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长江上游泥石流危险度区划研究*

钟敦伦　谢　洪　韦方强

(中国科学院、水利部成都山地灾害与环境研究所　成都　610041)

提　要　长江上游资源丰富,人口众多,生态环境脆弱,泥石流活动强烈.为了长江上游的资源开发和经济建设,开展了泥石流危险度的区划工作.区划采用综合研究与重点研究相结合,区域总体研究与典型区研究相结合,因素分析与相关分析相结合,间接自然指标与直接自然指标相结合,以及自然危险度与经济发展程度相结合的方法,将长江上游划分为五级泥石流危险程度不同的类型区.

关键词　长江上游　泥石流　危险度　区划

长江干流宜昌以上为上游,其流域面积100.5万km²,全长4 500km,位于24°28′—35°50′N,90°30′—111°20′E.长江上游的流域面积占长江全流域面积的55.8%,人口占37.5%,耕地占38.0%,牧地占71.5%,宜农林牧荒地占60.2%,水域面积占25.7%,可开发利用的水能资源占86.3%.区内由金沙江、雅砻江、大渡河和岷江等流域的森林组成的林区,为我国第二大林区;铁铜钛钒磷等矿产资源在全国占有重要地位[1].可是长江上游地貌和地质条件复杂,加之有人类消极活动(如森林过伐、毁林开荒、陡坡耕作、筑路和采矿不合理弃碴与排废等),致使区内生态环境变得更加脆弱,许多青山变成秃岭,不少草原沙石化.由此泥石流频繁发生且日趋严重.这不仅给当地国民经济建设和人民生命财产安全带来严重威胁和危害,而且把大量泥沙输入长江干流.由有关资料得知,每年通过宜昌站的泥沙量平均达533Mt[1],其中大部分来自泥石流活动区.大量泥沙输入长江干流危及其开发利用.为了减灾防灾,保护国家和人民生命财产安全,造福子孙后代,必须开展长江上游泥石流危险度区划研究.现将研究结果概述如后.

1　长江上游泥石流活动现状

1.泥石流分布广泛.区内除青海境内高原面上和四川盆地内共约3.2万km²基本无泥石流分布(V_{61-4}区)外,其余地区均有泥石流分布(见刊前"长江上游泥石流危险度分区图").

2.泥石流数量众多,活动频繁.据不完全统计,长江上游泥石流沟(坡)6 800余条(处),其中每年都有数十至数百条(处)暴发泥石流.

3.泥石流危害严重.本区泥石流危害城镇、村庄、工厂、矿山、水利水电工程、交通通讯,堵塞江河,破坏生态环境,每年都要造成众多人员伤亡和巨大经济损失.

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1)水利部长江流域规划办公室编.长江流域社会经济资料汇编.1987.10—13,32.

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4. 区内人口剧增，人类消极活动增强，生态环境恶化，泥石流活动趋势不断增强.

2 长江上游泥石流危险度区划工作的特点

区划通常分为两种：类型区划和区域区划. 根据区划的目的，并便于对比与应用，对本区泥石流危险度采用的是类型区划，只要区域危险度相同，都划入同一级危险类型区. 区内区划工作具有如下特点.

1. 综合研究与重点研究相结合. 本区划是在收集大量文献和野外考察资料的基础上加以综合分析的，重点探讨泥石流的危害状况、形成环境、活动特征、分布规律和发展趋势等，并对重点泥石流沟进行了编目.

2. 区域总体研究与典型区研究相结合，因素分析与相关分析相结合. 由长期研究结果得出：动力条件、物质条件和激发条件是泥石流形成的主要条件. 控制泥石流形成的主要要素为地貌、地质、气温和降水. 这四个要素本身又有多种因素构成. 尤其是地貌、地质的构成因素多而区域分异十分复杂，即使在一个小区内也变化多端，因此要想在长江上游这样大的范围内取得各因素的详尽数值，是极端困难的. 于是在区内选择 56 个泥石流流域，详尽量测其地貌、地质各因素值，并作出因素分析. 据此建立综合数学模型，进而计算出典型流域地貌、地质的综合评价值，又用因素值与综合评价值进行相关分析，选择出综合能力和包容能力皆是最强的、在大范围内又能获取的因素作为综合评价的主要因素. 这样既突出了主导因素，又考虑了综合因素，而且使因素的量化工作变得切实可行.

3. 间接自然指标与直接自然指标相结合. 泥石流自然危险度分区指标分为两类：一类是直接自然指标，即泥石流作用的结果；另一类是间接自然指标，即泥石流发育的环境条件. 长江上游泥石流研究中存在着大量资料空缺区，因此若用直接自然指标进行区划，其结果必然与泥石流活动的实际情况不相符合. 于是本区划采用泥石流形成和活动的环境条件作为划分泥石流自然危险区的指标(即间接自然指标)，而对研究程度较深、资料较完整区就用直接自然指标加以验证. 这样既克服了因区内泥石流研究程度和资料详略不一而带来的困难，又使区划指标的合理性和可靠性获得足够的保证.

