赣西北地球化学实验图集

地质矿产部地球物理地球化学勘查研究所
地质矿产部江西省地球物理地球化学勘查大队
地质矿产部北京计算中心

技术指导　谢学锦
（地质矿产部地球物理地球化学勘查研究所）

施工设计
薛水根　徐新杰
（江西省地球物理地球化学勘查大队）

采样
徐生根　吴木水　李开保
（江西省地球物理地球化学勘查大队）

分析
光谱　龚文绮　曹文辉
化学　王永烈　邢励
（江西省地球物理地球化学勘查大队）

数据整理
尹思文　张忠槐　庞太和　谢满华
（江西省地球物理地球化学勘查大队）
李玉清　李应桂　刘艳青　王立华
（地球物理地球化学勘查研究所）

电算处理
刘茹英　曹邦功　俞全宏　郭汉伦　邬宽廉　单银根　王依华
（北京计算中心）
余伯常　朱保国
（地球物理地球化学勘查研究所）

编图
万特　李玉清
（地球物理地球化学勘查研究所）

图件清绘
赵宏
（地球物理地球化学勘查研究所）
巫正英　吴永彤　朱翠华
（江西省地球物理地球化学勘查大队）

封面设计
李同　常勇
（地球物理地球化学勘查研究所）

地质出版社

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技术指导

谢学锦

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绪　言

世界上最早出版的地球化学图集是北爱尔兰地球化学实验图集（Webb et al., 1973），它的出版对全世界区域化探的进展起了深刻的影响。目前许多国家都在进行全国性地球化学普查，所制作的图件已成为国家基础图件。尽管已出版了许多单张的地球化学图，但正式出版的地球化学图集还为数不多（Bowie et al., 1978_a，1978_b；Webb et al., 1978）。

我国的全国性区域化探扫面计划是1978年提出来的（谢学锦，1979_a，1979_b），但作为这项计划的试点，早在1974年已在江西省开展了区域化探工作（薛水根，1979），1976年在赣东北26561平方公里范围内，完成了水系沉积物采样，1978年完成了江西省西北部23062平方公里的野外采样工作。当时，区域化探全国扫面计划所需要的高灵敏度的多元素分析与监控方案尚在研制阶段。江西省物化探大队决定不等待新的分析系统的完成而先使用半定量光谱方法作初步扫描。一些关键性元素，如Ag、As、W、P则用原子吸收光谱方法或比色方法进行分析。

利用这些半定量数据制作地球化学实验图集的想法是1979年提出的。它的目的是检验成图的方法与格式，以便为今后制作正式地球化学图作准备。

本图集包括18个元素的地球化学图，14个元素的异常图，以及一系列地质地理图件（包括地质图、地貌图、地势图、土壤图及植被图）。

本图集尽管是利用半定量数据编制的实验图集，但仍可用它来选择矿产勘查的靶区，并已在实际工作中取得一些成功。本图集还可供环境科学以及农、林、牧、医等其它领域进一步考察与研究时应用。

地质地理图

地质图　此图根据江西省地质矿产局提供的1:500000地质图加以简化而得。这种简化有助于更好地研究元素区域性分布与地质因素之间的关系。从图上可以看到本区在长期地质发展过程中，经历了多次强烈而复杂的构造运动，形成了各种构造体系和构造形式。其中以北北东向构造最为发育。本区地层发育比较齐全，由震旦系至第四系均有出露，广布的前震旦纪变质岩系属一套地槽浅海相的碎屑岩复理石建造，组成本区的褶皱基底。古生代地层作为盖层而分布，岩性多样。本区岩浆活动频繁，从超基性、基性到中酸性，由深成到浅、超浅成以至喷出。九岭期与燕山期酸性、中酸性岩浆活动最为强烈，其岩浆成矿作用的强度由老到新有增强的趋势。

地貌图　此图根据江西省区域地质调查大队、水文地质大队1980年1:500000地貌图，在中国科学院地理研究所苏时雨副研究员的帮助下加以简化而改编的。其地貌类型显著地以构造地貌、流水（剥蚀与侵蚀）地貌、岩溶地貌及河湖地貌为特色。由于地表形态反映成因，成因控制形态，因此，我们选择形态与成因相结合的分类分级系统。它不仅展现外部形态，而且揭示出地貌的发生和发展过程。

地势图　此图根据江西省测绘局提供的1:500000地形图，抽稀等高线填绘网纹而成。选取非等间距的方法是征求了各方面学者的意见，力求以较少层次反映地表形态。它是编制一系列地质地理图的基础。本区西高东低，北陡南缓。山地与盆地相间而出，大体近北东东向展布。海拔50米以下是鄱阳平原和长江沿岸谷地，地势低洼，水网最密、湖泊众多。海拔100米左右是平原各河流上游谷地，显示高低岗地。海拔250米以下是丘陵，红土化作用强烈。海拔500米以下是红壤分布的轮廓。海拔500—750米反映红黄壤、黄壤的分布，常是坡积物的界限。海拔1000米以上反映中山走向。

土壤图　此图根据《江西省第二次土壤普查技术规程》，在中国科学院地理研究所

苏映平副研究员的帮助下，综合地质、地貌、第四纪地质、地势图等资料编辑而成。它是以表生成土（气候与植物的影响）原则分类分级的。不同于农业用、森林用、工程用的土壤分类分级系统，它反映了垂直地带性规律控制成土过程。土类是综合了自然条件而划分的；亚类是反映地貌淋洗过程和剖面性态的差异；土属是反映成土母质和地形部位。本区地处东亚季风区，气候温和雨量充沛，森林覆盖面积较大，土壤类型多样。主要以红壤、黄壤为主，具有酸、瘦、板、粘等特性。一般从山地到低丘随海拔降低，坡度渐缓，土层增厚，腐殖质含量减少；山地红黄壤、棕壤的母质为花岗岩、砂页岩和多种变质岩的残坡积物，植物茂密，土层较薄，但表土腐殖层较厚；丘陵红壤土层较厚，植被覆盖差，腐殖质含量少；冲积平原多为耕植褐色的水稻土，人为活动影响其剖面性状。

