青藏高原
河流湖泊生态地质环境
遥感调查与研究

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地质出版社

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地质出版社
·北　京·

内 容 提 要

本书通过遥感调查查清了青藏高原河流、湖泊的分布及变迁规律并据此进行生态地质环境区划，为青藏高原的生态环境保护提供依据。

本书可供从事青藏高原地质、环境研究的人员及相关院校的师生参考。

图书在版编目（CIP）数据

青藏高原河流湖泊生态地质环境遥感调查与研究/朱大岗等著．—北京：地质出版社，2007.7
ISBN 978-7-116-05320-5

Ⅰ．青…　Ⅱ．朱…　Ⅲ．①青藏高原－河流－生态环境：地质环境－遥感地面调查　②青藏高原－湖泊－生态环境：地质环境－遥感地面调查　Ⅳ．P942.707　X171.1

中国版本图书馆 CIP 数据核字（2007）第 111548 号

责任编辑：孙亚芸
责任校对：李　玫
出版发行：地质出版社
社址邮编：北京海淀区学院路 31 号，100083
咨询电话：(010)82324508（邮购部）；(010)82324569(编辑室)
网　　址：http://www.gph.com.cn
电子邮箱：zbs@gph.com.cn
传　　真：(010)82310759
印　　刷：北京地大彩印厂
开　　本：787 mm×1092 mm 1/16
印　　张：14.75　彩版：4 幅
字　　数：359 千字
印　　数：1—700 册
版　　次：2007 年 7 月北京第 1 版·第 1 次印刷
审 图 号：GS（2007）1723 号
定　　价：45.00 元
书　　号：ISBN 978-7-116-05320-5

Introduction

Basing on total more than 9000km routing geological investigation in field including southern Tibetan valley area (Lhasa-Xigazê-Lhazê-Saga-Paryang-Moincêr-Bar-Zanda-Shiquanhe, Zanda-Burang-Saga-Lhazê-Tingri-Gyirong-Nyalam-Dinggyê-Yadong-Gyangzê-Nagarzê-Qüxü) and along Qinghai-Tibetan road area (Lhasa-Damxung-Nagqu-Bilung-Amdo-Tanggulashankou-Wudaoliang-Kunlunshankou-Xidatan), we have known geological structure, geomorphology, glacial remnants (glacial till, ice-water deposit and so on), lacustrine deposits (lacustrine stratum, lake-shore levees, lacustrine beach rock and so on), lacustrine landform (lacustrine eroding cave, lacustrine eroding flute, lacustrine eroding cliff), fluvial deposit, Quaternary geology and geomorphology, the modern fluvial-lacustrine and other facets basic feature in Qinghai-Tibetan plateau.

Geological investigation in field, remote sensing interpretation in laboratory and other integrative studies have been carried out during the last two years. The main achievements of remote sensing geology and Quaternary geology are shown as following.

1. The regional geology, geomorphology, lacustrine and fluvial geology

The fluvial and lacustrine investigation on Qinghai-Tibetan plateau were taken two times. On the first geological investigation, we took investigation on key paleo-lake and geological events, observed and sampling the late Cenozoic key lacustrine geological section, and found the interpretive symbol of remote sensing of the key rivers and lakes with remote sensing interpretation in laboratory, dating of structural events and so on. On the second geological investigation in field, we measured several lacustrine stritigrapic section on different area and different period of late Cenozoic, established the standard section of the late Cenozoic key lake, systemically collected samples.

1.1 The tectonic location of Qinghai-Tibetan plateau

Qinghai-Tibetan plateau is located in eastern Tethys-Himalayan tectonic domain section between the Eurasia and Gondwana continent. It is held by the three ancient rigid blocks that are Tarim-China-Korea block on north, Yangtze block on east, India block on south. There exists abnormal thickness of crust and altitude of geomorphology. Active structures develop and mountain-lakes spread on the plateau.

1.2 The basic crustal structure of Qinghai-Tibetan plateau

The crustal structure of Qinghai-Tibetan plateau which is surrounded by "plasticity platform" of the old block and formed by different period "micro-continent" is different from other crustal structure of stability carats "plateau" in the world. We divided it into five micro-continents and five sutures from north to south. They are shown as following: west Kunlun-Qilian mountain Caledonian suture, Qaidam block, Kunlun Variscan suture, Bayan-Har block, Jinsha River India suture, Qiangtang block, Bangong Co-Nujiang suture, north Tibetan block, Yarlung Zangbo Jiang-Himalayas suture, Himalayas block. They are the products of the repeatedly collision of plates since Paleozoic.

