Preliminary Observations on the Structure and Cenozoic Deposition in the Lijiang-Dali region of Western Yunnan

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I. Cenozoic Stratigraphy[1]

Cenozoic deposits in the Lijiang region are relatively widely distributed, rather completely developed, abundant in paleontological data, and produce a number of useful mineral products. A concise synopsis of these sediments is displayed in Figure 1.

1. Lower Tertiary-Lijiang Formation

As previously stated by P. Misch,[2] "there is a thick limestone breccia ... rather broadly distributed over northwest Yunnan that may extend to eastern Yunnan, and may be regarded as an older Tertiary breccia." These sediments were first noted by Jinglan Feng (in the early part of the century known as K.L. Fong) as the "Lijiang Breccias" (Misch, 1945). However, due to the lack of paleontological data, the age of these deposits was considered equivocal.

In February of 1962 the author of this paper discovered two sites that produced a large collection of mammalian fossils at the top of the "Lijiang Breccias." After diagnosis by colleagues Yuxuan Xu and Zhanxiang Qiu, and verification by Professor Minchen Chow from the Institute of Vertebrate Paleontology, Paleoanthropology, the following taxa were identified: *Prohyracodon* sp., *Juxia* sp., *Eomoropus* sp., cf. *Lopholetes* sp., cf. *Depretella* sp., cf. *Teleolophus* sp., Amynodontidae, Brontotheriidae indet., Anthracotheriidae indet., and others (Plate I). After these identifications, it was surmised that "this fauna is basically consistent with the Upper Eocene fauna previously discovered from Lunan by C.C. Young and Meinian Bian, and worked slightly later by Minchen Chow. Consequently, the age of the Lijiang fossil localities is recognized as Late Eocene."

The stratigraphic positions of the two fossil localities are equivalent (Fig. 2), lying on the south slope of Xiangshan Mountain, at Lijiang. The lower member of the section is unexposed, but the 70 meters of exposed sediments consist of: lower member as limestone breccia and conglomerates grading to red lenticular sandstones; middle member as massive red sandstones with portions of gravel coarsening upwards to conglomerates; upper member as light gray-green, gray-white marls grading to sandstones and conglomerates containing abundant fossil mammals with fragmentary impressions of fresh water gastropods. Remnants of this upper unit occur only at a few localities (Plate II, Fig. 1).

Deposits similar to the coarse and fragmentary red units occur in abundance in the eastern montane regions of the Lijiang Basin, the eastern mountane region of Qinghe, and several other localities (Fig. 1). As these lithologies may exceed 1000 meters in thickness, it may be speculated that with thicknesses as such, the lower section of these deposits may extend chronologically into the Lower Eocene to Paleocene, or may even partially represent the Cretaceous. This set of rocks has been provisionally erected as the Lijiang Formation but more advanced subdivisions must wait for further studies.

The Lijiang Formation unconformably overlies Triassic and Jurassic rocks in the northwest Jianchuan region.[3] Here the Lijiang Formation is partially disconformably overlain by the Shuanghemei Formation (refer to the following text).

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[1] This text is based upon two field excursions encompassing the winter of 1962 to the spring of 1963, and the winter of 1963 to the spring of 1964.

[2] A more concise synopsis of this series of rocks is provided in *The Tectonic History of Yunnan* by P. Misch.

[3] Here the Twelfth Geological Brigade of Yunnan Province discovered paleobotanical material in the Lijiang Formation, diagnosed by Baoyu Huang from the Nanjing Institute of Paleontology as *Sequoia* sp. (from a report by the Twelfth Geological Brigade of Yunnan).

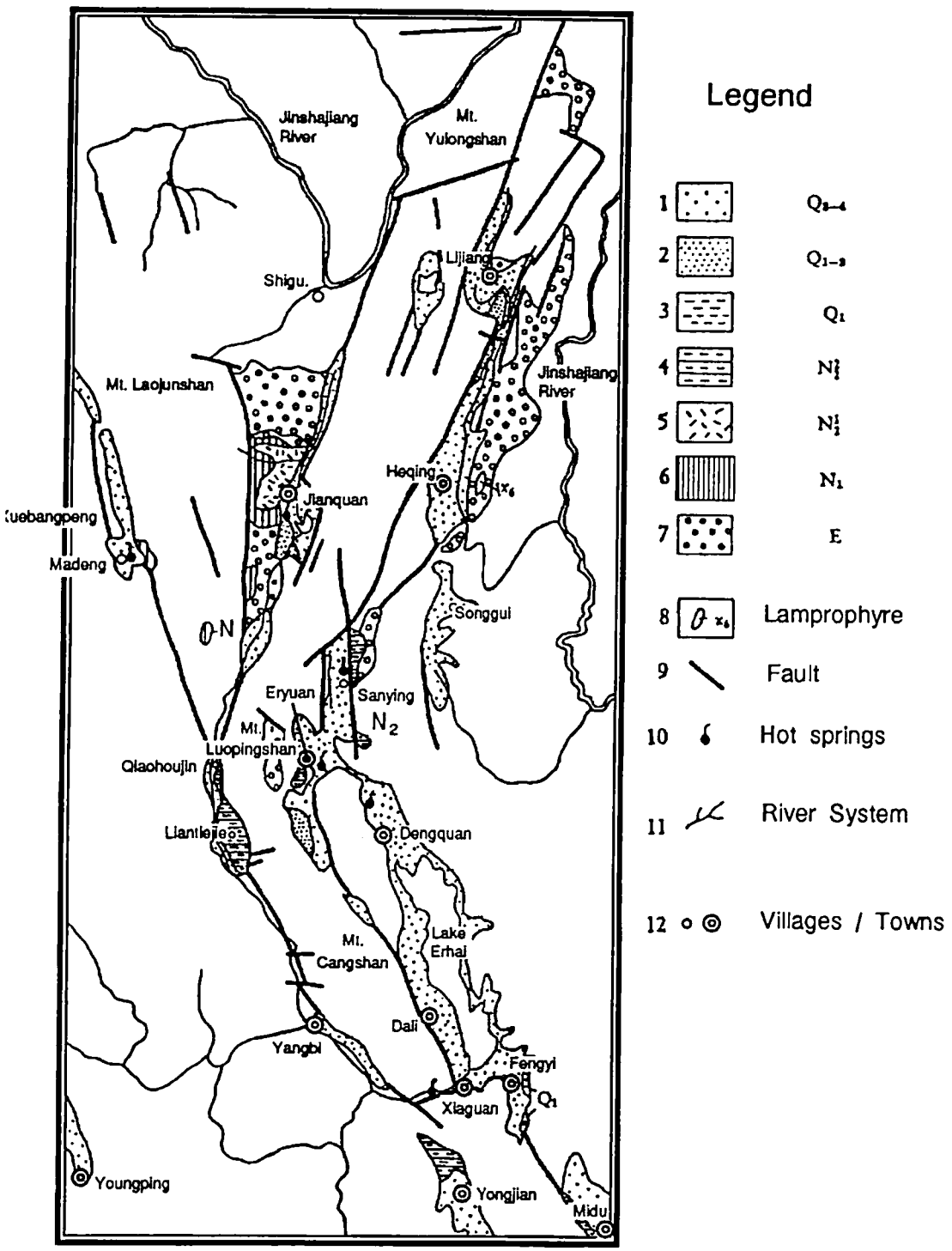

Figure 1. Sketch map of Cenozoic geology in the Lijiang, Dali Region (based upon a draft of a geologic map compiled by the Yunnan Regional Survey Team).

