

STUDY ON THE YUNNAN STONE FOREST KARST CHINA

中国

路南石林喀斯特研究

新华书店

科学出版社

PDG

中国路南石林 喀斯特研究

云南省风景园林学会地质地貌专业委员会
路南石林风景名胜区管理局 ● 石林研究组

云南科技出版社

P642.252.744
79



责任编辑:袁 莎
封面设计:王玉辉
责任校对:叶水金

中国路南石林喀斯特研究

云南科技出版社出版发行 (昆明市书林街 100 号)
滇黔桂石油勘探局昆明印刷厂印装
开本:880×1230 1/16 印张:10.8 字数:225 千
1997 年 4 月第 1 版 1997 年 6 月第 1 次印刷
印数:1-3000

ISBN 7-5416-0533-6/X·8 定价:28.80

STUDY

RESEARCH

STUDY

STUDY

STUDY

STUDY

STUDY

STUDY

STUDY

STUDY

STUDY

STUDY

STUDY

STUDY

STUDY

STUDY

STUDY

STUDY

STUDY

STUDY

STUDY

STUDY

STUDY

STUDY

STUDY

STUDY

STUDY

STUDY

STUDY

STUDY

STUDY

STUDY

STUDY

STUDY

STUDY

STUDY



前 言

中国路南石林在海内外享有很高的声誉，被誉为“天下第一奇观”。在古代，路南石林是滇桂、滇黔古驿道站；明朝万历年于乃古石林建石峰寺。十九世纪末，法国人张国良(Paul Vial)在巴黎一家杂志发表了有关路南石林、路美邑彝族撒尼人的文章和生活照片(这是迄今所知的最早将路南石林介绍给西方世界的文献)。20世纪30年代，云南省政府龙云主席拨款建设石林。80年代以来，路南石林接待了上百万的海外游客，上千万的中国游客，有数十个国家的国家元首、政府要员游览过石林。单就国内而言，石林接待过四位国家主席(刘少奇、宋庆龄、李先念、杨尚昆)，三位全国人大常委会委员长(朱德、万里、乔石)，一位全国政协主席(李瑞环)。国务院已故总理周恩来两次游览石林，中国改革开放的总设计师邓小平也在石林留下足迹。他们在石林写下了留芳千古的题辞。石林成为路南各族、云南各族人民与国内外交往的重要媒体。

石林这块孕育了勤劳、美丽、善良、智慧的彝族人民的自然奇景吸引了古今中外的游客，她的科学奥秘也引来了无数中外专家、学者、科普爱好者。公元前300余年的楚国大夫屈原的“焉有石林”之问，揭开了认识石林之先河。近百年来，尤其是20世纪40年代以来，到路南石林地区进行过研究考察的中外学者上千人，涉及到历史学、民族学、社会学、经济学、人类学、文化语言学、地质学、地貌学、地理学、植物学、动物学、环境学、生态学、风景名胜学、资源学和旅游学，其中有许多著名学者。如闻一多、李公朴、潘光旦、吴晗、张光年、朱自清等在40年代对石林彝族撒尼文化和社会进行过考察和研究；著名历史学家方国瑜教授研究彝族文化历史，涉足过撒尼人；文学家李广田教授等整理了撒尼史诗《阿诗玛》；中国科学院院士、古生物学专家杨钟健教授研究过路南盆地的新生代地质；中国科学院院士吴征镒教授分析研究过路南地区的植被区系；30年代马希融首次研究石林喀斯特的地貌学；中国科学院院士、著名地质地理学家、喀斯特研究专家任美镛教授、袁道先教授对石林进行过专门研究。针对经济建设需要，中央政府和地方政府多次派专业队到石林考察研究地质、矿产、水文、植物和动物、风景名胜资源等。80年代以来，专程到石林考察的世界著名喀斯特专家逐渐增多，他们惊叹路南石林的古、奇、险、美和撒尼人的民族风情。他们中有世界著名喀斯特专家、英国的M.M.斯威丁教授(Dr M.M.Sweeting)，国际洞穴协会前主席、喀斯特研究专家、奥地利的H.特里默尔教授(Dr Huber Trimmel)，国际洞穴协会副主席澳大利亚的J.詹姆斯教授(Dr Julia James)，美国的米歇尔·戴教授(Dr Michael J.Day)，英国的A.C.沃尔什姆博士(A.C.Waltham)，加拿大的D.C.福特教授(Dr D.C.Ford)，法国的J.N.沙勒孟教授(Dr J.N. Salomon)和新西兰的P.W.威廉姆斯教授(Dr P.W.Williams)等。石林研究的深入和越来越多的海内外游客的向往，引起了中国政府和国际组织的重视。1982年，