1.3 The active structural feature of Qinghai-Tibetan plateau

Fault block movement that mostly differential uplift, fault depression and fault under whole uplifting is the basic style of Qinghai-Tibetan plateau active structure. Folds only can be seen in several segments.

The basic framework of the active structure on Qinghai-Tibetan plateau is shown as following, the early compressional structure superimposed on late extend-strike slip structure in the background of the plateau whole uplifting, that is the early marginal convergent belts, marginal upwarding belts, inner uplifting areas and "X" conjugate fault systems superimposed on late NS, NE and NW fault belts, strike slip faults and block slips.

1.4 The Quaternary geological and morphologic feature of Qinghai-Tibetan plateau

Quaternary geology and morphology of Qinghai-Tibetan plateau can be divided into three great regions approximately by the Qinghai-Tibetan road, that is eastern external drainage area, western internal drainage area and periphery area. The morphology can be divided into 14 types and shown as following: glacier deposit, glacial marginal deposit, lacustrine deposit, fluvial deposit, gravitational pile, mudflow pile, blown sand pile, spring deposit, volcanic pile, chemical deposit, weathering crust and paleosol pile, talus pile, cave pile and peat swamp deposit. Moraine, lacustrine and glacial morphology developed best in western internal drainage area. Fluvial deposit, gravitational pile, fluvial and gravitational morphology developed best in eastern external drainage area and glacial deposit, glacial morphology, fluvial deposit, river valley morphology and gravitational morphology developed in periphery area.

2. Remote sensing interpretation of rivers and lakes on Qinghai-Tibetan plateau

We use ETM remote sensing images to interpret the trunk rivers, lakes geological topography, divide the rivers into superimposed river and prior river according to the relationship between the river developing history and the tectonic movement history, to understand the changes about nearly 30 years by contrasting the interpretation of the 1970s MSS (refer to the historical geographical terrain information) to the beginning of 21 century's ETM image of major lakes and trunk rivers.

2.1 The interpreting symbol of rivers and lakes on Qinghai-Tibetan plateau

According to the status investigation of rivers and lakes on Qinghai-Tibetan plateau based on the information of 1 : 250000 ETM remote sensing data, we made the edges enhancement processing and composite negative processing, established working standard of the remote sensing investigation, ascertained the interpreting symbol of the rivers and 6 interpreting symbols (tectonic lake, glacier lake, crater lake, fluvial lake, check-up lake, man-made lake) of the lakes on Qinghai-Tibetan plateau, which provided technical methods for extracting remote sensing information of rivers and lakes and studying the evolution of the rivers and lakes.

2.2 The current distribution of the rivers on Qinghai-Tibetan plateau

The trunk river and its 3-level branch both of external drainage system and general internal drainage system, and the trunk river and its 2-level branch of normal internal drainage system have been interpreted by remote sensing. There exist 8 external drainage systems such as Yellow River, Changjiang, Lancangjiang, Nujiang, Yarlung Zangbo Jiang, Yiluowadijiang, Ganges and Indus river, and 5 internal drainage river areas such as Hexi corridor, Tarim basin, Qaidam-Qinghaihu basin, Qiangtang and Mapam Yumco in study area. External drainage in total include 34 I-level branch and 188 II-level branch, internal drainage in total include 36 I-level branch and 269 II-level branch which belong to 27 I-level and 170 II-level internal drainage and 4 major internal drainage of Tarim river, Qarqan river, Shule river, Heihe river. There exists 12 trunks, 70 I-level branchs and 457 II-level branchs in study area.

2.3 The distributing law of the rivers on Qinghai-Tibetan plateau

Drain water of the external drainage system come from the hinterland of the Qinghai-Tibet plateau, from northwest to southeast in a radiation shape, and its tributaries have different levels of the distribution branches. The source areas of main river have flat terrain with more snow and rain but less evaporation, so there are lots of lakes and marshes. In the southeast of Qinghai-Tibet plateau, paralleling to the main river and the mountains, there are high mountain and valley landscape, Where the mountain are dissected, there formed in verted flow, three rivers juxtaposed flow and turning flow landscape.