2. Late Tertiary

1. The Shuanghemei Formation:[4] These rocks are distributed west and northwest of Jianchuan. Subsequent to 1950 bituminous coal had been mined from these deposits, but the geologic age was still unclear. The Yunnan Regional Survey Team designated these rocks as the "Shuanghemei Series."

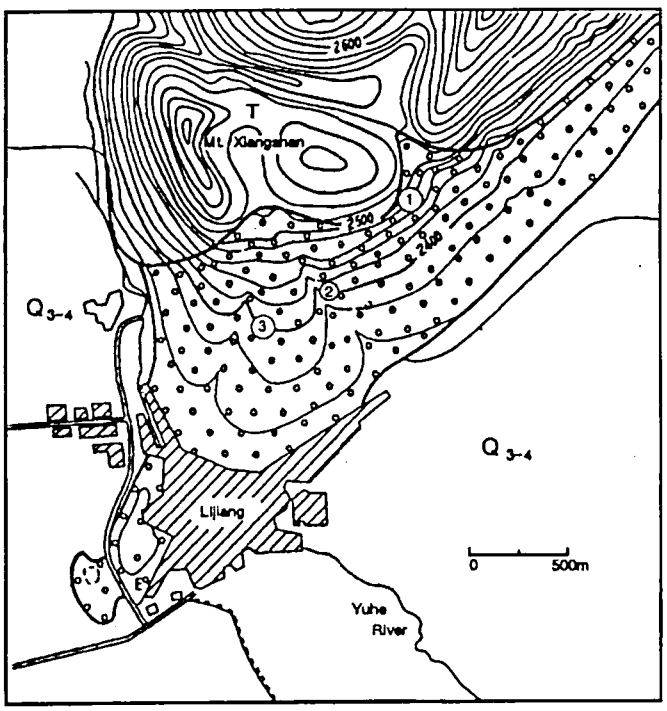

Figure 2. Geologic and topographic map of the Late Eocene fossil localities at Lijiang.
T-Triassic limestones, E-Lijiang Fm., Q3-4-Pleistocene and Holocene alluvium and lacustrine sediments. Circled numbers indicate Late Eocene mammal localities. Broad black lines are formation boundaries.

This lithologic system is dominated by gray-yellow sands and shales, with numerous gray limestones in the upper section. The total thickness is over 100 meters, as measured on the south bank of the Shicaijiang River in northwest Jianchuan (Fig. 3). Bituminous coal is recovered from Units 2 and 3, although these coal seams do not exceed 2.5 m in thickness. The carbonate units of the upper section have produced over 100 specimens of fossil leaves and fruits. After study and diagnosis by colleague Junrong Tao and confirmation by Professor Ren Xu from the Laboratory of Paleobotany, Institute of Botany, Academia Sinica, the assemblage was identified as containing: *Quercus* cf. *relongtanense* Colani, *Quercus* sp., *Sryophyllum yunnanensis* Colani, *Cinnamomum*

[4] Studies upon the Shuanghemei Formation have been consecutively undertaken by the author and colleagues Jishun Ren, Jingchuan Qu, and Yaozhi Chen (1962), with later assistance from Zhaochen Ru and Minghong Chen from the Laboratory of Paleobotany, Institute of Botany, Academia Sinica (1963).

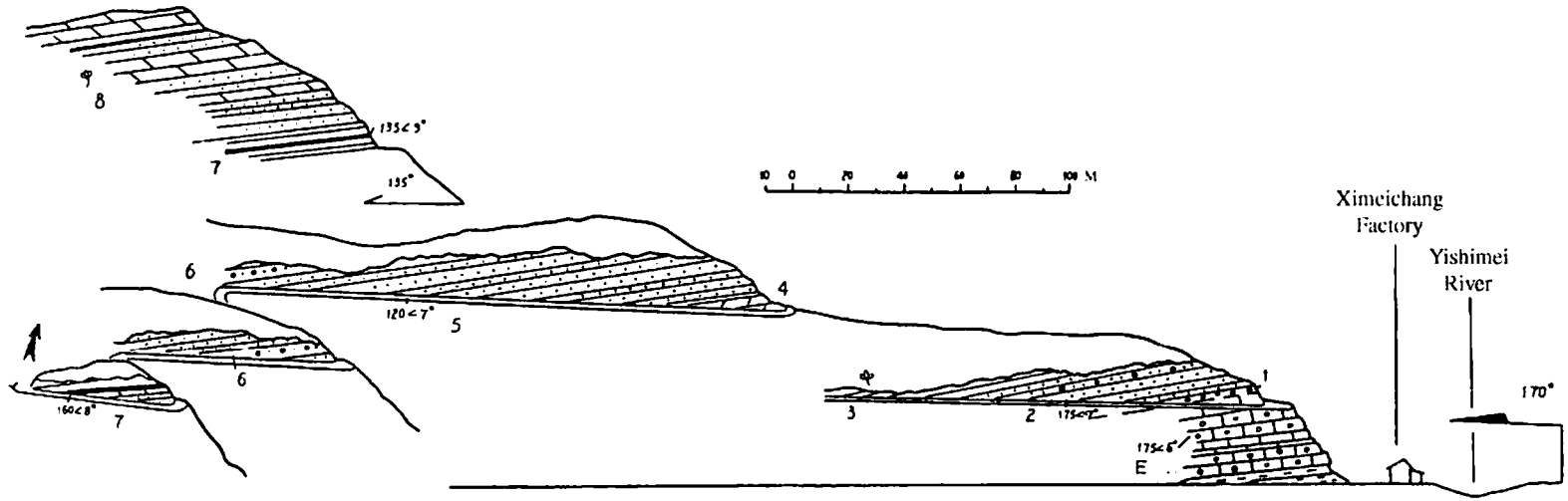

Figure 3. Cross-section of the Shuanghemei Fm. at Ximeichang Factory.
8. Sandstones interbedded with limestones; 7. Argilaceous shale interbedded with carbonaceous shale; 6. Calcareous rudaceous coars sandstone; 5. Yellow fine sandstone; 4. Limestone; 3. Incompletely exposed sandy shale occasionally interbedded with conglomerates; 2. Sandstones and calcareous shales; 1. Basal conglomerate disconformably overlying Eocene (E) sediments. Heavy dark lines indicaate coal seams.