4. 泥石流自然危险度与经济发展程度相结合. 影响泥石流危险度的因素，一是泥石流的自然危险度，二是经济发展程度. 前者反映了当地泥石流的破坏能力，后者反映了当地泥石流可能使被危害对象所蒙受的经济损失. 把两者结合起来考虑，对泥石流危险度区划具有重要理论意义和实用价值.

3 泥石流危险度分区概况

长江上游泥石流危险度分区(见刊前“长江上游泥石流危险度分区图”)有下列五级.

1. 泥石流最重度危险区 I_{1-9}，即由 9 个小区组成，面积 3.2 万 km^2，占长江上游流域面积的 3.2%.

2. 泥石流重度危险区 II_{1-18}，即由 18 个小区组成，面积 13.3 万 km^2，占长江上游流域面积的 13.2%.

3. 泥石流中度危险区 III_{1-21}，即由 21 个小区组成，面积 23.1 万 km^2，占长江上游流域

面积的23.0%.

4.泥石流较轻度危险区Ⅳ$_{1-20}$,即由20个小区组成,面积30.6万km^2,占长江上游流域面积的30.4%.

5.泥石流轻度危险区和基本无泥石流危险区Ⅴ.根据区内具体状况,又将其划分为两个次一级区:a.泥石流轻度危险区Ⅴ$_{a1-15}$,即由15个小区组成,面积27.1万km^2,占长江上游流域面积的27.0%;b.基本无泥石流危险区Ⅴ$_{b1-4}$,即由4个小区组成,面积3.2万km^2,占长江上游流域面积的3.2%.

4 今后抓紧的几项工作

1.建立泥石流预警体系.欲想对本区泥石流在短期内全面进行治理,虽在技术上是可能的,但在经济上却是不合理的,因此应建立泥石流预警体系.目前长江上游流域已建立了万县、宜宾、武都3个泥石流一级预警站(行使管理职能)和若干个二级预警站(行使管理兼监测职能)与三级预警站(行使监测职能),但还不够.本区划研究结果显示,应需建立11个一级预警站;在泥石流最重度危险区1—2个县、泥石流重度危险区2—3个县、泥石流中度危险区3—5个县,分别建立1个二级预警站;在泥石流较轻度危险区根据预警网络和其他需要建立二级预警站;三级预警站据实际需要加以设立.

2.开展泥石流综合防治与经济开发相结合的试点试验研究.目前对长江上游的泥石流采取预警措施是完全必要的,但从长远来看是不够的.因为预警措施只能预告泥石流即将暴发的信息,得以避难保安全,减轻损失;而综合治理能优化流域环境,缩小和控制泥石流的规模与危害.因此在长江上游应选择典型泥石流流域进行综合治理,以发展流域经济,让当地群众富裕起来,进而建立一套治理泥石流与开发流域经济相结合的模式,为泥石流治理树立典型,激发群众治理泥石流的积极性.

3.对资料空缺区进行调查研究.在本区划执行过程中,对许多资料空缺区本应进行实地考察,但由于受经费和时间限制而未能如愿以偿.建议有关部门拨出专款即对上述区域进行调查研究.

本区划研究过程中及时完成了《长江上游泥石流危险度区划研究总结报告》,编制了《1:200万长江上游泥石流危险度区划图》,祈指点和指正.本专辑蒙《山地研究》编辑部大力支持,不胜感激.

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RESEARCH ON THE REGIONALIZATION OF DEBRIS FLOW DANGER DEGREE IN THE UPPER REACHES OF CHANGJIANG RIVER

Zhong Dunlun Xie Hong Wei Fangqiang

(*Institute of Mountain Hazards and Environment, Chinese Academy of Sciences & Ministry of Water Conservancy Chengdu* 610041)

Abstract

The upper reaches of Changjiang River, including the part above Yichang Municipality, Hubei Province, is located in 24°28′—35°50′N, 90°30′—111°20′E. Its drainage area is 100.5×10^4km^2 (and full length of the trunk stream is 4 500km), and area accounts for 55.8% of the total drainage area of Changjiang River. The population is 37.5%, grazing area 71.5%, farmland 38.0%, uncultivated land 60.2%, water area 25.7% and usable water energy resources 86.3% of the total drainage of Changjiang River.

The relative height of the region is 7 513m with the highest altitude 7 556m and the lowest 43m. There are southern, middle and northern subtropical zones, warm temperate, temperate and frigid temperate zones, and ice field zone in the region. Most part of the region belongs to monsoon climate region with a wet and hot season due to the influence of SE and SW monsoons; only the part of Qinghai-Xizang Plateau belongs to continental climate region with frigidity and dryness. The regional differentiation of climate is clear. The annual average temperature is −2.5—21.9℃ and the annual average precipitation is 262—1 923mm.

The ecological environment becomes more fragile and many barren mountains and deserted grasslands appear in the region because of the complex geology and landform conditions, and human unreasonable activities (forest over cutting, destroying forest for farmland, farming on steep slope and unreasonably discarding slay and soil in road construction and mining, etc.).

