环境演化的趋势，对本区生态、社会、经济的影响既有利也有弊，应正确处理好该区人地关系，进行产业结构调整，注重生态建设。

西南季风作为亚洲季风系统的重要组成成员，其形成演化受欧亚大陆与印度次大陆两大板块会聚碰撞改变的海陆格局、青藏高原隆升等的影响，大约在 8.5Ma BP 时完成了由古海陆风到西南季风的转型。西南季风对纵向岭谷北部三江并流区自然环境形成与演化起到十分重要的作用。西南季风形成演化深受纬度、太阳辐射、海陆变迁（边缘海）、青藏高原形成和演化、热带海洋等因素的影响，而较少受“冰量周期”的影响，演化周期以 41ka 和 23ka 周期为主，水汽输送以纬向为主，盛行风向为西南风，有明显的干季和雨季之分。在早更新世时期，因青藏高原海拔较低，阻挡作用有限，西南季风随横断山脉抬升而增厚，受西风急流南支的导引、东亚季风较弱和阻隔作用不强等因素的影响，西南季风影响我国西南、华中、华北等较大的区域范围。进入中更新世以来，随着青藏高原隆升加快，高度增加，对西南季风气流阻挡作用增强，开始出现西南季风和东南季风对我国第四纪自然环境影响力的转型事件，西南季风影响区域范围有所减小，逐渐退缩到长江上游以南的西南地区和青藏高原的东南部地区。

纵向岭谷的特殊地貌空间分布格局，使该区具有明显的通道——廊道、阻隔——屏障效应以及河谷-山地的高梯度效应（包括能量、降水、气候、地貌、自然带谱、资源赋存和利用、人文社会经济活动、人居环境等的高梯度效应和局地的地-气-水-生-人的耦合效应）。同时，也是形成该区较为突出的干热河谷特殊的地生态现象的主要因素之一。干热河谷具有生态地理环境脆弱、现代地表过程活跃、植被生态系统退化、下干上湿和下热上凉的气候、植被结构单一和旱生特征突出等生态地理特征。干热河谷的形成，不是仅由焚风效应或山谷风局地环流所导致的那么简单，也决不是人类活动干扰而衍生出来的地生态现象，而是多因素叠加复合所导致的。地史演化是其成因的基础性因子，大气环流是其成因的外动力因素，人类活动是其加剧或遏制生态恶化的影响因子。干热河谷的形成是构造—地貌—古生态效应、环流—季风—“狭管”效应、地形波—降水—局地环流—焚风效应、植被—土地利用—人类活动—加剧效应等的综合产物，主要性质是原生性的地生态现象。

关键词：纵向岭谷区；云南夷平面；长江第一弯；西南季风；通道-阻隔效应；高梯度效应；干热河谷；三江并流区

The Landform Development and Environmental Effects of Three Parallel Rivers

Abstract

The area of Three Parallel Rivers through which Nujiang River, Lancangjiang River and Jingshajiang River flow parallel from north to south, is regarded as unique Longitudinal Range-Gorge Region (LRGR) in Southwest China. This area includes south-eastern part and fringe of Tibet Plateau. It is a key area not only to study natural environment evolution of southeastern Tibet Plateau and northwestern Yungui Plateau but also to unveil the response of environmental variations of Yungui Plateau to uplift of Tibet Plateau.

Fluvial landforms in the north part of LRGR are characteristic with: ①unique marvelous three parallel river spectacle consisting of outstanding longitudinal range-gorges; ②intense relief and deep incision of river; ③tectonics (especially fault) control on evolution of gorge landforms; ④diversities of landforms and their assemblements; ⑤ecological vulnerability of geological and geomorpholgocial environment systems; ⑥uneven tributary distribution of both sides of rivers deriving from plateau lakes, and so on. It is a typical representative area characteristics by high mountains, deep incision gorges, as well as assemblement of mountains and gorges in Hengduan Mountains even all river valleys in China. Based on investigations carried out in the whole area and focus on ages and causes of Hutiaoxia Gorge in Jingshajiang River, the results conclude that Yulong-Haba snow mountain is an almost integrated block and Hutiaoxia gorge reach of Jinshajiang River does not develop along the faults controlled by tectonics, headward erosion is not also responsible for this spectacle. The continuous extension of gorge layered landform surfaces from upper reach to low reach indicates that the identical layered landforms of upper reach and low reach are synchronous. The first bend of Yangtze River is not a bend due to river capturing but the junction of paleo-Shuilou River, paleo-Chong River and paleo-Jinshajiang River. The Hutiaoxia Gorge is shaped by incising downward antecedent stream bedrock under the background of tectonic uplift. Based on the ages of Yulong snow mountain glaciers, lacustrine sediments in Lijiang Basin, Pleistocene sediments in Diancangshan, mammalian fossils on terraces or dale surfaces, we primarily infer that the landforms in the Hutiaoxia Gorge formed by river incision since Middle-Pleistocene. Kunlun-huanghe Movement is a transformational event to trigger the evolvement of landforms and drainages.

