

**RESULTS OF TECTONIC MEASUREMENTS
IN THE LUNAN STONE FOREST, CHINA**

REZULTATI TEKTONSKIH MERITEV V
"KAMNITEM GOZDU" PRI LUNANU,
KITAJSKA

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Izvleček

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Stanka Šebela: Rezultati tektonskih meritev v "Kamnitem gozdu" pri Lunanu, Kitajska

V Kamnitem gozdu pri Lunanu so glavne smeri tektonskih razpok 315-330° (SZ-JV), sledi smer 45-60° (SV-JZ) in smer 285-300° (SZ-JV). Plasti permijskih apnencev vpadajo proti SZ in Z pod kotom 5-20° ter so blago nagubane v več manjših antiklinal in sinklinal.

Ključne besede: Kamniti gozd, Lunan, merjenje razpok in plasti, rozeta, provinca Yunnan, Kitajska

Abstract

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Stanka Šebela: Results of Tectonic Measurements in the Stone Forest, Lunan, China

The main tectonic trending in the Lunan Stone Forest is from 315 to 330° (NW-SE), followed by a trending 45 to 60° (NE-SW) and by 285 to 300° (NW-SE). The layers of Permian limestones strike towards NW and W dipping by an angle of 5 to 20° and are slightly folded into several smaller anticlines and synclines.

Key words: measurements of fissures and layers, roseta, Lunan Stone Forest, Yunnan Province, China

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INTRODUCTION

Within an international cooperation between the Karst Research Institute ZRC SAZU and Yunnan Institute of Geography, Kunming, Yunnan Province, China, we explored karst terrains in wider regions of Lunan Stone Forest in July 1996. The project entitled A Study of Lunan Stone Forest Karstic Phenomena and Underground Water Reservoir Leakage Problem is financially supported by a Committee of Scientific and Technological Cooperation (at Ministry of Science & Technology RS) between the Republic of Slovenia and People's Republic of China. The main topic of Slovene-Chinese researches is to help the Lunan Stone Forest to be listed into UNESCO World Natural Heritage.

The Lunan Stone Forest lies 126 km SE from Kunming and about 10 km NE from the town of Lunan (Figs. 1 and 2) from 1750 to 1950 m a.s.l. It covers 26.000 ha and 80 ha are displayed for tourist visit. In 1995 more than 1,4 million of tourists visited this park.

GEOLOGICAL DATA

"Stone forests" belong to karst plateaus in Eastern Yunnan (Sweeting 1995). Devonian and Permian limestones are covered by Eocene (and possibly Miocene) lake muds and clays and a deep lateritic soil cover.

The Lunan Stone Forest consists of Permian limestones and dolomites. According to geological map (1:50.000) the beds in park gently dip from 2° to 8°, in average for 5° and strike towards west. In the base the Devonian beds are overthrust to the Permian beds.

In limestone open synclines and anticlines with dips from 3° - 17° may be seen. Where the limestones are thick-bedded and strongly jointed, rock columns up to 30 m high can be formed (Sweeting 1995).

The stone pillars are developed in the Lower Permian Maokou (354 m thick) and the Qixia (100 m thick) limestones. Both of these limestones are very uniform in composition and are thickly bedded.

The Maokou is a platform, sparitic and bioclastic limestone (Song 1986). It is slightly dolomitized in places. The Qixia is a massive reef limestone and also dolomitic.