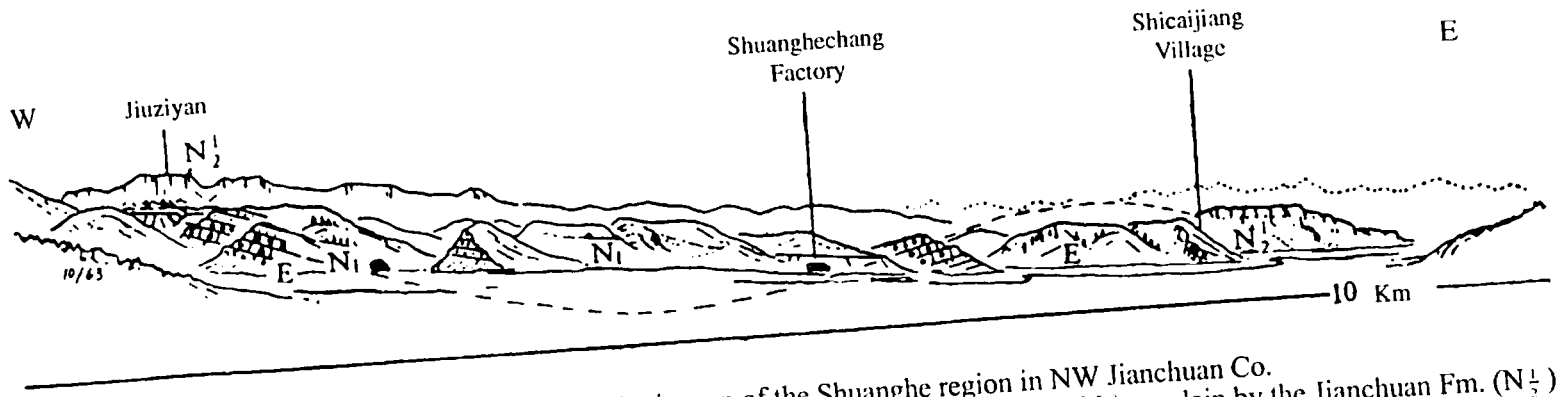

Figure 4. Scematic geologic map of the Shuanghe region in NW Jianchuan Co.
Note extensive folding (Jianchuan Movement) of the Lijiang Fm. (E) and Shuanghe Fm. (N_1) overlain by the Jianchuan Fm. (N_2^1).

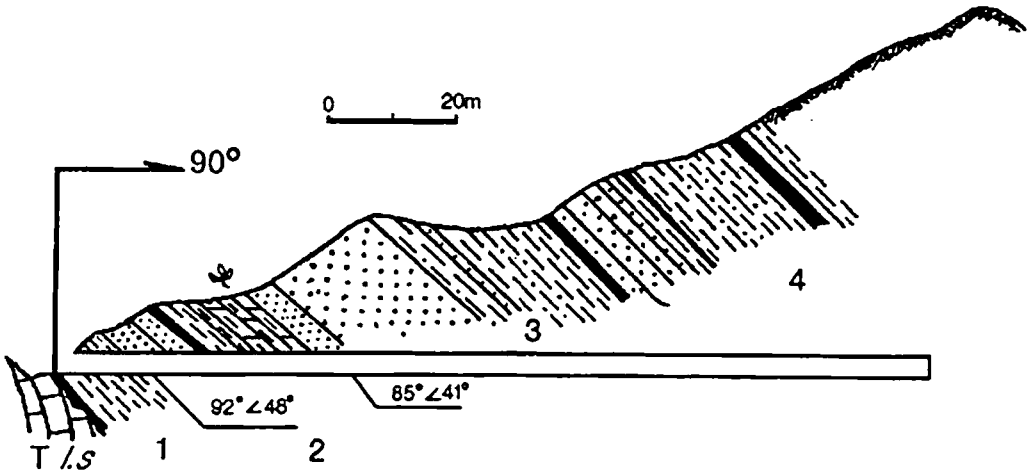

Figure 5. Lithologic cross-section of the Sanying Formation in the Shiyantou Mining Dictrict of Sanying.
1. Gray claystone: 2. Lower section as gray fine sands, upper section as calcareous mudstones bearing fossil plants; 3. Lower sections as gray-yellow fine and coarse sands, upper sections as clays; 4. Lower section as sands and sandy conglomerates, upper section as gray mudstones; Tls. - Triassic limestones; Black bands indicate lignitic units.

sp., *Phoebe pseudolanceolata* Colani, *Paliurus* sp. and others. The paleobotanists identifying this plant community recognize its age to be Late Miocene. Consequently, these carbonaceous deposits are recognized here as the Late Miocene Shuanghemei Formation. The Shuanghemei Formation is extensive in this region, disconformably overlying the Lijiang Formation. Clear observations of this disconformable surface are noticed at many localities along both banks of the Shicaijiang River (Plate II, Fig. 3). The basal conglomerate of the Shuanghemei Formation contains numerous elements derived from the Lijiang Group, including fragments of limestone breccia and red sandstones. A distinct irregular erosional surface occurs at the top of the Lijiang Group, in addition to the occurrence of calcite intrusions. The Shuanghemei Formation is partially unconformably overlain by pyroclastic deposits from the Jianchuan volcanic crater (Fig. 4).

2. The volcanics of Jianchuan Crater: These are principally composed of tuffaceous sandstones, pyroclastic or detrital tuff, and other angular volcanic rocks. Along both banks of the Shicaijiang River these deposits are approximately 200 meters thick. Coal seams and remnants of plant bodies may be observed occasionally in the lower member of this unit. This set of deposits was initially designated the "Chien Ch'uan Trachyte Formation" by P. Misch, who first recorded them (Misch, 1945). This paper hereby recommends abandoning the nomenclature of Misch in favor of the designation "Jianchuan volcanoclastics" based upon its principal pyroclastic sedimentary components. Misch collected several botanical specimens from the white tuffaceous sands in the lower member, which after undergoing preliminary diagnosis by Xingjian Si, were identified as including *Phyllites* sp. (?*Salix* sp.), *Laurus* sp., and *Cyperiles* sp. He believed the age was probably not older than "middle Cenozoic" (Misch, 1945). From the aspect of structural analysis, is appears there is a relationship between the first phase of Shuanghemei Formation deformation and volcanic activity. This clearly affected the degree of lithologic consolidation in the Shuanghemei Formation as it is higher than the overlying upper Pliocene rocks. The degree of coal alteration is also much higher than in the upper Pliocene. Consequently, it appears that regional orogenic activity began between the end of the Miocene to early in the Pliocene. The age of the Jianchuan pyroclastics are probably within this range.