The center of endorheic systems is lake or basin, distributing centripetally, finally inflood into lakes, or disappear in deserts. The headtreams of important and I-level endorheic systems are overlayered by mass serac, and the water is very abundant. The endorheic rivers break off, or become to intermittent stream when they inflood into basins in Hexi corridor, Tarim basin and Qaidam-Qinghai Hu basin.

2.4 The variance analysis of the rivers on Qinghai-Tibet plateau

Among 24 years, the variety of rivers is unobvious in Qinghai-Tibet plateau, some reach of drain water swing appreciablily, a little of reach in endorheic systems change its route or break off, and there are extendability or shrink appears in embouchure.

2.5 The distributing status of the lakes on Qinghai-Tibet plateau

The number of lakes is 1128 which area is larger than $1km^2$, the total area is $41183.74km^2$. There are 61 man-made lakes (reservoirs), and the total area is $772.17km^2$; there are 1067 natural lakes, and the area is $40411.57km^2$. Among the natural lakes, there are 3 giant lake (area $>1000km^2$), the total area is $8013.57km^2$; there are 11 great lake (area between 500 ~

$1000km^2$), the total area is $6785.76km^2$; there are 71 medium-sized lakes (area between $100\sim500km^2$), the total area is $13848.18km^2$; there are 303 small lakes (area between $10\sim100km^2$), the total area is $9612.83km^2$; there are 679 lakes which area is $1\sim10km^2$, the total area is $2151.23km^2$. The number of fresh water lake is 309, salt-water lake is 758; the tectonic lake is 897, glacial lake is 117, volcanic lake is 4, fluvial lake is 25, barrier lake is 24.

2.6 The distributing law of the natural lakes on Qinghai-Tibetan plateau

The lake area of Qaidam-Qinghai Hu basin and Qiangtang are the two biggest dense lake regions in Qinghai-Tibetan plateau, indeed in China. The lake ratio is 2.36% in Qaidam-Qinghai Hu basin, and 3.82% in Qiangtang region, which are respectively 2.5 and 4.0 times of the national lake ratio (0.95%).

The natural lakes distribute in source regions, upper reach of drain water and intermountain basin in Yellow river drainage area, Sanjiang drainage area and south-Tibet valley. Most of natural lakes are inland lake in source basin and intermountain basin, the lake water is a little salt to salt, and the lakes almost belong to tectonic lake. Most of the natural lake are outflow river in mountain ridge, upper reach of source region and river course of tributary, the lake water is fresh, and the lake almost belong to tectonic lake or glacier lake, a little is check-up lake.

The most of natural lakes are inland lake in Tarim basin, Qaidam-Qinghai Hu basin and Qiangtang lake regions. The lake water is salt to a little salt, the lake mostly belongs to tectonic lake, some is fluvial lake or check-up lake. The distribution of natural lake is firmly controlled by regional tectonics in Qiangtang regions, the direction of overall extendability and single lake major axis accord with the direction of regional tectonics.

The natural lakes are the end of river, or there are river cross, they are all the center of water catchment in Qinghai-Tibetan plateau. The water is mainly from direct surface runoff, spring water and precipitation. The surface of most rivers source region is covered by serac, where the waterhead is abundant.

2.7 The variety analysis of the lakes on Qinghai-Tibetan plateau

Among 24 years, most of natural lakes varies greatly in Qinghai-Tibetan plateau, some area is reduced, some area is enlarged; a small quantity of lakes are disassembled or amalgamative; some lakes that had been dried collect water again, and some lakes approach to dry. The result of remote sensing investigation indicates: the total number of natural lakes (area $\geqslant 1km^2$) increase from 1029 to 1067 in Qinghai-Tibetan plateau, the increasing number of lakes is 38, the increasing area is $199.42km^2$, which occupy respectively 3.56% and 0.50% of the number and total area of natural lakes in Qinghai-Tibetan plateau. From the former 1029 natural lakes, The area of 509 lakes is steady, the total area is $8568.32km^2$, it occupy respectively 47.70% and 21.20% than the total numbers and area of natural lakes in Qinghai-Tibetan plateau. The area of 322 lakes is reduced, the total area is $19692.98km^2$, it occupy respectively 30.18%, 48.73%. The area of 198 is enlarged, the total area is $11950.85km^2$, it occupy respectively 18.56%, 29.57%; the total reduced area of natural lakes is $1652.26km^2$, the increasing area is $1454.18km^2$, the both counteract one another, the net area added is $1.34km^2$; the total area of natural lakes increase from 40410. 23km^2 to 40411. 57km^2, the net area added is 1. 34km^2.