植被图　根据江西省农垦设计院1980年1:500,000森林图，并在江西大学生物系林英教授指导下，利用他们多年实地考察资料，结合地貌、土壤图而改编的。图中分类分级系统大致符合全国1:1,000,000植被图编制规范。本区地处东部亚热带常绿阔叶林带。年均温16—18°C，一月均温4—8°C，七月均温30°C；年降水量1500毫米以上，并且40—50%集中在4—6月份。水热条件丰沛，植被覆盖率大，种类繁多，是亚洲东南部亚热带植物区系的起源中心之一。由于山地、丘陵多，掺杂有暖温带植物区系，属落叶阔叶林、常绿阔叶林与落叶阔叶林混交类型。一般认为，目前植被以次生类型为主。由于海拔高度影响，植被有明显的垂直变化。图面上的山地、丘陵、岗地以酸性灌木草丛为主，九岭山脉阴坡多杉木林，阳坡多毛竹林。经济林主要是油茶、油桐、漆树和茶树。

单元素地球化学图

采样　野外采样工作是在1978年4月—12月进行的。在23,062平方公里范围内共采集水系沉积物样品39,057个。平均采样密度为1.69个/平方公里。采样点主要布置在一级水系口上及二级水系中。尽量要求采样点分布均匀，一般要求每平方公里网格中至少要有一个采样点。因条件困难无法布点的空格应减少到最低限度。在每一个采样点的上、下游5—6米范围内采集两个以上，重量相等的样品，合并为一个组合样，以提高样品的代表性。样品采集细粒物质（粉砂、淤泥或细砂）。样品干燥后过60目筛，拌匀，将60克小于60目的样品送交分析。

分析　用水平电极撒样光谱分析方法分析B、Ba、Be、Co、Cr、Cu、Mn、Mo、Ni、Pb、Sn、Ti、V、Zn 14种元素。用比色法分析W、P；原子吸收法分析Ag；受范斑点法分析As。各元素的检出限及分析精密度见表。表上最后一栏还列出了区域化探扫面要求达到的分析检出限。

元　素	分析检出限 ppm	区域化探扫面要求分析检出限 ppm	元　素	分析检出限 ppm	区域化探扫面要求分析检出限 ppm
B	10	10	Pb	5	1～10
Ba	500	50	Sn	2	1～3
Be	5	0.5～3	Ti	1000	100
Co	10	1	V	20	10～20
Cr	20	10～20	Zn	30	10
Cu	5	1	Ag	0.06	0.02～0.1
Mn	100	10～30	As	1	1
Mo	1	0.5～1	P	25	100
Ni	10	5～10	W	1	1

制图　制图工作是在M-160Ⅱ型计算机上进行的，应用了自行编制的GC-79数据存贮、检索与制图程序。

首先将数据网格化。即以1:200,000国际分幅为底图，按双数方里网以2公里为间距，将每4平方公里内的数据取加权平均值（先将每平方公里内的数据平均后，再求4平方公里内的平均值）。然后用简单的移动平均法对数据进行处理。选用的移动窗为2×2单位格子（16平方公里），移动时每次重叠1/2，选用0.1log ppm的间距勾绘等量线。GC-

79系统绘制等值线采取的是双立方曲面加密网格点，这可提高等值线的精度、且足够圆滑。在强异常部位等量线可适当放稀。由于M-160 Ⅱ 型计算机末配备彩色绘图装置，须将计算机制的图件用人工重新清绘并着色。

在图上将含量从低至高划分6个色区，代表不同含量范围。6个色区的划分参考下列原则（$\bar{x}$为全图幅数据平均值，s为标准离差）：

$<(\bar{x}-s)$	深兰色
$(\bar{x}-s)$ — $(\bar{x})$	浅兰色
$(\bar{x})$ — $(\bar{x}+s)$	灰色
$(\bar{x}+s)$ — $(\bar{x}+2s)$	淡红色
$(\bar{x}+2s)$ — $(\bar{x}+3s)$	深红色
$>(\bar{x}+3s)$	绛棕色

在图廓外还绘有全图幅及不同地质单元中元素含量分布频率直方图。不同地质单元中的直方图按给定的地质信息编码，对不同时代的地质体分别进行统计而得。纵座标表示频率百分数($f\%$)，横座标为含量（log ppm）。含量以0.07log ppm为基点（Lepeltier，1969），以0.1log ppm为间隔向两端伸展。例如，向高含量方向为0.07，0.17，0.27，0.37……log ppm，向低含量方向为0.07，-0.03，-0.13，-0.23，……log ppm等。这种规格化的作法有助于用肉眼直接比较元素在不同地质体内的分布特征。

单元素异常图

尽管用直观方法在地球化学图上根据地球化学地势已可辨认异常，但仍有必要明确地划定异常界限，以便对异常的面积、强度及其它特征进行更为客观的了解与对比。

过去在区域化探工作中，仅计算全区单一的异常下限值。这种作法显然不能适应大面积地质地理条件的复杂变化，并可能漏掉低背景区内有意义的低值异常。其后，采用划分地质及地球化学子区的方法，分别在各个子区内求出各自的异常下限值。也许更为合理的方法应该是计算出一个连续变化的地球化学背景面，在这个背景面上逐点计算并勾出异常。

根据上述想法，我们制定了新的勾绘区域化探的异常的方法，并在本图集的编制中使用。

方法的步骤如下：

1.首先求出全区某元素数据的平均值$\bar{x}_1$及标准离差s_1，剔除大于$\bar{x}_1+3s_1$及小于$\bar{x}-s_1$的数据，形成一个新的数据集，再求出其平均值$\bar{x}_2$及标准离差s_2。如此反复叠代，直至数据集内不再有大于$\bar{x}_n+3s_n$及小于$\bar{x}_n-3s_n$的数据为止。

2.以规定的大窗口进行移动平均。编制本图集使用的是784平方公里的窗口(即步长为2公里的14×14单位格子）。建议今后采用400平方公里的窗口（即10×10单位格子为宜。在进行移动平均时，凡窗口内大于$\bar{x}_n+3s_n$及小于$\bar{x}_n-3s_n$的数据分别皆以$\bar{x}_n+3s_n$及$\bar{x}_n-3s_n$代之。这样移动的结果，可在全区勾出一个连续变化的背景面。