3. Sanyingmei Formation: These sediments are distributed around the villages of Sanying, Niujie, and Taipingcun at the eastern margin of the Eryuan Basin, and composed predominantly of variegated light gray-green, gray-yellow, pinkish silts and clays, with a total thickness from 200 to 500 meters, as thicknesses vary between different localities. Numerous lignitic units are found in this formation (Figure 5). The Yunnan regional survey team referred to these lithologies as the "Sanyingmei Series."

Paleobotanical material was collected from the lower member of this formation in the Sanying mining region.[5] After analysis by Junrong Tao and confirmation by professor Xu Ren, the following taxa were identified, among others: *Quercus semicarpifolia* Smith, *Quercus spathulata* Seem., *Q. gilliana* R. & W., *Q. monimotricha* H.-M., *Q. pannosa* H.-M., *Acer paxii* Franch, *Acer franchetii* Pax., *Acer* sp., *Populus* sp., *Pinus yunnanensis* Fr., and *Abies* sp. The age of this floral community is believed to be Late Pliocene by those who identified the assemblage. Based upon this assumption, the Sanyingmei Formation is placed in the Upper Pliocene.

Lignitic deposits probably contemporaneous with these are noted at Dasongdian, Qiaohoujin to Liantiejie Valley in the southwestern region of Eryuan, and in the northern Yongjian Basin.

3 The Quaternary System

1. The Songmaopomei Formation: This formation is located at Fengyi and Songmaopo in the southern Erhai Basin in an east to southeast trending valley. Mining and industry have been established in the Fengyi-Songmaopo region due to the presence of lignite. The Yunnan Regional Survey Team designated these lithologies as the "Songmaopomei Series." The authors reconnaissance at Songmaopo resulted in the following cross-section description (Figure 6):

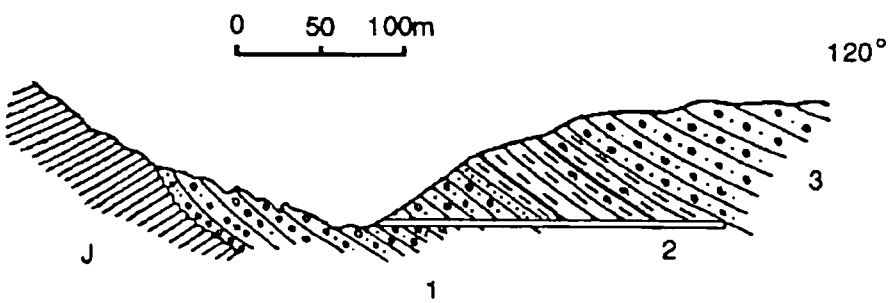

Figure 6. Stratigraphic cross-section of the Songmaopo Formation at Fengyi and Songmaopo. J-Jurassic redbeds; See text for explanation of Units 1, 2, and 3.

3. Yellow unconsolidated conglomerates and sandy conglomerates.....60m

2. Variegated light green-gray, gray-white, and pale brown fine sands and silts grading to numerous lignitic units and containing fossil mammals.....50m