经国务院批准,路南石林成为中国首批国家重点风景名胜区,石林的保护与开发纳入国家级管理。1991年,中国政府开始申请将石林列入世界自然遗产目录,中国政府寻求国际组织对路南石林保护开发的帮助和监督,1993年,联合国教科文组织下属的世界遗产保护执委会派员到石林考察,审查石林列入世界遗产目录的可能性。

与申请列入世界遗产目录的要求相比,不无遗憾地发现,石林的研究还有着系统性、完整性的不足,尤其是缺乏与世界各地石林喀斯特之对比,从而不能从世界角度说明路南石林喀斯特的显著特性和地位。不论我们感情上有这样和那样的激动,我们在申请石林列入世界自然遗产目录这一新的任务面前,不能不重视这一点,尤其在当今人类活动日甚,科学、合理、持续地利用石林喀斯特资源成为石林保护和开发的主题之时,全面、系统、深刻地揭示路南石林的科学和美学价值更成为必然。

1994年7月,在路南石林召开了喀斯特与洞穴风景旅游资源开发与保护国际研讨会,与会代表一致建议,系统研究路南石林喀斯特,出版一本独立的报告和一幅石林分布图等。1995年7月,再次召开的路南石林喀斯特国际研讨会上,与会代表再次提出了这一呼吁。

鉴于此,中华人民共和国建设部委托云南省建设厅、路南县人民政府、路南石林风景名胜区管理局组织有关专业人员,开展以石林喀斯特范围、类型、品质、发育演化规律为主要内容,兼顾石林地区人文、自然地理的研究。课题组于1995年开始工作。经历资料整理、野外填图调查、室内制图、路线检查、样品分析、报告编写,并于1996年2月,邀请了欧洲、美洲、澳洲的世界著名喀斯特专家D. C 福特教授、J. N 沙勒孟教授、P. W 威廉姆斯教授对工作组的主要工作路线和确定的路南石林主要类型进行考察鉴定,研究组的工作得到了他们的肯定。结合在世界各地石林喀斯特研究的经历,他们对石林进行了独立的评价。路南石林以其类型多样,形态多姿,发育历史久远复杂,融自然与民族文化为一体,而集世界各地石林喀斯特之大成,被誉为世界石林喀斯特博物馆。

我们希望这一研究成果既有助于路南石林申列世界自然遗产目录,更有利于科学、系统、合理地保护开发路南石林,使之成为当地社会、经济、文化发展,自然环境保护,生态系统建设的重要依据。

中国路南石林喀斯特研究组

1996年12月

SUMMARY

The well-known Lunan Stone Forest is located at $24^{\circ} 49'N$ and $103^{\circ} 19'E$, 85km southeast of Kunming, provincial capital of Yunnan, China. Lunan Stone Forest covers a total area of some 350 km². It is not only a great tourist attraction, being acclaimed as "one of the greatest natural wonders in the world", but also of important scientific and aesthetic value.

There have been a number of publications about the Lunan Stone Forest in terms of its origin, evolution and geomorphologic features, etc, but the study is far from adequate, therefore, this "Study on the Lunan Stone Forest Karst, China", which took two years to complete, is an effort to make up for the weakness of this respects. Main points of this study are summerized as follows:

1. Since very ancient time, the history, culture, and art of the local Sani people, Yin nationality, have been closely linked with the Lunan Stone Forest. Though there was at least 400 year's history of exploitation, it was not until 1980s that the Lunan Stone Forest came into a period of systematic protection and development.

2. Located at the junction of east, south and central part of Yunnan province, Lunan Stone Forest area, in addition to its pleasant climate and colourful minority nationality custom, is endowed with rich natural resources characterized by stone forest karst landscape, coal, marble and arable land, etc. Closely attached to the economic development of Kunming, tourism, coal, electricity power and commercial crops have become Lunan's pillar industries. Particularly in the last few years, tourism and tourist products centered in the Stone Forest grew rapidly.