3.将每个点上的小窗口（16平方公里）移动平均数值（制作单元素地球化学图所用的数值）与背景面在同一点的数值相除，求出在此点上的衬值(全值与背景值之比值)。

4.求出衬值的几何平均值$\bar{x}_G$及几何离差s_G（Lepeltier，1969），然后分别计算出正异常下限（T_p）和负异常上限（T_n）：

正异常下限 $T_p=\bar{x}_G\times s_G^2$

负异常上限 $T_n=\dfrac{\bar{x}_G}{s_G^2}$

正异常的梯度变化用T_p，$2T_p$，$4T_p$……，负异常用T_n，$\frac{1}{2}T_n$，$\frac{1}{4}T_n$……的等量线圈出。在自然界，负异常较正异常少得多，因而很少能圈出$\frac{1}{2}T_n$等量线的较“强”负异常。

结 束 语

编制本图集是为今后正式出版一系列地球化学图集（区域的、省的，大区的及全国的）作准备的一次实验性工作。

本图集不仅有18个元素的地球化学图，14个元素的异常图，还有简化的地质图、地貌图、地势图、土壤图与植被图。在本图集中不拟过于匆忙地对这些资料作任何联系对比与解释推断，但我们希望它的出版将引起各方面的兴趣与重视，促使地球化学图逐步成为地学的基础图件，为各方面广泛利用。事实将会证明，它不仅可用于找矿工作，而且还可用于基础地质，环境研究及有关国计民生的其它领域。

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I NTRODUCTION

The first geochemical atlas published in the world is the Geochemical Provisional Atlas of Northern Ireland (Webb et al., 1973). The publishing of that atlas has deeply influenced the advance of regional geochemistry all over the world. Today, national geochemical reconnaissance programs are being carried out in many countries and maps thus produced are recognized as a national cartographic requirement. Although many single sheets of geochemical maps have been prepared, not many atlases have been formally published (Bowie et al., 1978_a, 1978_b, Webb et al., 1978).

The national geochemical reconnaissance and mapping project (Regional Geochemistry-National Reconnaissance Project RGNR) in China was suggested in 1978 (Xie, 1979_a, 1979_b; Xie et al., 1981, 1983). Early since 1974, a regional stream sediment survey has already been carried out in Jiangxi Province as an orientation work. Samples were collected from an area of 26,561 km^2 in Northeastern Jiangxi in 1976, and from an area of 23,062 km^2 in Northwestern Jiangxi in 1978. At that time the RGNR Project as a whole, especially the highly sensitive multi-element analysis and data monitoring systems were still in the development stage. Geophysical and Geochemical Exploration Team in Jiangxi Province has decided to use a rapid semi-quantitative spectrographic method to make the primary scanning without waiting for the new analytical systems. Atomic absorption method and colorimetric method were used for those key elements such as Ag, As, W, P.

The idea to compile this provisional geochemical atlas using semi-quantitative data was suggested in 1979. Its purpose is to test the method and the format for compiling the standard RGNR atlas in future. It was due to many reasons that the original plan for the publishing of the same was postponed for several years.

This atlas, though provisional and semi-quantitative in nature, could be used in area selection for mineral exploration, and in fact, some success in finding economic ore deposits has already been reported. It could also be used in selection of problem area in a variety of socially and economically significant contexts, including agriculture, pollution and public health studies.

In this atlas, the geochemical maps of 18 elements are included together with anomaly maps of 14 elements derived from background surfaces. There is also a series of geologic and geographic maps, including: geologic map, landform map, relief map, soil map and vegetation map.

GEOLOGIC AND GEOGRAPHIC MAPS

Geologic map: The geologic map was prepared by simplifying the 1:500,000 blue prints provided by the Geological Bureau of Jiangxi Province. The simplified map will give a more clear picture showing the relation between regional distribution of an element and the geological factors.

Sedimentary rocks are presented mainly in the northern part of the region. Outcrops can be found from Pre-Sinian Period to the Tertiary Period. Widely distributed metamorphic rocks of the Pre-Sinian Period belongs to a series of clastic rocks with flysch structure of the geosyncline shallow-sea facies, forming the folded substratum. The strata of the Palaezoic Era are distributed as cover strata. The rock properties are rather complicated and of great variety. Magmatism in this region is very active. The outcrops of those rocks range from ultra-basic, basic, intermediate to acidic rocks, with the acidic rocks of Jiuling and Yanshan Period in predominance. There is an increasing tendency of mineralization intensity from old to new by magmatic rocks, mainly during Yanshan Period. Major faulting occurred in this region mainly along north-north-east, north-east and east-west directions.

Landform Map: The landform map was prepared according to the 1:500,000 map made by the hydrogeological team of the district mapping department of Jiangxi Province in 1980. The map is in blue prints which have not yet been publicly recommended. Under the help of Mr. Su Shiyu of the Geographical Institute of the Chinese Acadamy of Sciences, this map was simplified and adapted for use in this atlas. The types of the landform map has the characteristics of structural landforms, fluvial (corroding and eroding) landforms, and plain landforms. Because the surface configuration reflects the genesis factor which in turn controls the configuration of the surface, we have selected a classification and grading system of integrating surface configuration with the genesis factors. It presents the outward configuration as well as depicts the process of the occurrance and development of the landforms.

Relief Map: The relief map was prepared according to the 1:500,000 map provided by the Topographic Bureau of Jiangxi Province, by thinning out the contour lines so as to reflect the surface configuration with less contours. For example: The area below 50-metre contour above sea-level are the Poyang Plain and the valleys along the Yangtse River. The area is full of low-lying land with criss-crossing rivers and lakes. The areas around 100-metre contour above sea-level are the valleys at the upstream of different rivers of the plain, showing high or low hillocks. The areas around 250-metre contour above sea-level are hilly areas with chemical weathering and the formation of red earth prevails. The areas around 500-metre contour above sea-level show a contour line of widely distributed red soil. The areas around 750-metre contour above sea-level reflect the boundary of slope wash with widely distributed yellow-red soil and yellow soil. The areas around 1,000-metre contour above sea-level reflect the trend of medium mountains.