1. Loosely consolidated gray-yellow sands and sandy conglomerates with gravel elements predominantly derived from the Dongshan Aotao Series 100m

~~~~~~~~~~~~~~Unconformity~~~~~~~~~~~~~~

Underlying units: Jurassic redbeds.

[5]Fossil collections were made by the author with colleagues Zhaochen Ru and Minghong Chen.
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In 1963, Shiying Wang of the Institute of Southwest Geology made a collection of the following fossil mammals from these rocks:[6] *Stegodon* sp., *Elephas* sp., *Tapirus* sp., and *Bison* cf. *paleosinensis*. During that same year the author of this paper recovered a single bovid tooth from the mine. The Songmaopomei Formation may be considered Lower Pleistocene in age based upon the characteristics of its faunal community.

2. Sheshan Formation: A conspicuous mesa is present in the southern region of the Lijiang Basin, the top of which lies 70 meters above the surrounding topography. This mesa is referred to as Sheshan Mountain (Plate III, Fig. 2). Sheshan is composed entirely of semiconsolidated silts, fine sands, and coarse sands. A small amount of these units grade to white mudstones and black carbonaceous silts. Generally these units are thinly laminated, but some display fluvial cross-bedding. Fresh water pelecypods and gastropods frequently occur within these sediments which are apparently fluviolacustrine in nature (Fig. 7).

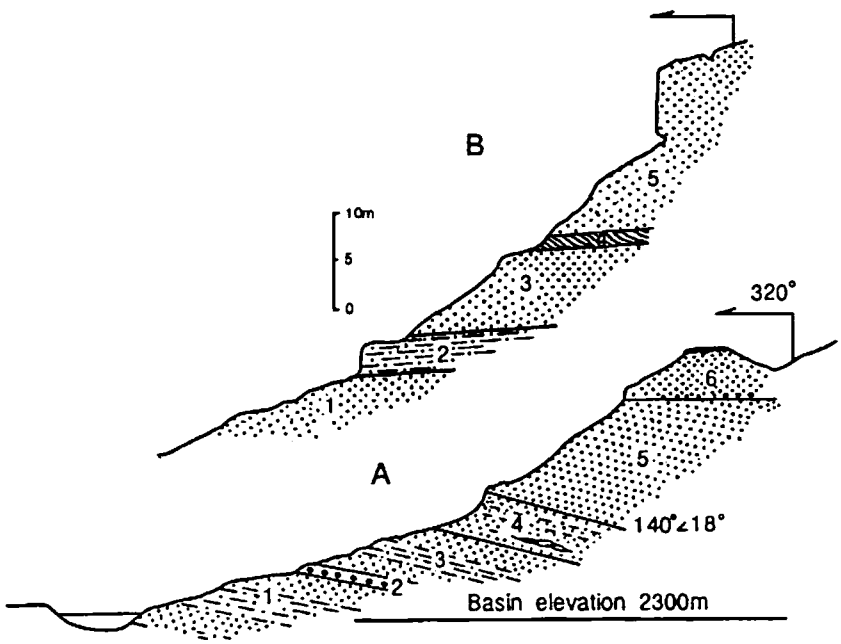

Figure 7. Cross-section of the Sheshan Formation.

A. Lower deposits at the north margin of Sheshan Mesa: 1. Thinly bedded, semiconsolidated silts and argilaceous silts; 2. Conglomerate; 3. Gray-green thinly bedded sands grading to carbonaceous clays; 4. Silts grading to clay ribbons; 5. Gray-green fine and coarse sands; 6. Brown-yellow coarse sands with an angular unconformity separating it from Unit 5.
B. Southwest side of Sheshan Mesa: 1. Thinly bedded sands and silts occasionally grading to carbonaceous clays; 2. Gray-white silty clays; 3. Thinly bedded yellow sands; 4. Light brown fluvially cross-bedded sands; 5. Moderately bedded coarse sands with a brown-red weathering surface and containing fossil mammals.

In February of 1964 the author of this paper collected three molars of *Rhinoceros sinensis* Owen, in addition to several fragmentary cervid antlers, and bovid teeth, confirming that the age of these sediments cannot be older than Early Pleistocene.

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[6]The engineer Shiying Gao (pers. comm.) states that the fossiliferous mammal unit may be correlated to the fossiliferous Zhaotong lignite beds, the latter established as being Lower Pleistocene in age (Chow and Zhai, 1962).

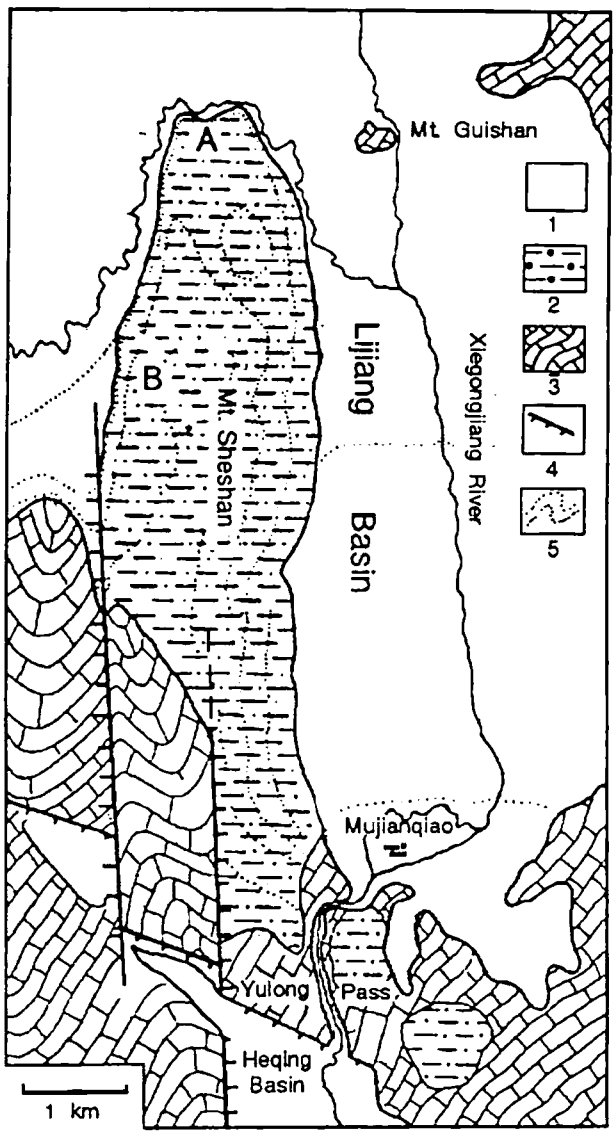

Figure 8. Faulted Tertiary deposits at Yulongguan.
1. Late Pleistocene to Holocene alluvium and lacustrine sediments; 2. Lower to Middle Pleistocene (Sheshan Formation); 3. Triassic limestones; 4. Quaternary faulting; 5. Contour lines.

Structural relationships exist between the morphology of Sheshan Mesa, the aforementioned sedimentary deposits, and the later occurrence of a single fault (refer to the text below). After the formation of this mesa, the basin received Late Pleistocene sedimentation entombing mammalian and hominid fossils (Li, 1961). Consequently, it is believed the Sheshan sediments encompass the Middle to Early Pleistocene, and are recogognized as the Sheshan Formation.

The Sheshan Formation may also be observed at the northern margin of the Heqing Basin. Equivalent sediments have also been noticed in the Jianchuan Basin (Plate II, Fig. 5), and the Fengyu Basin southwest of Eryuan.

3. Late Pleistocene: As aforementioned, Late Pleistocene fossils have been recovered from within the southern part of the Lijiang Basin south of Mujianqiaocun Village (Fig. 8). The fossiliferous lithologies occur as fluvial-lacustrine facies, but may be traced northward to occur as a transverse transition phase of alluvium and glacial deposits and further northward as ephemoral stream deposits and intermontane basin moraines (Plae III, Fig. 1).

4. Holocene (partial)
Refer to Table I for a general summary of these sediments.

II. Cenozoic Structure

1. Stages of Structural Movements

The Cenozoic structural movements of this region are not only dynamic, but numerous. Preliminary subdivisions consisting of five succesive phases are made here.

Phase I The Lijiang Formation may be distinguished from the lithologies of prior eras, in that it does not cover the region in a planar fashion, but appears as narrow bands along principal fault zones (Figure 1), suggesting its deposition within rift valleys. From another aspect, it retains characteristics of molassic composition,[7] which indicates differential movement along the rift valleys during time of deposition. With regard to all these features, it is believed here that after the Yanshan deformation movement there was a phase of rapid faulting. This activity concluded in the Eocene.