There is still great potential to promote local economy through further tourism development, but at the same time, the impact of tourism on the environment must be noted.

3. With a large variety of karst landscapes, Lunan Stone Forest is positioned in the subtropical, monsoon climate, plateau karstic lake area of eastern Yunnan. Soil here is relatively poor and stony land is common. Climax vegetation is climatic climax-subhumid broad-leaved evergreen forest, and soil climax-evergreen deciduous forest. But the existing vegetation is mostly secondary forest represented by that around Changhu lake, consisting of limestone be-aring broad-leaved evergreen coppice shrubwood, Yunan pine, limestone juniper brushwood and water vegetation. Secondary vegetation has grown rapidly in this area, total coverage of forest

and brushwood has currently reached at least 36%. Natural environment has been improved considerably and local ecological variety has been restored. However, the impact of human activities is profound.

4. Lunan Stone Forest as well as associated diverse karstic landscapes and groundwater system of the stone forest area resulted from its complex geological evolution and various rock sequences as well as structural features. Except for several short subaerial erosion intervals, due to closing to the Niushoushan old land, most of the time from the Devonian to the Lower Permian, the Stone Forest area was under shallow sea environment and deposited a carbonate sequence of limestone-dolomitic limestone-dolomite. Hercynian (Dongwu) movement made this region ascend as an area, lying between the Niushoushan uplift in the north and the marginal seas in the south, at the same time, faults and joints took place in carbonate strata with the dominant conjugate joint set orientated in $40^{\circ} \sim 70^{\circ}$ and $300^{\circ} \sim 340^{\circ}$. Along with the development of underground water channels, stone teeth and columns of certain extent in height and scale began to take shape. In the early phase of the Upper Permian, because of the eruption of the terrigenous basaltic lava (Emeishan Formation), most of this area and early karstic relief was covered under basalt, and some thermal alteration occurred in the contact of the early stone teeth and the basalt. From the last phase of the Upper Permian to the Palaeocene, this area experienced a long period of slow but constant ascent and suffered planation denudation and erosion. Also during this time, fissures in the carbonate rock further widened, groundwater systems further diversified and the stone forest karst further complicated. By the early Eocene, the area evolved into a closed intermountain basin as a result of block faulting, and Lunan freshwater paleo-lake took shape, a sequence of fluvial and lacustrine deposits consisting of syngenetic basal conglomerate, clastic rock, mudstone, argillaceous limestone and dolomite took place. Meanwhile, carbonate rock in the vicinities of the lake suffered intensive erosion, which, while providing quite amount of carbonate material to the lake, made the landform more karstified. Thereafter the lake, with its centre moving southwards, gradually shrank, and finally in the end of Oligocene, as the discharge channel-Bajiang river joined Nanpanjiang river in the south, lake water drained out and the history of the Lunan inland palaeo-lake terminated. Since the Miocene, drawn by the ascending Qinghai-Tibet plateau, this area was uplifted to a much higher altitude and former planation surface gave way to moderate relief plateau surface. Plateau lifting and the cutdown of the Bajiang river encouraged full development of fissures and groundwater channel systems, which in turn made the stone forest karst rapidly develop. As a result of the differential uplifting, Lunan Stone Forest area and other

karstic areas of southwestern Yunan. lie at different erosion bases. The structural geomorphologic accident-Grand Waterfall in the lower reach of Bajiang river, prevented the Stone Forest area from being affected by the headward erosion of the Nanpanjiang river. Locally, the bottom of the Bajiang river was the erosion basis, from which more stone forest karst emerged. The groundwater system at this time deversified and subsystems developed respectively in the eastern and southwestern parts of this area.

5. The evolution of groundwater system of this area is also complex, converting from a relatively simple early system into a highly complicated groundwater channel system. Six subsystems of groundwater have been identified. Channel network developed much better in the central and southwestern parts than in the east, and as a result, the well-developed stone forest karst also largely concentrated in the central and southwestern parts of this area.