Soil Map: Based on the "Technical Regulations of the Second Soil Reconnaissance in Jiangxi Province" and under the help of Mr. Su Yingping of the Geographical Institute of the Chinese Acadamy of Sciences, the soil map was prepared with the geologic, landform and relief maps as reference. It reflects the process of soil formation controlled by the vertical zonality. The soil sub-groups reflect the degree of leaching and the profile properties and configuration according to the geomorphology of the area; the soil family (genus) reflects the soil-forming material and the topographic location. This region is located at the East Asia seasonal wind zone. The weather is warm and rainfall abundant. The area covered by forest is comparatively large. Red soil and yellow soil are the main types. The characteristics of the soil are acidic, infertile, clayey and hardened. In general, the degree of the inclination of the slope decreases, the soil layer becomes thicker and the humus content in the soil decreases as the altitude decreases from mountain land areas to low downland. In mountain land areas, the parent materials of the red-yellow soil and brown soil are the residual deposit of granite, sandy shale and all kinds of metamorphic rocks. The vegetation is dense and the soil layer is thin, but the humus layer of the surface soil is quite thick. In the downland areas, the slope inclination is small, the red soil layer is thicker, the vegetation cover is poor, and the humus content is less. In the alluvial plain area, the soil is mostly of brown hydromorphic soil and its profile properties are influenced by human activities.

Vegetation Map: Based on the 1:500,000 forest map made by the Agricultural Reclamation Designing Institute of Jiangxi Province in 1980 and under the instruction of Prof. Lin Ying of the Biological Department of Jiangxi University, the vegetation map was adapted for use by making use of their materials obtained through many years of field investigations with the landform map and the soil map as reference. The classification and the grading system applied in the map is generally in conformation with the national 1:1,000,000 vegetation map compilation standard. The region is located in the moist zone of the eastern subtropical ever-green broad leaf tree belt. There are deciduous broad leaf trees and the ever-green and deciduous mixture of broad leaf trees. At the same time, owing to the influence created by human beings, the present vegetation is mainly of secondary types distributed in the mountain land and downland areas. And also owing to the influence of the altitude, the vegetation is clearly in a vertical changing state. From the map, one can see that the vast areas of mountain land, downland and hillocks are covered mainly by acidic shrubs and weeds. China firs are grown on the northern slope and bamboo grooves are grown on the southern slope of Jiuling Period mountain ranges. Tea-oil trees, tung oil trees, lacquer trees and tea trees are the main economic forests.

GEOCHEMICAL MAPS

Sampling: Sampling was carried out from April to December in 1978.39,057 stream sediment samples were collected from an area of 23,062 square kilometres. The average sampling density is 1.69/km². Sampling was mainly in the first-order tributaries and the second-order tributaries. Sampling locations were arranged as evenly distributed as possible, requiring one sample from a grid of one square kilometre. The number of grids which were impossible to collect samples had been reduced to a minimum. From a sampling location, two samples of same weight were collected within the range of five to ten metres, and then these two samples were mixed together to form one sample so as to make the sample more representative. Fine materials were sampled (mud, silt, or fine sand). Samples were sieved to pass a 60 mesh sieve after it was dried, and 60 grams of minus 60 mesh materials were sent to the laboratory for analysis.

Analysis: A spectroscopic method with samples spreading through horizontal electrodes was used to analyse 14 elements, such as: B, Ba, Be, Co, Cr, Cu, Mn, Mo, Ni, Pb, Sn, Ti, V and Zn. Colorimetric method was used to analyse W and P. Atomic absorption method was used to analyse Ag. Confined spot method was used to analyse As. Table 1 shows the detection limit and the analytical precision of various elements. The last column of the table shows the detection limit required by the Regional Geochemistry-National Reconnaissance (RGNR) Project.

Element	Detection limit (ppm)	Detection limit (ppm) required by RGNR	Element	Detection limit (ppm)	Detection limit (ppm) required by RGNR	Element	Detection limit (ppm)	Detection limit (ppm) required by RGNR
B	10	10	Mn	100	10—30	V	20	1—20
Ba	500	50	Mo	1	0.5—1	Zn	30	10
Be	5	0.5—3	Ni	10	5—10	Ag	0.06	0.02—0.1
Co	10	1	Pb	5	1—10	As	1	1
Cr	20	10—20	Sn	2	1—3	P	25	100
Cu	5	1	Ti	1000	100	W	1	1

Map Generation: The maps were generated with a M-160 II Computer in Beijing Computer Centre of the Ministry of Geology and Mineral Resources, using the GC-79 data-storing, retrieving and mapping system, which was developed in 1979 by Beijing Computer Centre. Irregular data points were transformed into regular cell values by calculating weighted averages within a 4 km² unit cell. Simple moving average method was used with a moving window of 2×2 unit cell to further smooth the data. A contour interval of 0.1 log ppm was selected. And a bicubic surface interpolation method was used to construct the contour map.

Owing to the fact that the M-160 II computer has no colour-drawing device, the maps were redrawn and coloured by hand.

Six colours were adopted to present six different colour ranges from low to high contents of the elements. The following is the description of the six colours used for different ranges:

$<(\bar{x}-s)$	deep blue
$(\bar{x}-s)-(\bar{x})$	light blue
$(\bar{x})-(\bar{x}+s)$	grey
$(\bar{x}+s)-(\bar{x}+2s)$	pink
$(\bar{x}+2s)-(\bar{x}+3s)$	red
$>(\bar{x}+3s)$	purple

Alongside of each of the maps, there are histograms showing the distribution frequency of element contents in different geological units and in the map as a whole. The vertical coordinates represent the percentage frequency (f%), and the horizontal coordinates represent the contents (in log ppm). The starting point of contents is set at 0.07 log ppm (Lepeltier, 1969) with 0.1 log ppm as interval extending towards two extremities. For instance: for higher contents, the points are set at 0.07, 0.17, 0.27, 0.37, ... log ppm; and for lower contents, the points are set at 0.07, -0.03, -0.13, -0.23, ... log ppm. This normalization can help people to compare directly with naked eye the characteristics of distribution of elements in different geological bodies.

ANOMALY MAPS

Although it is possible to identify the geochemical anomalies from the geochemical relief on a geochemical map by direct observation, it is still necessary to delineate definitely the anomalous regions so that we can study and compare the dimension, intensity and other characteristics of geochemical anomalies in an objective way.