2. 8 The variety analysis of lake subarea on Qinghai-Tibetan plateau

The variety types of natural lakes is differentiated 3 kinds by us, that is: the lake which MSS area and ETM area is the same is steady; the lake which MSS area is larger than ETM area is atrophic; the lake which MSS area is smaller than ETM area is outstretched. The induced area of atrophic lake than MSS area is atrophic ratio, the increasing area of outstretched lake than MSS area is outstretched ratio, the two ratio are the index that weigh the variety of lake. The factors that affect atrophic ratio and outstretched ratio is so many, for example, the time phase of remote sensing data and size of lake, that can not reflect intuitionisticly variety degree of lake, but they have some reference value. By calculating, the atrophic ratio of atrophic lake is 7. 73%, the outstretched ratio of outstretched lake is 13. 87%.

Based on all-side investigation of rivers and lakes, we choose giant and large lakes to investigate and research deeply. The achievement of actuality investigation and variety analysis are obtained, which are from 3 giant lakes: Qinghai Hu, Nam Co, Siling Co, and from 11 large lakes: Zhari Namco, Tangra Yumco, Yamzho Yumco, Ayakkum Hu, Bangong Co, Har Hu, Ngoring Hu, Gyaring Hu, Chibuzhang Co, Ulan Ul Hu, Ngangla Ringco.

3. Laboratory studies

By mensurating the age of sample systemicly, identifying micropaleontology and paleobotany, the index of paleoecology and paleoenvironment, we want to estimate the climatic change that reflected by the variety of rivers and lakes in Qinghai-Tibetan plateau. By founding an ecologic geological environment model, we discuss the course of environment change and its evolvement.

3. 1 The trend of climatic change in Qinghai-Tibetan plateau

According to the change characters of temperature and precipitation for nearly 40 years past in Qinghai-Tibetan plateau, we forecast the climatic changes in future 30 years and 300 years. The study indicates: ①during the last 40 years in 20 centry in Qinghai-Tibetan plateau, the temperature changes is reverse with southwest China but same to north China, which rises in a little high range; ②the temperature has complex spatial differentiation in summer in Qinghai-Tibetan plateau, which is different from other regions in China, but the temperature rises greatly in winter, which is same as the other regions; ③the temperature variety ratio is higher than other regions in China, cold and warm behaves obviously in 40 years; ④the annual precipitation reduce gradually in Qinghai-Tibetan plateau, which is same as other regions in China while the precipitation increase in north-Tibetan and most of Qinghai province where the precipitation reduce since 1990s.

3. 2 The quantitative analysis of lake evolution in Qinghai-Tibetan plateau

According to the variety of temperature and precipitation in every drainage area, the variety of inland river runoff, the variety of outflow rivers runoff and the variety of lakes for recent several decades, we developed the quantitative analysis of lake evolution in Qinghai-Tibetan plateau. The study indicates, the global climate become warm for recent several decades, and resource is empoldered and used too much, which lead to different variety of lakes in regions, such as the level of some lake water descends, the area of lakes shrinks, the salinity of lake water increase, and some lakes die out gradually. At the same time, as the climate become warm and dry, the runoff descend greatly.

Among 24 years, the total number of natural lakes (area $\geqslant 1km^2$) increase from1029 to 1067 in Qinghai-Tibetan plateau, the increasing number of lakes is 38, the total area is 40411.57km^2. At the begining of 21 century, because of the global climate getting warm, the glacier thaws, and the numbers of lakes increase. As the climate get warm and dry, the lake shrinks in semiarid and arid inland, the entironment is deteriorated gradually.