6. Lunan Stone Forest Karst, resulted from its multi-phase evolution, occurred in various topographies, numerous stone forest patches are widely scattered across the landscape, occurring from hilltops and summit ridges to hillsides and valley bottoms. Pinnacle Karst, tower-shaped karst, ruin-form karst, razor-sharp karst, mushroom-shaped karst and irregular-shaped karst are the typical forms. In terms of geomorphologic locations, the stone forest karst here can be classified into stone forest depression, valley, slope, hill and basin, etc. Studies of stratigraphic sequence, palaeo-weathering crust, tufa dating, solution rate, topography and groundwater system indicate that the development history of the Lunan Stone Forest Karst can be divided into four major periods, i. e. Pre-basalt period (prior to the Upper Permian); Pre- Lunan ancient lake period (Upper Permian to Paleocene); Lunan ancient lake period (Eocene to Oligocene); and Plateau- Bajiang river period (Miocene to the present).

Lunan Stone Forest area is one of the representative geomorphologic landscapes in the southwestern part of China. Through studies of the Lunan stone forest karst, the regional geological and geomorphologic evolution history and major geological events can be clearly traced. The following are the main phases: continental-oceanic alternation and basalt eruption in the Permian; planation erosion in the Mesozoic; intermountain basin and inland lake development in the early Tertiary and afterwards, plateau uplifting and valley widening, etc.

7. Pinnacle karst occurred all around the world, of which some notable ones have been included in the world Heritage List, such as Madagascar, Mulu Sarawak (Malaysia) and Mt. Kaijende (Papua New Guinea). Compared with the above remarkable stone forest karsts, the

Lunan Stone Forest Karst, in addition to the common pinnacle karst characteristics, has its own unique features and outstanding universal values: it is unrivalled in the multi-phase complexity of its evolution from the early Permian to the present. It encompasses within just one district all representative styles of stone forest karst, containing spire, ruin-form, and emergent pinnacle forms. It is also one of only a few sites comprising razor-sharp pinnacle karst. Combined with karst caves, lakes, hills Fengcong and vegetation types, etc. Lunan Stone Forest displays a magnificent, spectacular, and fascinating panoramic view of karst landscape, being acclaimed in the geological world as "The museum of stone forest karst".

8. In Lunan the Stone Forest Karst has long been intergrated into the lifestyle of the local Yi people, which endowed the Stone Forest with cultural significance. Its considerable aesthetic appeal embodied not only in local people's art but also in traditional Chinese garden design.

9. Lunan Stone Forest is at present a great tourist attraction. Systematic and effective management has been established, but with the increase of the population and economic development, there is a contradiction between exploitation and protection of the natural resource. It has been noted that human activities over thousands of years have had an extensive and sometimes devastating impact on the vegetation, soil, and karstic landforms, therefore future development and management of the Lunan Stone Forest should, with respect to the world Heritage site criteria, give protection a top priority. An integral scientific protection system is needed, in which the stone forest karst, lakes, groundwater, caves, vegetation types, soil, air, geological and culture relics, minority people's culture and residential style, etc. are concerned, so that a sustainable use of the marvellous natural resources can be achieved.

In brief, Lunan Stone Forest is of extreme scientific and aesthetic value and significance. It belongs not only to Lunan, but also to the world, deserving profound concern and protection.

目 录

前 言.....	(1)
第一章 中国路南石林地区地理概况	(1)
1.1 路南石林地区自然环境与资源特	(2)
1.1.1 地形地貌特征	(2)
1.1.2 地表水系特征	(3)
1.1.3 气候特征	(4)
1.1.4 土壤植被特征	(4)
1.1.5 土壤植被生态系统	(7)
1.1.6 资源特征	(7)
1.2 路南石林地区民族和社会经济概况	(11)
1.2.1 人口和民族	(11)
1.2.2 民族文化	(11)
1.2.3 社会经济和旅游经济	(13)
第二章 中国路南石林地区地质与地下水系统	(15)
2.1 石林地区区域地质与构造特	(15)
2.1.1 区域地层基本特征	(15)
2.1.2 区域构造基本特征	(20)
2.2 地质演化与古环境变迁	(25)
2.3 地下水系统	(31)
2.3.1 地下水系统的划分及命名	(31)
2.3.2 地下水系统分述	(31)
2.3.3 地下水水化学特征及溶蚀性分析	(33)
2.4 地下水系统的演化	(40)
第三章 中国路南石林喀斯特景观特征	(45)
3.1 路南石林地区喀斯特类型及特征	(45)
3.1.1 石林	(46)
3.1.2 溶丘洼地	(47)
3.1.3 石芽原野	(47)
3.1.4 夷平面	(48)
3.1.5 溶蚀湖	(48)
3.1.6 峰丛洼地	(48)
3.1.7 喀斯特洞穴与洞穴沉积物	(48)
3.1.8 暗河伏流和天生桥	(49)
3.1.9 侵蚀丘陵	(50)
3.1.10 构造侵蚀中、低山	(50)
3.2 路南石林喀斯特景观组合类型	(50)
3.2.1 划分原则	(50)
3.2.2 石林景观组合类型及特征	(51)
3.2.3 石林喀斯特组合类型的空间变化	(54)