The outlines of the pillars are related to the directions of the jointing, the

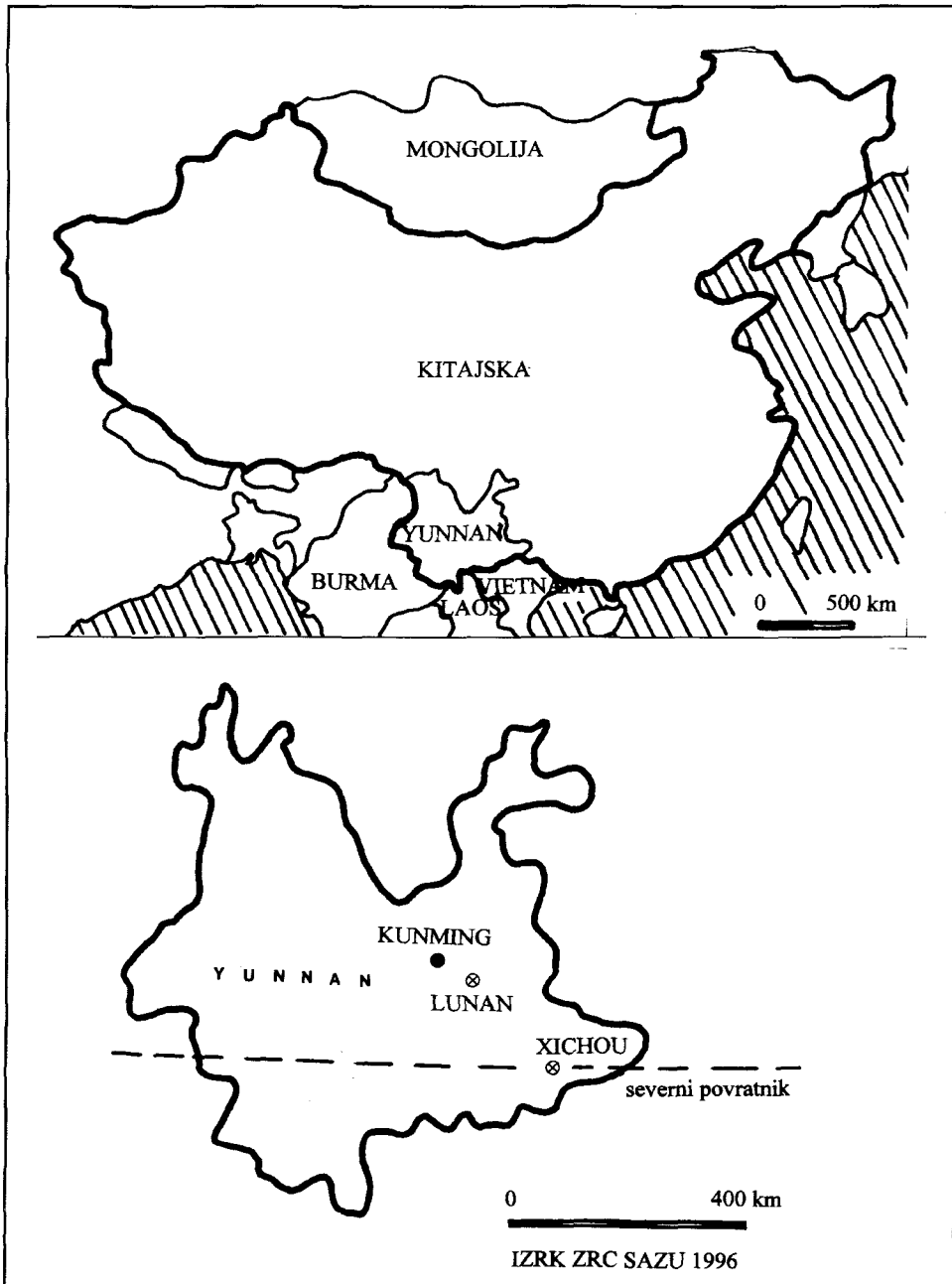


Fig. 1: The situation of the Yunnan province
Sl. 1: Položaj province Yunnan

main joints at the Lunan Stone Forest being N20°W, N50°W and N50°E. The N20°W joints are pre-Cenozoic and are filled with calcareous tufa, but the other joints are Cenozoic in age and are open vertical intersecting fissures which cut the subhorizontal Maokou limestones (Sweeting 1995).

Lunan Stone Forest lies east from Jiu-Xian-Shiyakou fault which makes part of Xiaojiang folded belt. Geological elements of the fault are 70-80/60.

Local water table in the Lunan area are Sword Peak Pond, Lotus Flower Pond and Stone Forest Lake. The superficial and underground waters drain into the river Bajiang, towards S and SW. The underground water flows in epiphreatic channels.

Water level in Sword Peak Pond and Lotus Flower Pond may increase for 10 m (Song 1986).

The situation of the Lunan Stone Forest is determined by movements along Jiu-Xian fault zone. These movements controlled the deposit of Eocene rocks and permitted gentle covering of Permian limestones. More than 500 m thick layer of red loam was deposited in the Lunan area.

Zhang (1980) distinguishes three stages in karst development:

1. early stage - pre-Triassic includes the oldest appearance of karst. After Indo-Sinian and Yanshan movements and also after early Himalayan movements these clastic rocks over the limestone had been removed and caused a new phase in a karst development.
2. Young stage lasted from the Mesozoic to the end of Miocene.
3. Modern stage includes the late Miocene to the Holocene, some 7 to 4 million years ago. This stage corresponds to intensive uplifting of the Tibet plateau and records the appearance of deep valleys (Miocene - Holocene). The uplifting of the Earth crust in the Tertiary and the Quaternary played an important role at karst development in southern and western China. It caused the changes in karst water level. Continental crust of China is intensively affected by neotectonic movements (the modern Himalaya's displacements) which is important for development and various types of karst in China.

MEASUREMENT OF FISSURES IN THE LUNAN STONE FOREST

I measured dip and strike of fissures in the area of the Lunan Stone Forest. Limestone pavement is formed along the most frequent trendings of fissures.

In a rosette (Fig. 3 and Table 1) is shown the frequency of the fissure directions. Out of total number of fissures (N=202) the direction 315-330° (NW-SE) is the most common (20.79%). The second place (15.34%) occupies the direction 45-60° (NE-SW) and the third one (14.35%) the direction 285-300° (NW-SE).