3.3 The ecologic geological environment regionalism in Qinghai-Tibetan plateau

Based on investigation and evolution analysis to rivers and lakes, we developed the effect analysis of ecologic geological environment, according to 1 : 1500000 rivers and lakes remote sensing image interpretation of Qinghai-Tibetan plateau, we work out 1 : 1500000 map of ecologic geological environment about rivers and lakes in Qinghai-Tibetan plateau. By the sign with status of natural lakes evolution, we differentiate the ecologic geological environment of rivers and lakes with improving region, steady regions and degenerate regions. Focus on describing primary partition sign of rivers, lakes ecological and geologic environment, giving integrated estimate to ecological and geologic environment of rivers and lakes in important developing region in Qinghai-Tibet plateau.

目　次

绪　言

本书以青藏高原1∶25万区域地质调查及前期开展的“西藏纳木错第四纪环境演变调查研究”项目为基础，将国土资源大调查与前缘性重大科学问题的研究紧密结合起来，系统调查晚新生代以来重点湖泊与河流的分布范围及其演变关系，深入研究青藏高原晚新生代以来的环境变迁过程与地质生态演化规律，为我国长江、黄河演变、东亚古环境变迁与全球气候、环境变化研究，为青海、西藏等西部省区社会经济发展规划，提供重要的基础资料。

一、目的任务

1. 总体目标

建立青藏高原湖泊与河流的遥感解译标志，厘定湖泊与河流的分布范围、现—近代演化时段，编制青藏高原湖泊与河流遥感解译图，探讨湖泊与河流演变及其与环境变迁、高原隆升历史的相关性。测定晚新生代以来重点湖泊不同时期的古环境参数，在纳木错等湖泊高精度标准剖面建立的基础上，初步探讨青藏高原晚新生代以来环境演化过程与动力学机理，为研究青藏高原湖泊与河流尤其是长江、黄河的演变，对我国东部地区气候变化的影响等，提供科学依据。

2. 主要任务

（1）调查、鉴别重点湖泊与河流的地域分布

搜集以往地理、地貌资料，结合典型地区野外观测资料，调查、鉴别、筛分青藏高原重点湖泊与河流的地域分布及演变过程，分析重点湖相地层的时空分布及其组合特征，为湖泊与河流遥感解译提供地质依据。

（2）综合解译重点湖泊与河流

鉴别青藏高原重点湖泊与河流的地理地貌特征，建立遥感解译标志和属性特征，并运用这些特征判定青藏高原重点湖泊与河流的分布范围、演化过程，分析重点湖泊与河流环境变化及其与高原隆升历史的相关关系。

（3）分析重点湖泊与河流的动态变化趋势

在重点湖泊与河流遥感解译的基础上，判定主要河流干流变迁方向及幅度，计算不同时期主要湖泊面积大小及湖面升降幅度；同时，根据湖泊水化学和物理性质，大致判别湖水的性质，确定湖泊的成因类型。分析重点湖泊与河流季节性变化及近30年来的变化趋势等。

二、总体技术路线

本项研究以 ETM、MSS 遥感数据为信息源，采用遥感解译与野外检查验证相结合的技术路线，进行青藏高原河流、湖泊现状调查和变迁分析。

1∶25 万河流、湖泊遥感解译：以 MAPGIS（6.1）软件为平台，在建立解译标志基础上，进行逐一解译。

1∶50 万、1∶150 万河流、湖泊现状遥感解译图和变迁遥感解译图编制：以 1∶25 万河流、湖泊 ETM、MSS 遥感解译资料为依据，在 MAPGIS（6.1）软件平台上分别进行逐级缩编，同时标记河流、湖泊的相关属性。

1. 技术路线

以遥感地质为主要手段，充分发挥遥感技术在地质调查中的重要作用。在遥感解译的基础上选择重点地区，将区域地质调查与前缘性科学问题的研究紧密结合在一起，将第四纪地质事件调查与古环境变迁联系在一起，将晚新生代重点湖泊标准剖面测制与样品的古环境参数测定有机地结合在一起，将不同技术方法良好地配合起来，将调查与研究、点上突破－线上深入－面上展开、定性与定量、区域分析与全球对比相结合，围绕中心任务，系统、深入地开展各项工作。