3.3 路南石林喀斯特景观发育特征	(56)
3.3.1 石林喀斯特景观发育的地层特征	(56)
3.3.2 石林喀斯特景观发育地层的岩石化学特点	(60)
3.3.3 石林喀斯特发育区的构造特征	(60)
3.3.4 石林喀斯特景观发育与地下水的关系	(63)
3.3.5 石林喀斯特景观发育与区域地貌演化关系	(66)
3.4 路南石林喀斯特景观发育的年代和期次	(68)
3.4.1 石林发育时代的地层依据	(69)
3.4.2 路南群的岩性与古石林的发育和剥蚀	(69)
3.4.3 古风化壳、上第三系与石林发育	(70)
3.4.4 石林发育年代的钙华样年龄依据	(72)
3.4.5 地表溶蚀与土下侵蚀对石林发育的影响及溶蚀率与石林发育年代	(73)
3.4.6 石林发育年代的主要依据	(75)
3.4.7 石林发育年代和期次	(76)
3.5 路南石林喀斯特景观的发育模式	(76)
第四章 石林喀斯特的对比和中国路南石林的地位	(80)
4.1 中国路南石林喀斯特的典型特征	(80)
4.1.1 中国路南石林喀斯特的典型发育特征	(80)
4.1.2 中国路南石林景观所反映的古今环境特征	(83)
4.1.3 中国路南石林喀斯特景观的形态与美学特征	(85)
4.2 世界其他石林喀斯特及与路南石林喀斯特的对比	(85)
4.2.1 马达加斯加石林喀斯特	(86)
4.2.2 马来西亚沙捞越穆鲁石林喀斯特	(88)
4.2.3 巴布亚新几内亚凯靖德山石林喀斯特	(88)
4.2.4 澳大利亚石林喀斯特	(89)
4.2.5 菲律宾巴拉望石林喀斯特	(90)
4.2.6 欧洲的石林喀斯特	(90)
4.2.7 中国其他地区石林喀斯特	(91)
4.3 中国路南石林的显著价值和地位	(91)
4.3.1 评价的准则	(91)
4.3.2 中国路南石林的科学价值和地位	(92)
第五章 中国路南石林的保护与开发	(96)
5.1 路南石林喀斯特景观保护开发现状和动态趋势	(96)
5.1.1 保护开发现状	(96)
5.1.2 路南石林地区的变化因子	(97)
5.1.3 存在的主要问题	(99)
5.2 自然景观和人文景观的保护开发依据与原理	(100)
5.2.1 关于保护与开发的世界性公约条文	(100)
5.2.2 关于对自然景观和文化景观进行保护开发的中国法律条文	(104)
5.2.3 中国其他相关法律中有关保护和开发的条款	(106)
5.2.4 可持续发展和中国 21 世纪议程	(111)
5.2.5 各类自然保护区保护开发范式	(112)
5.3 路南石林的保护与开发	(113)

5.3.1 石林保护开发的原则	(113)
5.3.2 路南石林保护开发对象和等级	(114)
5.3.3 路南石林保护开发措施建议	(116)
结 论.....	(120)
后 记.....	(123)
附 录.....	(124)
主要参考文献.....	(151)
英文目录	
英文摘要	