The period between the Yanshan deformation and the phase of initial faulting was a period of stasis or an erosional phase, as ancient topographic planes are noted in several regions. This is exemplified by the paleosurface near the top of Xiangshan Mountain at Lijiang, where paleo river courses and paleo karst topography are overlain by a thick red weathering crust. Sediments of the Lijiang Formation occur at the south side beneath the pinnacle of the mountain (Fig. 2).

Phase II The Oligocene is absent in this region, but Late Miocene systems unconformably overly the Lijiang Formation. This depositional hiatus reflects structural activity during the Oligocene. It is inferred here that the region underwent relatively large-scale orogenic activity. In addition the history of redbed deposition from the Late Triassic onwards concludes at this point. The Upper Miocene floral communities reflect a relatively temperate climate.[8]

Phase III Subsequent to Late Miocene deposition there occurred a phase of deformation and faulting. Both the Lijiang Formation and Shuanghemei Formation underwent compression to form extensive north-south trending deformational features followed by lamprophytic intrusions (Fig. 4). Activity also occurred along the Madeng and Yongjian fault zones forming Pliocene carbonaceous basins such as Yongjian, and the Qiaohoujing-Liantiejie basins (Fig. 1).

This was the phase of the most radical activity in the region, occurring from the Late Miocene and concluding in the Early Pliocene.

Phase IV Structural activity was relatively tranquil during the Middle to Late Pliocene. Consequently, several partially denuded surfaces were created with Late Pliocene lignitic deposits overlying them, as exemplified by the denudation surfaces along both sides of the Eryuan Basin

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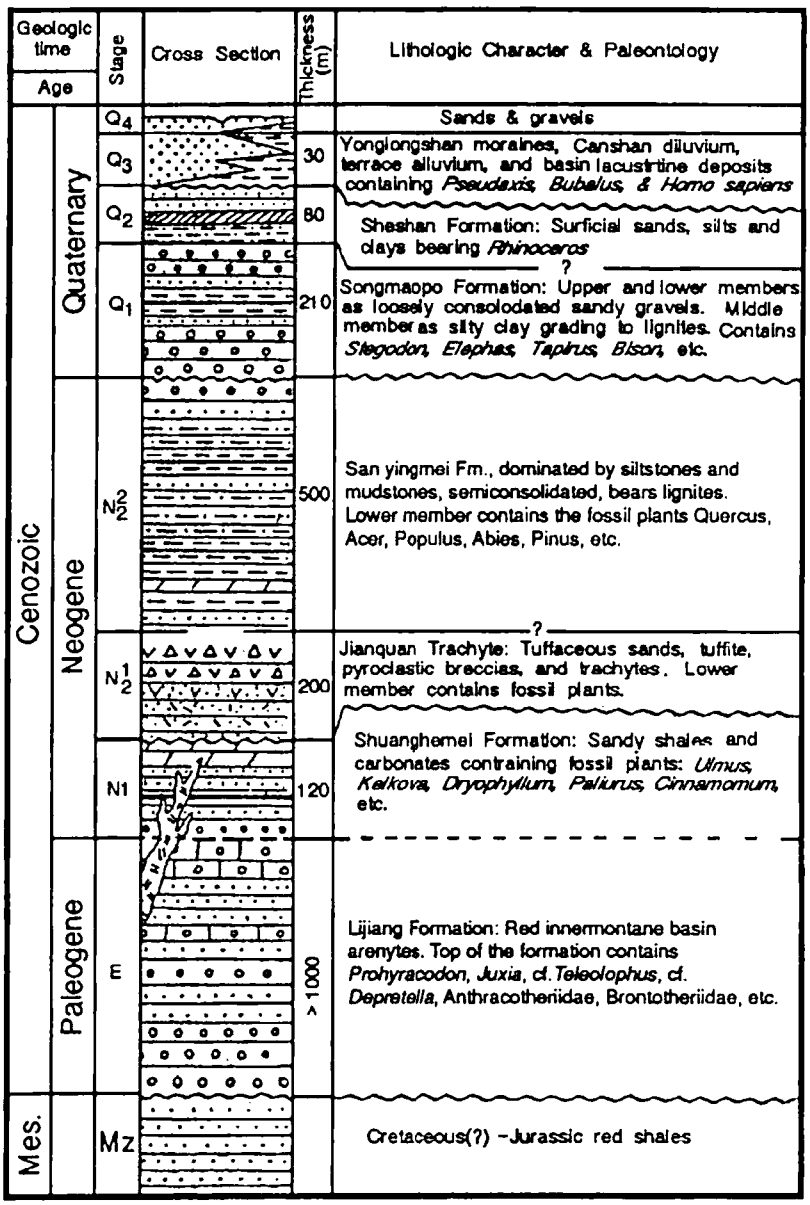
[7] Misch describes these sediments as "Nagelfluh" in "The Lijiang Geological Record."

[8] Colleagues Junrong Tao and Zhaochen Ru (pers. comm.) state that flora representing different climates are found in the same unit of the Shuanghemei Formation (warm temperate to cold). It is believed here that this reflects climatic gradient zones, or that topographic gradients were relatively large at that time.

(Fig. 9). At the end of the Pliocene a phase of block faulting erupted. The Eryuan Basin may be observed as an example of a typical graben structure (Fig. 9). At the time of its formation, both sides of the Pliocene denudation surface were block faulted and upthrown, ascending approximately 500 to 600 meters above the surface of the basin, followed by deformation and rifting of the Sanying Formation. The oldest sediments deposited within this graben are Lower to Middle Pleistocene.

Table 1. Stratigraphic cross-section of Cenozoic deposits in the Lijiang Basin.



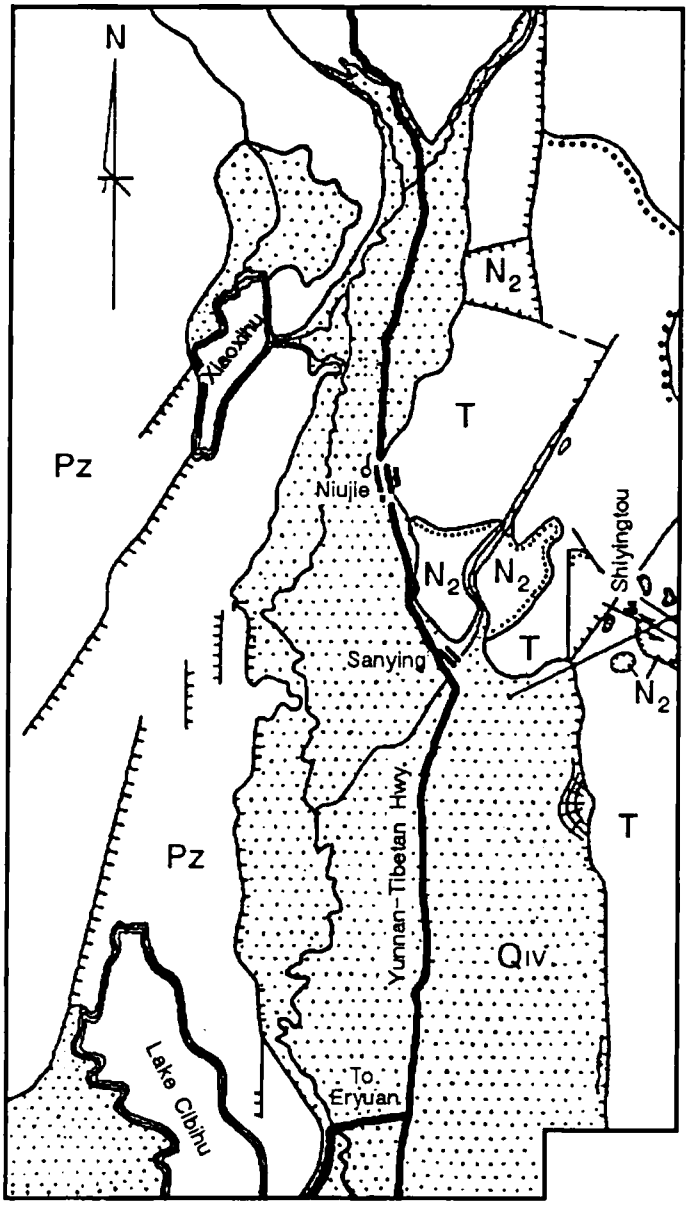


Figure 9a. Structural map of the northern margin of the Eryuan graben.

The Mt. Luopingshan horst lies west of the Eryuan graben (Fig. 1). The timing of its orogenic movement was contemporaneous with that of the Eryuan graben, as illustrated by the following data: (1) Within the Qiaohojin-Liantiejie Valley lies the Sanying Formation, the basal conglomerates of which are composed totally from the red Jurassic sandstones derived from the west of the valley, while Mt. Luopingshan elements are absent (slightly altered Paleozoic rocks). (2) In this region the Sanyingmei Formation forms a syncline, with its axis consistent with the valley. The east wing of the syncline was influenced by extensional drag faulting from the west side of Mt. Luopingshan. (3) The southwest side of Mt. Luopingshan is a semi-regular sharply faulted escarpment reaching 800 meters in elevation. (4) On the eastern slope of Mt. Luopingshan

the Pliocene denudation surface has been uplifted approximately 500 meters above the Eryuan Basin.

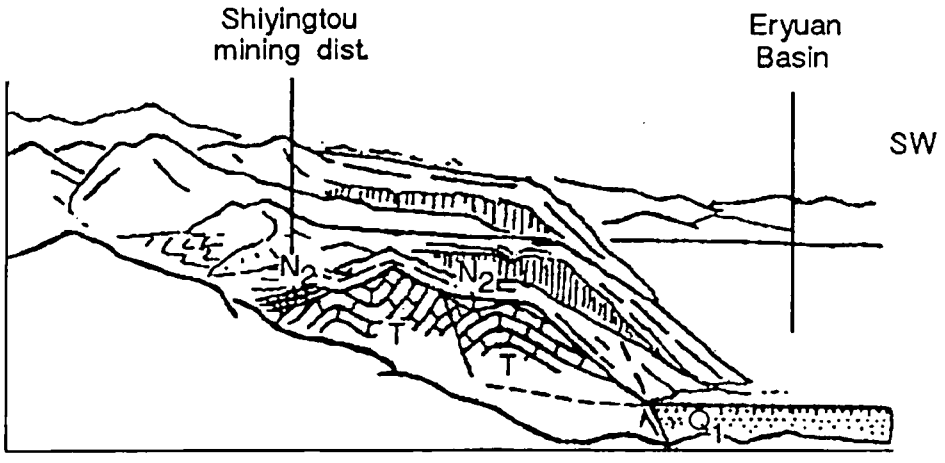


Figure 9b. Block fault diagram as viewed south of Shiyantou illustrating Pliocene surface denudation and deformation. P_Z-slightly altered Paleozoic; N_2-Late Pliocene Sanyingmei Formation; Q_{IV}-nearly Holocene alluvium and lacustrine sediments: hash marks along the fault lines indicate the downthrown side, arrowheads on both sides indicate confirmed direction of strike-slip faulting, dog tooths indicate thrust faults.