Therefore, debris flow occurs frequantly and becomes more and more active. It not only threatens and harms national economic construction and people's life and property, but also carrys enormous silt to the trunk stream, so as to harms exploiting and utilizing the Changjiang River. According to relevant data, the average annual silt passing through Yichang Station is 533Mt, and most of them stem from debris flow ravines.

In order to reduce and prevent hazards, safeguard people's life and property, the regionalization of debris flow danger degree in the upper reaches of Changjiang River should be researched.

The following results were obtained after "the Summary Report of Research on Regionalization of Debris Flow Danger Degree in the Upper Reaches of Changjiang River" and "1:2 000 000 Division Map of Debris Flow Danger Degree in the Upper Reaches of Changjiang River" were worked out in 1992.

1 Distribution of Debris Flow

There are 6 800 debris flow gullies (slopes) in the region. Rainstorm debris flow occurs mainly in the plateau and middle mountainous region with rich rain. Glacier debris flow occurs in alpine and extreme high mountainous region with maritime glaciers. In the region, from 1753 to 1989, there were 11 hazard points, which≥100 people were killed in one debris flow hazard, and 45 cities (counties) were threatened and harmed. During 1970—1988, debris flows along Chengdu—Kunming Railway killed 370 people, harmed 15 railway stations, overturned 3 trains and broke transportation about 60 times(1 200h). Annual economic loss caused by debris flows is 0.8—1.2G yuan(RMB).

The laws of debris flow distribution are as follows:

1) Debris flow is most active in two interim zones from the first landform ladder to the second and from the second to the third of China.

2) Debris flow develops in great fault belt and earthquake zone concentrately.

3) Debris flow occurs mainly in small ravine.

4) The distribution of debris flow shows an azonality.

5) The developing tendancy of debris flow is uninterruptedly strengthened.

2 Characteristics of the Regionalization of Debris Flow Danger Degree

According to the aim of the regionalization and convenience for contrast and application, the type regionalization was adopted. The concrete ways are as follows:

1) Combining comprehensive research with major research.

2) Combining research on whole region with typical area.

3) Combining element analysis with interrelated analysis. 56 typical debris flow ravines were chose to measure their factor values of geology and landform in detail and make out element analysis. Therefore, a comprehensive mathematical model was worked out to count the values for comprehensively evaluating geology and landform factors of the 56 typical ravines. Main comprehensive evaluation factors, which have a most strong comprehensibility and are obtained easily in a wide range, were chose by the interrelated analysis in the values of factors and comprehensive evaluation.

4) Combining the direct natural indexes with the indirect. Indirect indexes which control the formation and activity of debris flow were chose as the index to divide the natural debris flow danger degree, because there are many zones without any data in research on this region. The natural danger degree regionalization was tested and verified by the zones with full data.

5) Combining the natural danger degree with economic development level. The natural

danger degree reflects the damaging capacity of debris flow, as well as the economic development level reflects the possible economic loss due to debris flow hazards.

3 Division Survey of Debris Flow Danger Degree

The region was divided into following division of debris flow danger degree:

1) I -District = district of most catastrophic debris flow danger degree, consisting of 9 parts. Its area is $3.2\times10^4km^2$ and accounts for 3.2% of the region.

2) Ⅱ -District = district of catastrophic debris flow danger degree, consisting of 18 parts. Its area is $13.3\times10^4km^2$ and accounts for 13.2% of the region.

3) Ⅲ -District = district of middle debris flow danger degree, consisting of 21 parts. Its area is $23.1\times10^4km^2$ and accounts for 23.0% of the region.

4) Ⅳ -District = district of light debris flow danger degree, consisting of 20 parts. Its area is $30.6\times10^4km^2$ and accounts for 30.4% of the region.

5) V -District = district of lighter debris flow danger degree and one nearly without danger; a) V_a-District = district of lighter debris flow danger degree, consisting of 15 parts. Its area is $27.1\times10^4km^2$ and accounts for 27.0% of the region; b) V_b-District = district nearly without debris flow danger, consisting of 4 parts. Its area is $3.2\times10^4km^2$ and accounts for 3.2% of the region.

4 Several Works That Should Be Paid Closely Attention

1) Building forecasting and warning system of debris flow. The system building should be strengthened if controlling debris flow from the whole region in short term is expected. 3 I-grade forecasting and warning stations of debris flow (executing administration function) as Wanxian, Yibin and Wudu Stations, certain Ⅱ -grade stations (executing administration and monitor function) and certain Ⅲ -grade stations (executing monitor function) have been built. The results of the regionalization show it is necessary that 11 I -grade stations are built, 1 Ⅱ -grade station is built per 1—2 counties in I -District, per 2—3 counties in Ⅱ -District, per 3—5 counties in Ⅲ -District; Ⅰ -grade stations are built in Ⅳ -District according to the needs of forecasting and warning networks and others, and that Ⅲ -grade stations are built according to actual need.

2) Carrying out experiments and test research on combining debris flow control with economic development. In order to develop economy in the region, and worked out a set of model for combining debris flow control with economic development, this work is very urgent.

3) Researching on the zones without any or complete data.

Key words upper reaches of Changjiang River, debris flow, danger degree, regionalization