In the work of regional geochemistry in the past, a single threshold was calculated for the whole region. It is obvious that this method is not suitable to cope with the complexity of changes of geological and geographical conditions, and that it is quite possible to overlook those anomalies of great significance in some of the low background areas. Later, another way of dividing the whole area into geological and geochemical sub-regions was adopted. Threshold value was calculated for each sub-region. Maybe the more reasonable way is to calculate a continuously changing geochemical background surface and then calculate point by point the deviation or contrast with changing background and delineate the extent of geochemical anomalies

According to the above-mentioned ideas, we have developed a new method to draw the regional geochemical anomaly maps. It is done according to the following steps:

1. First, calculate the mean value $\bar{x}_1$ and the standard deviation s_1 of the data of a certain element in the whole region. Reject those data greater than $(\bar{x}_1+3s_1)$ and smaller than $(\bar{x}_1-3s_1)$ to form a new group of data. And then calculate the mean value $\bar{x}_2$ and the standard deviation S_2. The iteration process is repeated until no data greater than $(\bar{x}_n+3s_n)$ and smaller than $(\bar{x}_n-3s_n)$ appear in the new data group. And these two values are taken as the critical values in the subsequent moving average calculations.

2. A very large moving window (784 km^2 or 14×14 unit cell) was used. •Moving distance for each averaging is 2 km. When calculating the moving average, those data greater than $(\bar{x}_n+3s_n)$ and smaller than (x_n-3s_n) within the window were sorted out and substituted with (x_n+3s_n) and $(\bar{x}_n-3s_n)$ respectively. A continuously changing background surface of this region was thus obtained.

3. Divide small window (16 km^2) moving average values (the value used to prepare the geochemical maps) at every point by the value obtained at the same point on the background surface so as to obtain the contrast value at this point (the ratio between the whole value and the background value).

4. Calculate the geometric mean value $\bar{x}_G$ and geomefric deviation s_G(Lepeltier, 1969)of the background value. And then calculate respectively the upperthreshold for positive anomalies (T_p) and the lower threshold for negative anomalies(T_n).

The upper threshold for positive anomalies is

$$T_p = x_G \times \bar{s}_G^2;$$

the lower threshold for negative anomalies is

$$T_n = \frac{\bar{x}_G}{s_G^2}.$$

The concentration gradient within the anomalies are normalized presented by isometric lines drawn by T_p, $2T_p$, $4T_p\cdots$, or by T_n, $\frac{1}{2}T_n$, $\frac{1}{4}T_n\cdots$ Owing to the fact that the negative anomalies are much fewer than the positive anomalies in nature, it is quite rare to get an "intensive" negative anomalous isopleth smaller than $\frac{1}{2}T_n$.

CONCLUDING REMARKS

In the atlas, there are not only the geochemical maps of 18 elements and the anomaly maps of 14 elements, but also simplified geological map, landform map, relief map, soil map and vegetation map. We are not supposed to make any inference and interpretation hastily. This work will be left to the users from all fields and for all purposes.

This atlas is an experimental prototype which will, we hope, stimulate the formal publication of a series of definite geochemical atlases later on, including regional, provincial, multi-provincial and finally national atlases in China. They will become fundamental atlas for geological sciences and be utilized widely by people of all walks of life.

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铬　Chromium (Cr) 12
铜　Copper (Cu) 13
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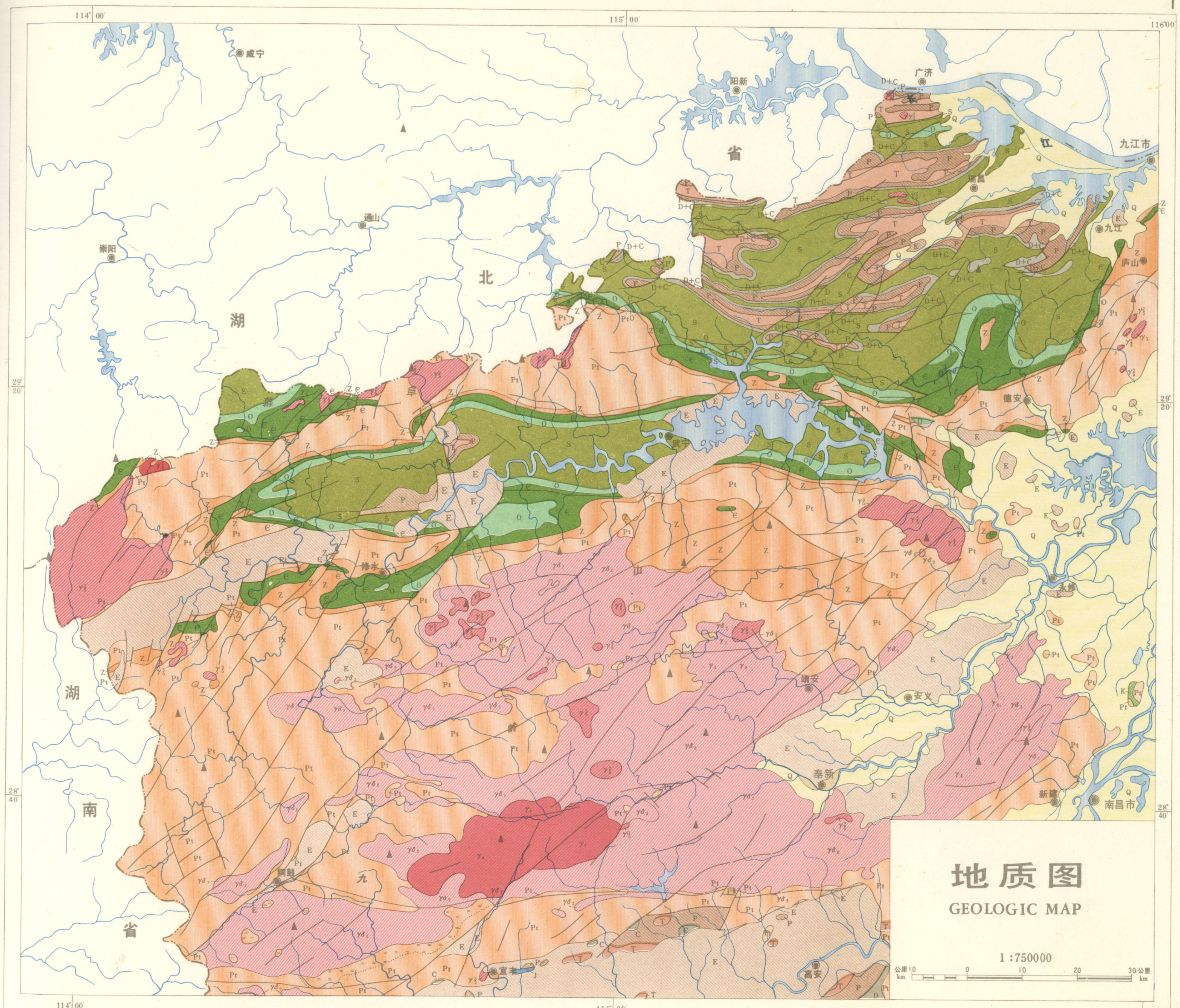