2. 主要技术方法

（1）遥感综合解译

采用常规遥感技术开展以下几方面的调查与研究：

1）湖泊、河流解译：利用 ETM 遥感图像解译主干河流、湖泊的地质地貌，如湖蚀崖、湖蚀平台、湖蚀岬角、湖岸堤、沙坝、沙岛、湖岸沙丘、湖积平原、湖岸阶地等，恢复河流和湖泊晚更新世以来的分布及成因类型。

2）湖泊、河流分类与成因：根据河流发育历史与构造运动历史的关系，将河流划分为叠置河与先成河两类。叠置河是指在古老的构造基岩面上有松散层覆盖，在松散层上发育的河流；先成河是指河流发育在下部的构造最后发生变形之前形成的。通过遥感调查和对地质构造、火山活动、河流、冰川、冰缘、风蚀、喀斯特、地质灾害等的解译确定湖泊成因，如构造湖、火山湖、河成湖、冰蚀湖、风蚀湖、堰塞湖、人工湖等。

3）湖泊、河流演变：通过对 20 世纪 70 年代 MSS（参照历史地理地形资料）和 21 世纪初 ETM 图像的对比解译，选择重点湖泊（如冰川湖等）、主干河流，了解其近 30 年来的变化。根据湖泊与河流周边地表温度、色调、植被的遥感调查与对比，判定湖泊与河流的季节性变化，研究变化所带来的生态环境效应。

（2）测试与分析研究

在遥感综合解译分析基础上，视经费情况，选择重点河湖的少量样品进行：

1）地质测年：包括 U 系法、ESR 法、TL 法、OSL 法、^{14}C 法等方法，测定晚新生代重点湖泊的地层与古地质事件的时代。

2）古环境测定：包括粒度分析、磁化率测定、碳酸盐测定、石英颗粒电镜扫描与环境地球化学分析等方法，确定晚新生代重点湖泊的古环境参数。

3）古生态分析：包括微体古生物组合、孢粉组合分析，古生态指标分析等方法，恢

复晚新生代重点湖泊的古生态环境。

4）古气候对比：包括晚新生代重点湖泊的古气候与青藏高原内部地区、青藏高原周缘地区、东亚及全球古气候对比分析。

（3）生态地质环境区划分析

在上述调查研究成果基础上进行河流湖泊生态地质环境效应分析，建立生态地质环境评价模型，划分生态地质环境研究区级别（Ⅰ、Ⅱ、Ⅲ）与类型（常规、一般、应急），初步分析各级各类研究区今后应重点研究的内容、周期、方法等。

三、工作概况

完成的主要调查研究内容是：在研究青藏高原藏南谷地、青藏公路沿线等地遥感地质背景的基础上，完成了长达数千千米的长距离路线地质调查，室内对数百张 1∶25 万 ETM、MSS 遥感图进行解译，选择典型湖相地层剖面作重点解剖，并对湖岸堤、湖蚀地貌等开展了水准仪测量，1∶50 万、1∶150 万遥感图编制，对湖相地层剖面样品进行了 U 系法、^{14}C 法等同位素测年，旨在运用遥感地质、环境地质的有关理论，在本区深入探讨对比区内的湖泊、河流的环境演变规律，为在工作区开展青藏高原生态地质环境遥感调查与研究提供科学的思路和具体的技术路线。

调查研究工作分阶段实施，包括如下几个阶段：

1）遥感地质、第四纪地质调查准备阶段：收集必要的遥感地质、区域地质、第四纪地质与地质环境资料，进行遥感地质、区域地质调查和第四纪地质工作方法初步研究，进行遥感图像处理和初步遥感地质解译。

2）遥感地质、野外第四纪地质调查阶段：系统开展全区野外遥感地质调查、第四纪地质调查、实测剖面、湖岸堤和湖相沉积的水准测量、遥感资料野外验证和综合研究工作，对研究区遥感地质、第四纪地质与地貌开展了全面的地质调查与系统的研究工作。

3）资料整理和综合研究阶段：在室内工作中开展遥感解译、清绘地质图，整理、登记各类标本、样品、照片，开展岩矿鉴定、测试分析工作，编制实际材料图、遥感解译图和第四纪地质图，进行综合研究，撰写论文，编写专著。