The Luopingshan horst trends southwest in conjunction with the Mt. Diancangshan horst. The Lake Erhai graben lies just east of Mt. Diancanshan. The oldest sediments in this graben are the Songmaopo Formation.

Another horst extends north of Luopingshan to Mt. Yulongshan, with its margins limited to the west by the Jianchuan graben and to the east by the Heqing-Lijiang graben. The oldest sediments found within these grabens are the Sheshan Formation (Fig. 10)

It is evident that this phase of tectonic activity was the foundation for today's alternating basin and range topography in this region. This activity initiated in the Late Pliocene to Early Pleistocene.

Phase V Relatively small-scale rifting activity occurred from the Middle to Late Pleistocene, exemplified by the Yulongguan faults between the Lijiang and Heqing basins (Fig. 8). The Sheshan Formation was uplifted, deformed, and partially rolled and fractured, while the formerly united Lijiang and Heqing basins were severed in two. Subsequently, the Lijiang Basin received Late Pleistocene sedimentation. The synclinal deformation of the Songmaobomei Formation was probably contemporaneous with this last period. The west side of the Jianchuan Basin was displaced by 100 meters, and Pleistocene deposition occurred within the Madengyu Valley. This phase is probably equivalent to the "Houyuanmei Rifting" as defined by Meinian Bian (Bien, 1940).

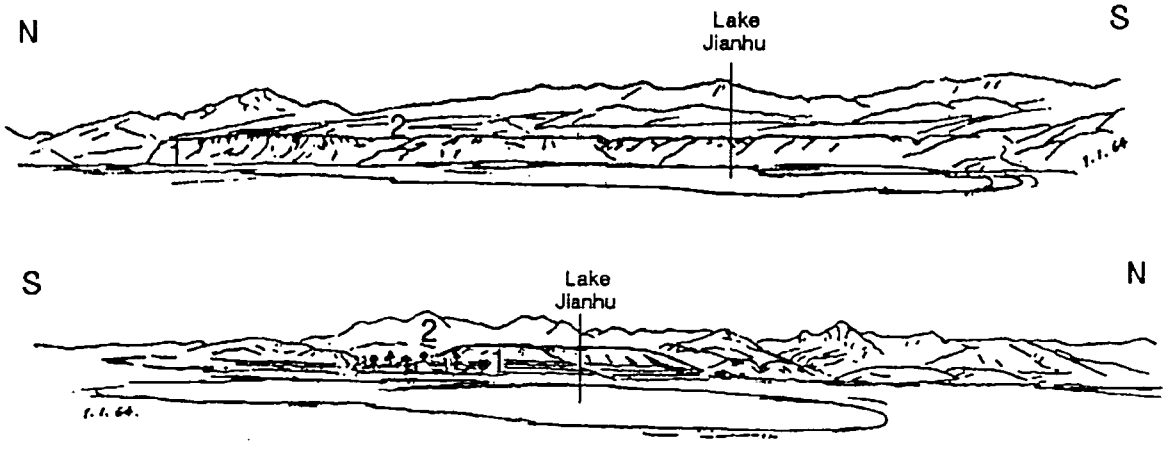


Figure 10. Sketch of both sides of the Jianchuan graben.
Above: East side. 1-faulted escarpment; 2-upthrown paleosurface
Below: West side 1-100 m platform (composed of fluviolacustrine sediments); 2-Folded and faulted features composed of the Lijiang Formation and Jianchuan Formation.

Current structural activity in this region is still extremely dynamic. From 1500 AD to 1964 the accumulative record of destructive seismic phenomena has reached thirty-two. The distribution of seismic activity occurs in two distinct zones. The first zone, designated the Dali Seismic Zone, comprises Midu, extends north-northwest through Xiaguan, Dali, Dengchuan, Eryuan and reaches the Lanping region. The second zone, designated the Li(jiang)-Jian(chuan) Zone, manifests a north-northeast trend between Jianchuan, Lijiang, and Heqing.[9] Numerous hot springs occur within these two zones, particularly around the municipality of Eryuan, from which the appellation "The City of Hot Springs" is derived.

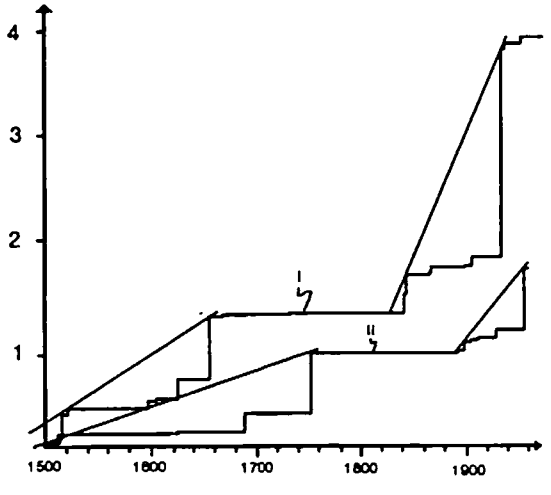


Figure 11. Graph of hypothetical progression lines comparing the Dali Seismic Zone (I) and Li-Jian Seismic Zone (II).

[9]Based upon analysis from the seismological table of the Institute of Geophysical Research.

Although the general fluvial activity in western Yunnan Province strongly entrenches the topography, indications of relatively continuous subsidence may be observed in such regions as Eryuan and Dengchuan where there is fluvial siltation, meandering stream activity, and high positions of subsurface aquifers. Consequently the industrial and agricultural industries of this region cannot neglect the factors of current tectonic activity.

In summary, each structural phase may be illustrated as follows:

Cenozoic	Recent Activity	----------	Himalayan Subcycles
	Stage V	Between Middle to Late Pleistocene	
	Stage IV	Late Pliocene to Early Pleistocene	
	Stage III	Late Miocene to Early Pliocene	
	Stage II	Oligocene	
	Stage I	Late Cretaceous (?)-Eocene	Yanshan Subcycle

2. A Preliminary Discussion of Types and Methods of Deformation

It is not difficult to discern from the data above that structural deformation in this region is dominated by basement rifting.[10] accompanied by overlying faulted and folded Cenozoic strata and igneous activity that form a series of block fault tectonic structures and folded-block fault tectonic structures. The former are represented by the aforementioned horsts and grabens, while the latter are represented by the folded and block faulted mountains composed of the Shuanghemei and Lijiang formations in the northwest section of Jianchuan.

It is also not difficult to deduce that the north-northwest trending Midu-Dali-Madeng rift zone, and the massive north-northeast trending Jianchuan rift and Ljiang rift[11] (Fig. 1) were active many times during the Cenozoic, controlling the phases of structural development, the distribution of sedimentation, and geomorphologic evolution during each phase. The southwest margins of the latter two rifts were detached from the former rift, with the point of dislocation developed as a north-south trending secondary structure.

The locations of the two seismic zones in this region coincide appropriately with the aforementioned rift zones, implying certain consistencies between surface structure and the structure occurring at the deep seismic epicenters.