图例 LEGEND

- Q 第四系 QUATERNARY
- E 第三系 TERTIARY
- K 白垩系 CRETACEOUS
- J 侏罗系 JURASSIC
- T 三叠系 TRIASSIC
- P 二叠系 PERMIAN
- D+C 泥盆，石炭系 DEVONIAN CARBONIFEROUS
- D 泥盆系 DEVONIAN
- S 志留系 SILURIAN
- O 奥陶系 ORDOVICIAN
- Є 寒武系 CAMBRIAN
- Z 震旦系 SINIAN
- Pt 元古界 ERATHEM
- γ_5^3 燕山晚期 / γ_5^2 燕山早期 YENSHAN LATE PERIOD / YENSHAN EARLY PERIOD
- γ_5^1 印支期 INDOSINIAN PERIOD
- γ_4 华力西期 VARISCIAN PERIOD
- γ_2, $\gamma\delta_2$ 雪峰期 XUEFENG PERIOD
- 实测／推测断层 SURVEY FAULT / PREDICATED FAULT
- 片麻岩 GNEISS
- 渐变地质界线 PREDICATED GEOLOGIC BOUNDARY LINE

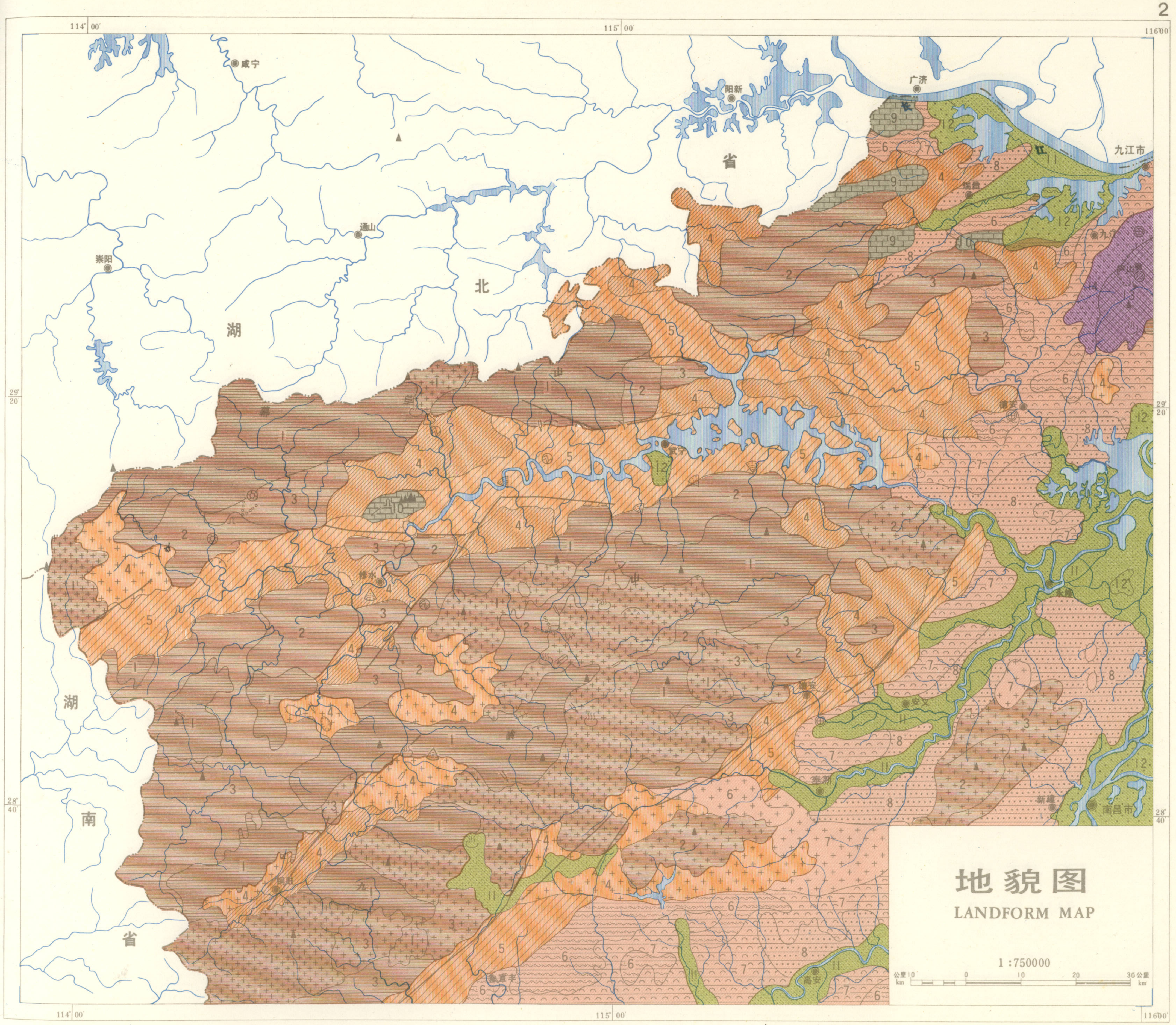


图 例 LEGEND

地貌类型 LANDFORM TYPE

一 侵蚀构造地形 EROSIONAL STRUCTURAL LANDFORM

1 锯状垅状陡峻中山 STEEP MIDDLE MOUNTAIN

2 锯状垅状陡峻中低山 STEEP MIDDLE AND LOW MOUNTAIN

3 锯状垅状陡峻低山 STEEP LOW MOUNTAIN

二 构造剥蚀地形 STRUCTURAL DENUDATIONAL LANDFORM

4 垅状馒状高丘陵 HIGH HILL

5 陡坡山前低丘陵 LOW HILL

三 侵蚀剥蚀地形 EROSIONAL DENUDATIONAL LANDFORM

6 缓坡低丘陵 GENTLE LOW HILL

7 波状高岗 HIGH ROLLING LAND

8 微波低岗 LOW ROLLING LAND

四 溶蚀侵蚀地形 KARST LANDFORM