四、主要实物工作量

本项研究完成的主要实物工作量如下：

1）解译 1∶25 万青藏高原河流、湖泊 ETM 影像 217 幅；

2）解译 1∶25 万青藏高原河流、湖泊 MSS 影像 202 幅；

3）编制 1∶50 万青藏高原河流、湖泊现状遥感解译图 61 幅；

4）编制 1∶50 万青藏高原河流、湖泊变迁遥感解译图 61 幅；

5）编制 1∶150 万青藏高原河流、湖泊现状遥感解译图 1 幅；

6）编制 1∶150 万青藏高原河流、湖泊变迁遥感解译图 1 幅；

7）编制 1∶150 万青藏高原河流、湖泊生态地质环境区划图 1 幅；

8）编辑青藏高原主要湖泊 ETM 影像特征图 1 册；

9）编制青藏高原1∶50万分幅河流、湖泊遥感调查表1册。

10）野外地质调查路线9000km；

11）野外观测湖相地层剖面3条；

12）湖相沉积物分析鉴定（包括^{14}C法、U系法、ESR法测年等）样品32个。

本专著是经过充分讨论、分工负责、集体编写而成的。绪言由朱大岗执笔，第一章由朱大岗、孟宪刚、邵兆刚执笔，第二章由郑达兴、乔子江执笔，第三章由乔子江、杨朝斌、王津执笔，第四章由郑达兴、乔子江、朱大岗、邵兆刚执笔，第五章由朱大岗、孟宪刚、杨朝斌执笔，第六章由邵兆刚、乔子江、韩建恩执笔，第七章由乔子江、郑达兴、余佳执笔，第八章由孟宪刚、朱大岗、孟庆伟执笔，第九章由朱大岗、郑达兴执笔。“青藏高原河流湖泊分布图和区划图”由郑达兴、乔子江统编，并指导余佳、韩建恩、孟庆伟、吕荣平、王艳等清绘。本书最后由朱大岗、孟宪刚、郑达兴汇总、统编、定稿。

五、主要成果

通过野外对藏南谷地（拉萨—日喀则—拉孜—萨嘎—帕羊—门士—巴尔—札达—狮泉河、札达—普兰—萨嘎—拉孜—定日—吉隆—聂拉木—定结—亚东—江孜—浪卡子—曲水），及青藏公路沿线（拉萨—当雄—那曲—布隆—安多—唐古拉山口—五道梁—昆仑山口—西大滩）几条总计长达9000多千米的野外路线地质调查，全面了解了青藏高原的地质构造、地质地貌、冰川遗迹（冰碛物、冰水沉积物等）、湖相沉积（湖相地层、湖岸堤、湖滩岩等）、湖成地貌（湖蚀洞、湖蚀凹槽、湖蚀崖等）、河流沉积、第四纪地质与地貌、现代河流湖泊等方面的基本特征。经过两年的野外地质调查和室内遥感解译及其综合研究工作，研究区内遥感地质、第四纪地质调查与研究所取得的主要成果进展包括以下几个方面。

（一）在区域地质地貌、湖泊与河流地质方面

对青藏高原河流与湖泊的现状调查，分两次进行。第一次野外地质调查工作中，主要对重点古湖泊、古地质事件开展调查，对晚新生代重点湖泊地质剖面进行观测与采样，配合室内遥感初步解译、古地质构造事件测年等，建立重点河流、湖泊遥感解译标志；第二次野外地质工作中，实测了不同地区、不同时期晚新生代湖相地层剖面，建立了晚新生代重点湖泊标准剖面，系统采集样品。

1. 确定了青藏高原的大地构造位置

青藏高原位于欧亚大陆与冈瓦纳大陆之间的巨型特提斯-喜马拉雅构造域东段，夹持于三大古老刚性地块之间，北有塔里木-中朝地块，东有扬子地块，南有印度地块，具有异常的地壳厚度和地貌高度，活动构造极为发育，山川湖泊星罗棋布。

2. 确定了青藏高原地壳的基本结构

青藏高原与世界上大多数稳定克拉通“高原”的地壳结构明显不同，它是围限于古老地块之间的“塑性槽型”构造区。其地壳由不同时期形成的“微大陆”拼合而成。由北到南可划分出5个微陆块和“焊接”它们的5条缝合带，依次是：西昆仑-祁连山加里东缝合带、柴达木地块、昆仑山华力西缝合带、巴颜喀拉地块、金沙江印支缝合带、羌