Professor Rongshimei calculated the serious Dali earthquake of 1925 to have an epicenter depth of 25 kilometers; other seismic activity may be equivalently deep. A comparison of

[10]Here conceptualized as "basement folding" (plis du fond).

[11]Ministry of Geology, Academy of Geological Sciences: In the volume *Fundamental Characteristics of Chinese Tectonics*, the former is considered a deep rift zone designated the "Weixi-Dali deep western rift."

hypothetical progression lines[12] regarding the seismic activity along these two zones is provided in Figure 11. It is startling to notice that the entire progression of Zone II activity always chronologically follows Zone I; however, its energy and rate of accumulation are less than that of Zone I. Consequently, it is hereby deduced that the recent structural activity of Zone II is derived from the activity of Zone I.

The aforementioned principle rifting zones lie appropriately at the boundary of the Yangzizhun Platform and the western geosynclinal zone.[13]

III Conclusions

1. The development of the Cenozoic is rather complete in this region. The depositional models and their spatial distribution are clearly structurally controlled.

2. The Cenozoic structural deformation in this region is both frequent and intense. Five phases of activity are recognized, dominated by basement rifting and associated with igneous activity and overlying sediments that have been folded, and fold-faulted, forming a variety of block fault and fold-fault structures into a corresponding basin and range topography.

3. The entire structural activity is controlled by north-northwest and north-northeast trending rift zones. These two rift zones lie appropriately on the boundary between the eastern platform and western geosyncline.

4. Recent structural activity in this region is extremely dynamic. Analysis of seismic data suggests that recent structural activity along the Li-Jian Zone is derived from activity of the Dali Zone.

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[12]Systematic historical data transcribed by the Institute of Geophysics records the month of seismic activity, the epicenter, and its intensity providing the author with a provisional formula for seismic grade and energy series: $I_0 = (0.9 \pm 0.6) + (1.5 \pm 0.08) M - (1.3 \pm 0.36) \lg h$, and $\lg E = 11.8 + 1.5 M$. Refer to Rongshi Mei (1960) for detailed observations of these calculations and methods.

[13]The northern boundary is still in dispute.

Plate I Explanation

1a-1b. *Prohyracodon* sp. right M^3, Li-f-56. X1. 1a. lingual view. 1b, occlusal view.

2. ?*Prohyracodon* sp. left lower molar, Li-f-44, X1. Labial view.

3a-3b. *Prohyracodon* sp. left M^3, Li-f-28, X1. 3a. labial view. 3b. occlusal view.

4. *Teleolophus* sp. upper molar, Li-f-75, X1.

5. *Eomoropus* sp. two left upper molars, Li-f-77, X1.

6. Brontotheriidae indet. protocone of molar, Li-f-76, X1.

7. Brontotheriidae indet. incisor, Li-f-59, X1.

8. cf. *Depretella* sp. two right upper molars, Li-f-55, X1.

9. Anthracotheriidae indet. fragmentary right M_3, Li-f-71, X1.

10a-10b. ?*Juxia* sp. broken mandible with lower molar, Li-f-74, X1. 10a, labial view. 10b. occlusal view.

11a-11b. *Lophtoletes* sp. lower molar, Li-f-20, X1. 11a. labial view. llb. occlusal view.

12. Amynodontidae indet. fragmentary lower molar. Li-f-37, X1.

Plate II Explanation

1. Upper Eocene fossil mammal bearing calcareous mudstones at the south slope of Xiangshan Mt., Lijianag.

2. Lamprophyric dike (2) intruding the Shuanghemei Formation (1) on the south bank of the Shicaijiang River.

3. Fault scarp displaying the disconformable contact between the Shuanghemei and Lijiang formations on the south bank of the Shicaijiang River (photograph by Jingyong Qu).

4. Exposures of the lower member of Jianquan (Chien ch'uan) volcanoclastics: (1) tuffaceous sandstones; (2) calcareous mudstones grading to lignines; (3) pyroclastic breccias.

5. Southwest Jianquan Basin 100 meter platform photographed toward the northwest.

Plate III Expanation

1. Aerial photograph of glacial moraines at the eastern foot Yulongshan Mountain. Light colored portion at top of image is the eastern slope of Yulongshan. Hanging glaciers are visable at the upper left corner. Lower portion displays complete depositional morphology of Late Pleistocene moraines. Two inclined bands of sediment at the left lower corner (trending northwest-southeast) are partial remnant deposits from earlier phases of this glacier buried by moraines from later glacial activity.

2. Northern section of the Sheshan Mountain platform, Lijiang. Photogralphed toward the west from Guishan Mountain.