9 岩溶高丘陵 KARST HIGH HILL

10 岩溶低丘陵 KARST LOW HILL

五 堆积地形 DEPOSITIONAL LANDFORM

11 冲积平原与河漫滩 ALLUVIAL & FLOOD PLAIN

12 阶地 TERRACE

六 侵蚀堆积地形 EROSIONAL DEPOSITIONAL LANDFORM

13 侵蚀陡坡山脊中山 EROSIONAL MIDDLE MOUNTAIN RIDGE

14 堆积成垅状扇状丘岗 DELOVIAL FOOTHILL AND PIEDMONT

岩性符号 LITHOLOGIC CODE

红土 RED EARTH

花岗岩 GRANITE

砂页岩 SANDY SHALE

石灰岩 LIMESTONE

形态符号 FORM CODE

瀑布 WATERFALL

山间盆地 INTERMOUNTAIN BASIN

冲积洪积扇 ALLOVIAL DELOVIAL FAN

侵蚀与剥蚀残山 REMNANT HILL

石芽 STALAGMITE

峰林 KARST FOREST

溶洞及其洞向 KARST CAVE

溶斗 DOLINE

暗河 UNDERGROUND RIVER

桌状山 TABLE MOUNTAIN

滑波 LANDSLIDE

崩塌 COLLAPSE

冲沟 GULLY

石流 MUD—STONE FLOW

废石堆 STONE DEPOSIT

温泉 HOT SPRING

地震震中 EARTHQUAKE

地貌形态线 GEOMORPHOLOGIC LINE

构造断层线 TECTONIC FAULT LINE

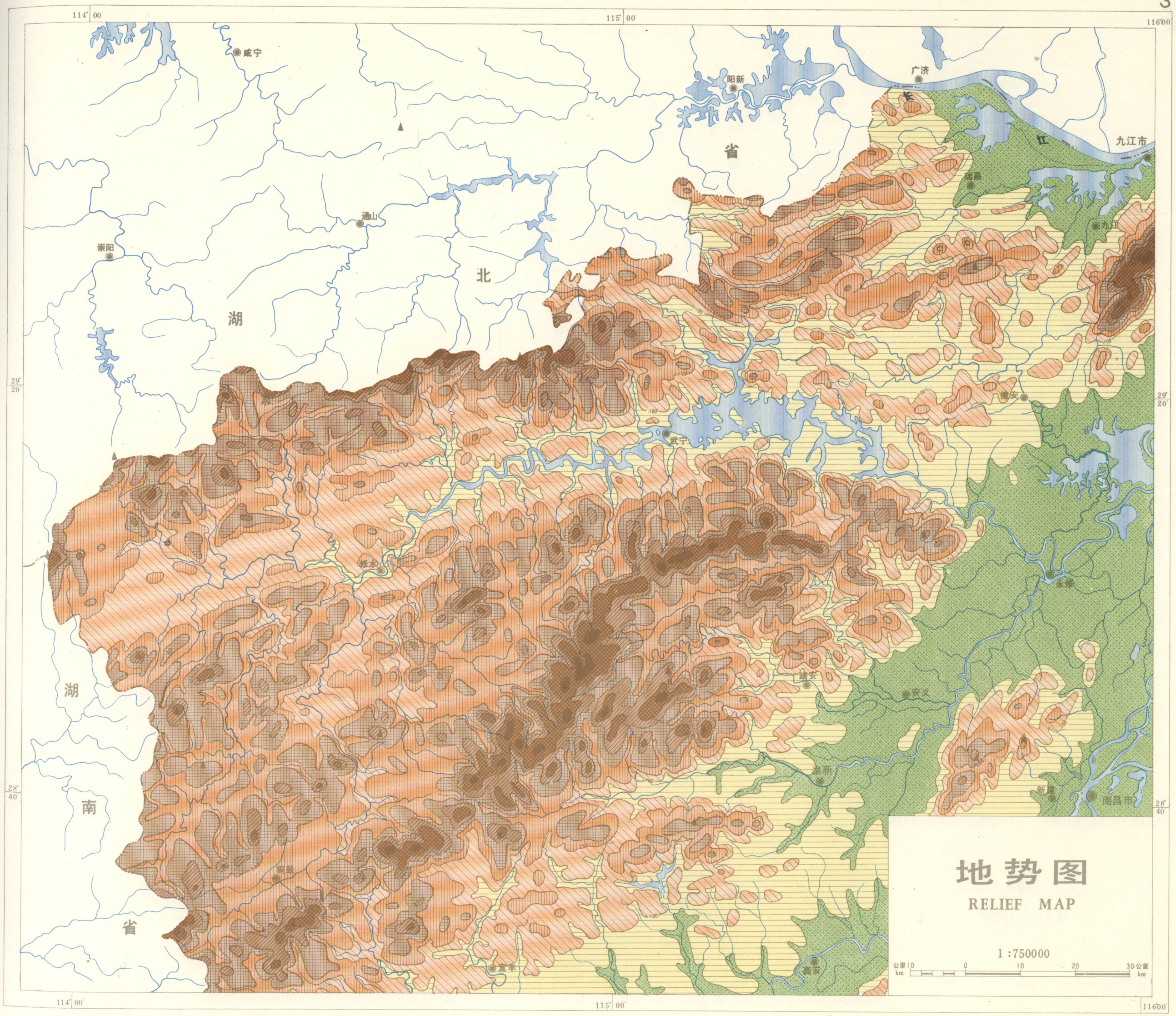
积雪盆地 SNOW BASIN

U形谷 U—SHAPED VALLEY

角峰 HORN

形态类型指标 LANDFORM CRITERIA

类型	绝对高程 m	相对高程 m
中山	1000—2000	> 500
中低山	500—1000	> 500
低山	500—1000	200—500
高丘	300— 500	200—300
低丘	< 300	50—200
高岗	< 100	30— 80
低岗	< 100	< 30
阶地		5— 80
平原	< 100	> 5