Impacted by uplift of Tibet Plateau, as well as active neotectonics, the planation surface in north Longitudinal Range-Gorge Region was displaced and broken down into several pieces with different levels by local tectonic movement and Tibet Plateau uplift. Even in the same region, the heights of the surfaces at both sides of a fault are not identical. As a whole, the

planation surface descends towards southeast due to uplift of Tibet Plateau, but its distribution is also complex. According to distribution of planation surface and existence of early Tertiary weathering crust or not, we conclude that there have been two extensive planation surfaces (Summit Surface and Main Surface), which are consistent with those on Tibet Plateau. Comparing the relevant sediments in this area to neighboring ones, we argued that the formation age of Summit Surface is 23Ma B. P. and Main Surface was formed in about early days of Pliocene and broken up caused by Hengduan Movement at the age of 3. 4Ma BP. In a word, all the evidences, existent planation surface, relevant basin sediments, together with evolvement of terraces in the rivers watershed, suggests that landforms evolution in north LRGR and the area of Three Parallel River results as multi-stage intermittent mountains uplift.

Caused by river capture or not? The genesis of the First Bend of Yangtze River has been controversial for a long time. In fact, the genesis of the First Bend of Yangtze River is closely relative to evolutions of north LRGR and drainages in Yunnan. The north of LRGR and drainages in Yunnan have undergone several stages of regional geomorphic evolvementment, which are exterior drainages before the end of Pliocene, inland drainages from the end of later Pliocene to early Pleistocene, exterior and modern drainages since early Pleistocene. In later part of middle Pleistocene, The direction of ground stress in the region translation from NW to nearly SNE resulted in 8 nearly EW uplifted ranges served as watersheds of rivers and also dammed the Jinshajiang River runoff, forced it to flow counter to its original direction along a reach which was abandoned by paleo-Shuilouhe River due to Jinshajinag River capturing in three river junction. The First Bend of Yangtze River is a junction of paleo-Shuilou River, paleo-Chong River and paleo-Jinshajiang River.

The Cenozoic landforms of north LRGR and Three Parallel River have gone through such process as compression ramping and basin inversion from late Eocene to the end of Oligocene, planation from the end of Oligocene to Pliocene, intense uplift from end of Pliocene to early Pleistocene, different uplift and development of longitudinal range-gorge landforms from early Pleistocene to present. The climatic environmental changes since early Tertiary in this area can be divided into several stages, i. e. subtropical trade wind climate before the early Tertiary, paleo-monsoon climate during late Tertiary and modern monsoon climate since Quaternary.

The evolvement of tectonic landforms, climate and drainage leads to a unique lithosphere- atmosphere-hydrosphere-biosphere coupling system. So the landscapes of early Tertiary subtropical dry-hot vegetation, later Tertiary humid and semi-humid forest, Quaternary subtropical forest and natural vertical zones emerged in turn. Because of its "longitudinal range-gorge corridor barrier", high gradient effect and complicacies of local settings, this area is famous for it's the richest biodiversity in China even the whole world, also a center of species differentiation and species origin in Asia. In the light of global changes, the trend of

ecological and environmental evolution of the Three Parallel Rivers in the north of LRGR would bring out both favorableness and harm in development of local ecology, societies and economies. Therefore we must harmonize the relation of human and nature with reason, adjust industrial structure and attach importance to ecological construction.

The evolution of Southwest Monsoon which is regarded as an important member of Asian Monsoon system has been affected by uplift of Tibet Plateau and framework variation of sea and continent due to the collision between Eurasia and Indian sub-continent. Till about 8.5Ma B.P., translation from ancient ocean-continent monsoon to Southwest Monsoon had been finished. The Southwest Monsoon plays an important role on environmental evolution of the Three Parallel Rivers. The latitude, solar radiation, oceanic advance and regression, evolution of Tibet Plateau, tropic ocean and so on are mainly responsible for evolvement of Southwest Monsoon while "glacial cycles" can hardly affect it. The dominant periods are 41ka and 23ka. The Southwest Monsoon transports humidity latitudinally and its dominant wind is southwesterly wind. The area controlled by the Southwest Monsoon is characteristic with obvious rainy and dry seasons. In early Pleistocene, the Plateau was too low to bring out the barrier function, so the Southwest Monsoon dominate a larger area including Southwest China, North China and Central China. During the Middle Pleistocene, the barrier function was strengthened by abrupt uplift of the Plateau and the transfer event that affected Quaternary environment in China with Southwest Monsoon and Southeast Monsoon took place. The area controlled by Southwest Monsoon had shrunk to the southwest of Yangtze River upper reach and the southeast of Tibet Plateau.

The special geomorphic spatial layout of LRGR results in obvious corridor-barrier, Rang-gorge high gradient effects (consisting of energy, precipitation, climate, climatic landform, natural zone pedigree, resource distribution and using, society and economy, resident condition gradient effects and local lithosphere-atmosphere-hydrosphere-biosphere-human coupling effects) and is also responsible for dry-hot earth and ecological landscape in this area. The dry-hot valley is characteristic with ecological environment vulnerability, active earth surface process, vegetation degeneration, dry-hot valley and wet-cold summit and single dry-fast vegetation. The formation of dry-hot valley is not only due to foehn effect, mountain valley circulation and human actions but due to many factors. In these factors evolution of geologic environment is dominant, atmosphere circulation is exterior control and human actions deteriorate environment. The dry-hot valley is a syntheses caused by tectonic movement-landform-paleoecology effect, circulation -monsoon "chimney" effect, mountain wave-precipitation-local circulation-foehn effect and vegetation -land use-human activity. It is characteristic with a crude earth and ecological landscape in principle.

Keywords: Longitudinal Range-Gorge Region (LRGR); Yunnan Planation Surface; the First Bend of Yangtze River; Southwest Monsoon; Corridor Barrier Function; High Gradient Effect; Dry-hot Valley; Three Parallel Rivers

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