图表目录

图 1-1	中国路南石林地区交通位置示意图.....	(1)
图 1-2	中国路南石林地区地貌区划图.....	(3)
图 1-3	中国路南石林地区植被生态系列示意图.....	(8)
图 1-4	中国路南石林地区植被演替系列图.....	(8)
图 2-1	中国路南石林地区区域地质图.....	(16)
图 2-2	中国路南石林地区大地构造位置简图.....	(20)
图 2-3	中国路南石林地区构造纲要图.....	(22)
图 2-4	早泥盆世岩相古地图.....	(25)
图 2-5	早二叠世茅口期岩相古地图.....	(26)
图 2-6	晚二叠世龙潭期岩相古地图.....	(27)
图 2-7	晚三叠世诺利期岩相古地图.....	(28)
图 2-8	早第三纪始新世晚期 - 渐新世岩相古地图.....	(29)
图 2-9	中国路南石林地区地下水系统空间分布图.....	(30)
图 2-10	I 系统黑龙潭 - 尾博邑暗河子系统示意剖面图.....	(33)
图 2-11	南古湖盆分布图.....	(42)
图 3-1	剑状石林.....	(45)
图 3-2	剑状石柱上的圆桶型溶槽.....	(46)
图 3-3	塔状石林.....	(46)
图 3-4	蕈状石林中的典型柱体.....	(47)
图 3-5	石芽原野.....	(48)
图 3-6	长湖地形.....	(49)
图 3-7	石林洼地.....	(51)
图 3-8	路南石林地区大石林景区(五棵树)线性构造(裂隙节理)图.....	(52)
图 3-9	石林岩丘.....	(53)
图 3-10	石林谷地.....	(54)
图 3-11	石林岭脊.....	(54)
图 3-12	石林坡地.....	(55)
图 3-13	覆盖于玄武岩下的古石芽.....	(55)
图 3-14	石林盆地.....	(56)
图 3-15	路南石林喀斯特组合类型分布图.....	(57)
图 3-16	石林喀斯特组合类型剖面图.....	(58)
图 3-17	路南石林地区地层组分布图.....	(59)
图 3-18	路南石林地区南部航卫片地质解译图.....	(61)
图 3-19	中国路南石林地区主要碳酸盐岩地层中的节理走向玫瑰花图.....	(62)
图 3-20	中国路南石林地区构造与裂隙岩溶及地下水关系图.....	(64)
图 3-21	石林发育与地下水系统演化关系图.....	(65)
图 3-22	中国滇东喀斯特高原(路南石林)至广西 孤峰盆地地貌类型图.....	(67)

图 3-23 石林发育期与喀斯特基准面变化关系模式图.....	(67)
图 3-24 中国路南石林玄武岩 (P ₂ β) 与石芽、石柱关系素描图.....	(68)
图 3-25 中国路南石林地区路南群与石柱、石芽接触关系素描图.....	(69)
图 3-26 中国路南石林地区新第三系与石柱、石芽接触关系素描图.....	(71)
图 3-27 地表溶蚀与土下溶蚀.....	(74)
图 3-28 中国路南石林清水塘石林与路南群接触关系剖面图.....	(75)
图 3-29 路南石林发育演化模式.....	(77)
图 3-30 路南石林典型发育过程示意图.....	(78)
图 3-31 路南石林的倒塌石柱.....	(79)
图 5-1 路南石林空间分布和保护范围示意图.....	(98)
表 1-1 路南县旅游风景名胜资源一览表.....	(9)
表 1-2 路南县社会经济在区域中的地位.....	(13)
表 1-3 路南石林地区国际、国内游客万人次一览表.....	(13)
表 2-1 路南石林地区各构造亚层特征表.....	(21)
表 2-2 路南石林地区褶皱特征表.....	(23)
表 2-3 中国路南石林地区断裂特征表.....	(24)
表 2-4 研究区主要岩层 (组) 含水与隔水性及其特征表.....	(32)
表 2-5 路南石林地区地下水系统特征表.....	(34)
表 2-6 石林地区部分水化学分析结果.....	(39)
表 2-7 路南石林地区不同地点水体的 Sc 值计算结果表.....	(40)
表 3-1 石林地区溶蚀洼地统计表.....	(47)
表 3-2 石林地区碳酸盐岩化学成分.....	(60)
表 3-3 石林地区钙华样特征及年代.....	(73)
表 3-4 石林地区碳酸盐岩的溶蚀率.....	(74)
表 4-1 中国路南石林喀斯特景观特征简表.....	(82)
表 4-2 中国路南石林喀斯特发育期综合简表.....	(83)
表 5-1 1997 年 ~ 2000 年石林风景区旅游规模预测表.....	(99)