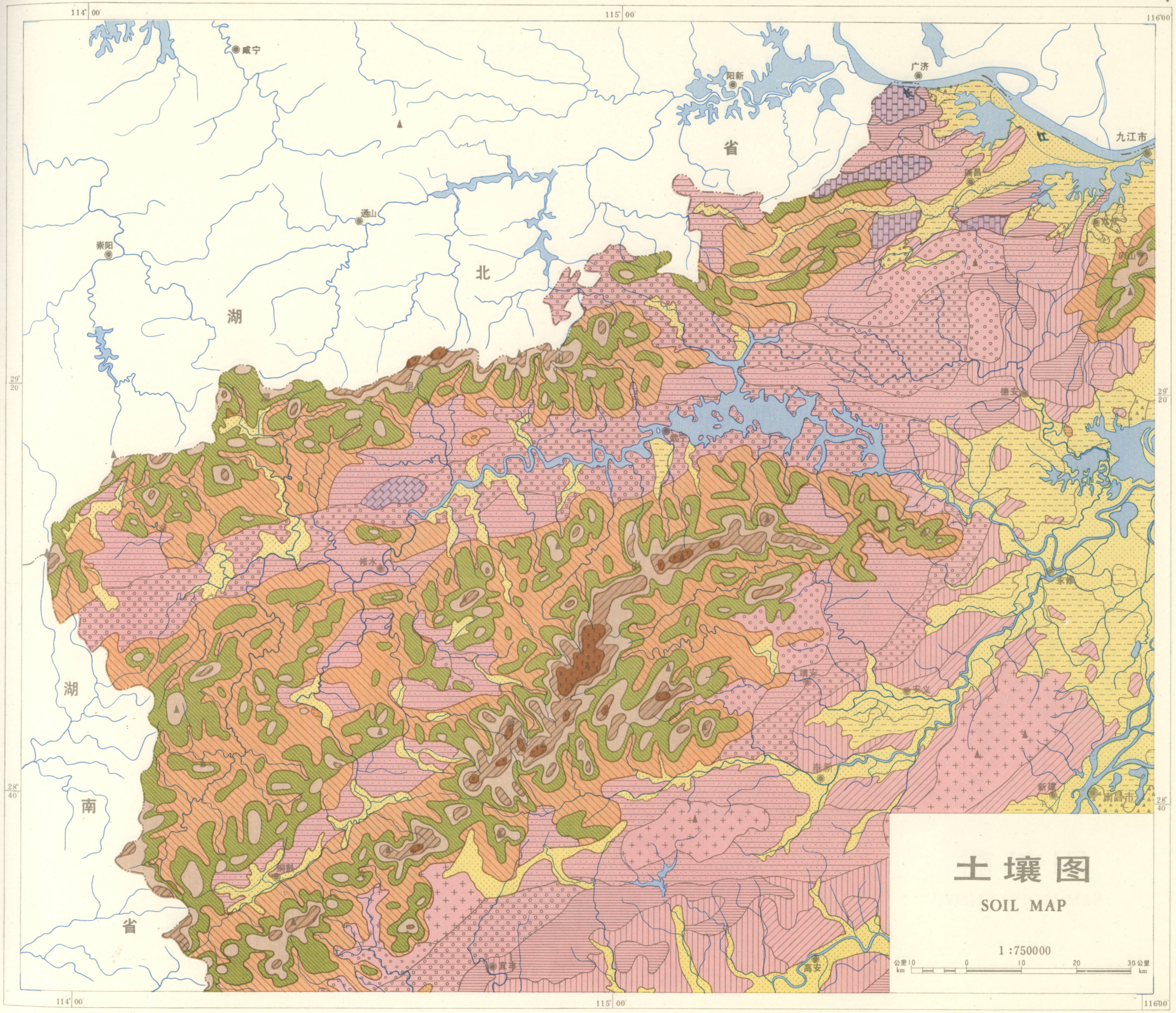
地势图
RELIEF MAP

1:750000

公里 10 0 10 20 30 公里
km km

图 例 LEGEND

高程指标 ALTITUDE CRITERIA	单位（米） UNIT m
	1250 以上 ABOVE 1250
	1000 — 1250
	750 — 1000
	500 — 750
	250 — 500
	100 — 250
	50 — 100
	50 以下 UNDER 50



图例 LEGEND

一、冲积土 ALLUVIAL SOIL

- 黄褐色冲积土 PALE YELLOWISH BROWN ALLUVIAL SOIL
- 黄棕色冲积土 DARK YELLOWISH BROWN ALLUVIAL SOIL
- 红壤化冲积土 RED ALLUVIAL SOIL

二、红壤 RED EARTH

- 红土 RED SOIL
  - 高岗红土 HIGH ROLLING LAND RED SOIL
  - 低岗红土 LOW ROLLING LAND RED SOIL
- 红壤 RED EARTH
  - 砾质红壤 GRAVEL RED EARTH
  - 砂质红壤 SANDY RED EARTH
  - 粘质红壤 CLAY RED EARTH
- 粗骨红壤 SKELETON RED EARTH
  - 麻骨土 GRANITE ROCKY SOIL
  - 碎石土 SANDSTONE—SHALE ROCKY SOIL

三、红色石灰土 LIMESTONE RED LOAM

- 高丘石灰土 HIGH HILL LIMESTONE SOIL
- 低丘石灰土 LOW HILL LIMESTONE SOIL

四、黄红壤 YELLOW—RED EARTH

五、黄壤 YELLOW EARTH

六、山地黄棕壤 MOUNTAIN YELLOWISH BROWN EARTH

七、山地棕壤 MOUNTAIN BROWN EARTH

八、山地草甸土 MOUNTAIN MEADOW SOIL