CONTENT

Preface	(1)
Chapter One General situation of Lunan Stone Forest area, (Shilin), Yunnan, China	(1)
1.1 Natural environment and resources.....	(2)
1.1.1 Topography and geomorphology.....	(2)
1.1.2 Surface water system.....	(3)
1.1.3 Climate.....	(4)
1.1.4 Soil and vegetation.....	(4)
1.1.5 Ecologic system of soil and vegetation.....	(7)
1.1.6 Natural resources.....	(7)
1.2 General situation of nationalities and local economy.....	(11)
1.2.1 Population and nationalities.....	(11)
1.2.2 National culture.....	(11)
1.2.3 Local economy and tourism.....	(13)
Chapter Two Geology and groundwater system of the Lunan Stone Forest Area.....	(15)
2.1 Regional geology and structure.....	(15)
2.1.1 Regional strata.....	(15)
2.1.2 Regional structure.....	(20)
2.2 Geological evolution and palaeoenvironmental variation.....	(25)
2.3 Groundwater system.....	(31)
2.3.1 Division and denomination of groundwater systems.....	(31)
2.3.2 Description of the subsystem of groundwater.....	(31)
2.3.3 Groundwater chemistry and solubility analysis.....	(33)
2.4 Evolution of the groundwater system.....	(40)
Chapter Three Features of the Lunan Stone Forest Karst Landscape.....	(45)
3.1 Types and features.....	(45)
3.1.1 Stone Forest.....	(46)
3.1.2 Karst depression.....	(47)
3.1.3 Stone teeth field.....	(47)
3.1.4 Planation surface.....	(48)
3.1.5 Karst lake.....	(48)
3.1.6 Fengcong depression.....	(48)

3.1.7	Karst cave and cave sediment.....	(48)
3.1.8	Subterranean stream and natural bridge.....	(49)
3.1.9	Erosion hill.....	(50)
3.1.10	Structural eroded moderate mountain.....	(50)
3.2	Compound types of the Lunan Stone Forest Karst landscapes.....	(50)
3.2.1	Principles adopted in type classification.....	(50)
3.2.2	Compound types and features.....	(51)
3.2.3	Spatial variation of the compound types.....	(54)
3.3	Features of development.....	(56)
3.3.1	Strata on which the landscape developed.....	(56)
3.3.2	Rock chemistry of the strata.....	(60)
3.3.3	District geological structure.....	(60)
3.3.4	Relations between the development of the landscape and groundwater.....	(63)
3.3.5	Relations between the development of the landscape and the regional geomorphological evolution.....	(66)
3.4	Age-sequence and development phases of the Lunan Stone Forest Landscape....	(68)
3.4.1	Stratigraphic evidence for the age-sequence of the Karst.....	(69)
3.4.2	Lithology of the Lunan Formation (Tertiary)and the development of the paleo- stone forest.....	(69)
3.4.3	Paleo-weathering of paleo-crust, upper Tertiary and the development of the stone forest.....	(70)
3.4.4	Tufa dating on the ages.....	(72)
3.4.5	Subaerial, subsoil erosion and erosion rate.....	(73)
3.4.6	Main evidences.....	(75)
3.4.7	Ages and phases.....	(76)
3.5	Development model.....	(76)

Chapter Four Comparison between the Lunan Stone Forest Karst and other stone forest

	Karsts in the world and the status of the Lunan Stone Forest.....	(80)
4.1	Outstanding features of the Lunan Stone Forest.....	(80)
4.1.1	Typical development features.....	(80)
4.1.2	Ancient and present environmental conditions reflected by the Lunan Stone Forest.....	(83)
4.1.3	Morphological and aesthetic characteristics.....	(85)
4.2	Other well-known stone forest sites in the world and comparisons of the Lunan Stone Forest with them.....	(85)
4.2.1	Madagascan stone forest.....	(86)