Table 1. Statistical evaluation of fissures trending in the Lunan Stone Forest (N=202)

| direction (smer) | no. of measurements (št. meritev) | % | position (zaporedno mesto) |
|----------------------|---|------|----------------------------------|
| 1-15 ⁰ | 0 | 0 | 12 |
| 16-30 ⁰ | 5 | 2.47 | 11 |
| 31-45 ⁰ | 8 | 3.96 | 9 |
| 46-60 ⁰ | 31 | 15.3 | 2 |
| 61-75 ⁰ | 22 | 10.9 | 4 |
| 76-90 ⁰ | 17 | 8.4 | 6 |
| 271-285 ⁰ | 8 | 3.96 | 9 |
| 286-300 ⁰ | 29 | 14.4 | 3 |
| 301-315 ⁰ | 19 | 9.4 | 5 |
| 316-330 ⁰ | 42 | 20.8 | 1 |
| 331-345 ⁰ | 10 | 4.95 | 8 |
| 346-0 ⁰ | 11 | 5.44 | 7 |

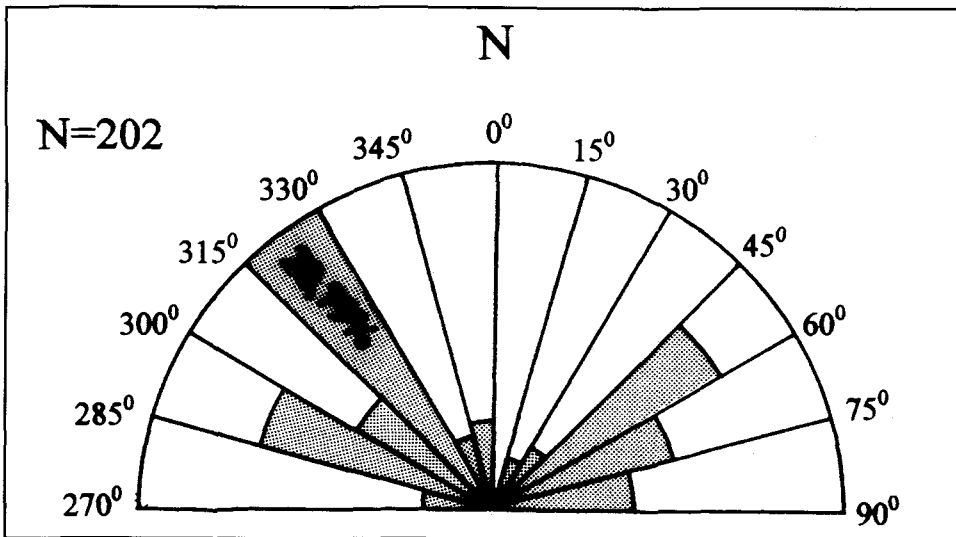


Fig. 3: Rosetta diagram of jointings in the Lunan Stone Forest (N=202)

Sl. 3: Rozeta smeri razpok

Poorly are represented the directions N-S although regionally important geological structure lines are of this direction. This fact implies the idea that the area of stone forest lies among stronger faults; a block is broken in two main jointings, NW-SE and NE-SW.

When the pathways in the park were made the fissures among the pinnacles were used and thus the main tourist ways are concordant to fissures in a limestone (Fig. 4).

It is typical of the fissures to dip very steeply, almost vertically (80-90°).

According to Sweeting (1995) the main joints are N20°W which differs for at least 10° from mine measured and analysed data.

In the book *Karst of China* (1991) Yuan summarizes the researches done by Shouyue (1983) who was the author of a linear structures map in the Lunan Stone Forest. According to this map the most frequent tectonic structures are N50°W.

In a central part of the Lunan Stone Forest (Fig. 5) the most expressed dip is 50° and transverse dip 140°, 160° and 180°. In E part of Stone Forest the dip 80° (N100W) prevails. West from touristically displayed pathways in the Lunan Stone Forest there is a thicker layer of red loam deposited in a valley, oriented to 110° (N10°E). South from the Stone Forest Lake and along the southern touristic pathway the direction of the jointing is 0-20° (E-W, N80°W, N70°W).

During field mapping I could not determine displacements along some joints. It is fact that on the mapped area (Fig. 5) there is not an uniform direction of joints intersecting all the others. Thus we perceive that directions NW-SE are intersected by directions NE-SW and vice versa. The relative age of the main joints in the Lunan Stone Forest thus cannot be determined for sure.

MEASUREMENT OF LAYERS IN THE LUNAN STONE FOREST

I measured 52 dips and strikes of strata. The results are shown in structural-geological sketch (Fig. 5), in Schmidt net (Fig. 6) and in rosetta (Fig. 7). The main direction of strike is NW and W (Fig. 6).

Due to small dipping of beds lithological column is accessible in a thickness of 200 m. In its lower part, accessible in the eastern part of the Stone Forest and also in its central part through deep fissures it contains limestone with inliers of cherts jutting out of a limestone. The layers in upper part of the lithological column are the least stable in case of earth-quakes. It is evidenced by numerous collapse blocks that had fallen into the fissures during the earth-quakes of the last decades.

At least 21.2 % of limestone layers have direction N16-30°E (Fig. 7 and Table 2) striking westwards for 5-20°, in average for 5°.

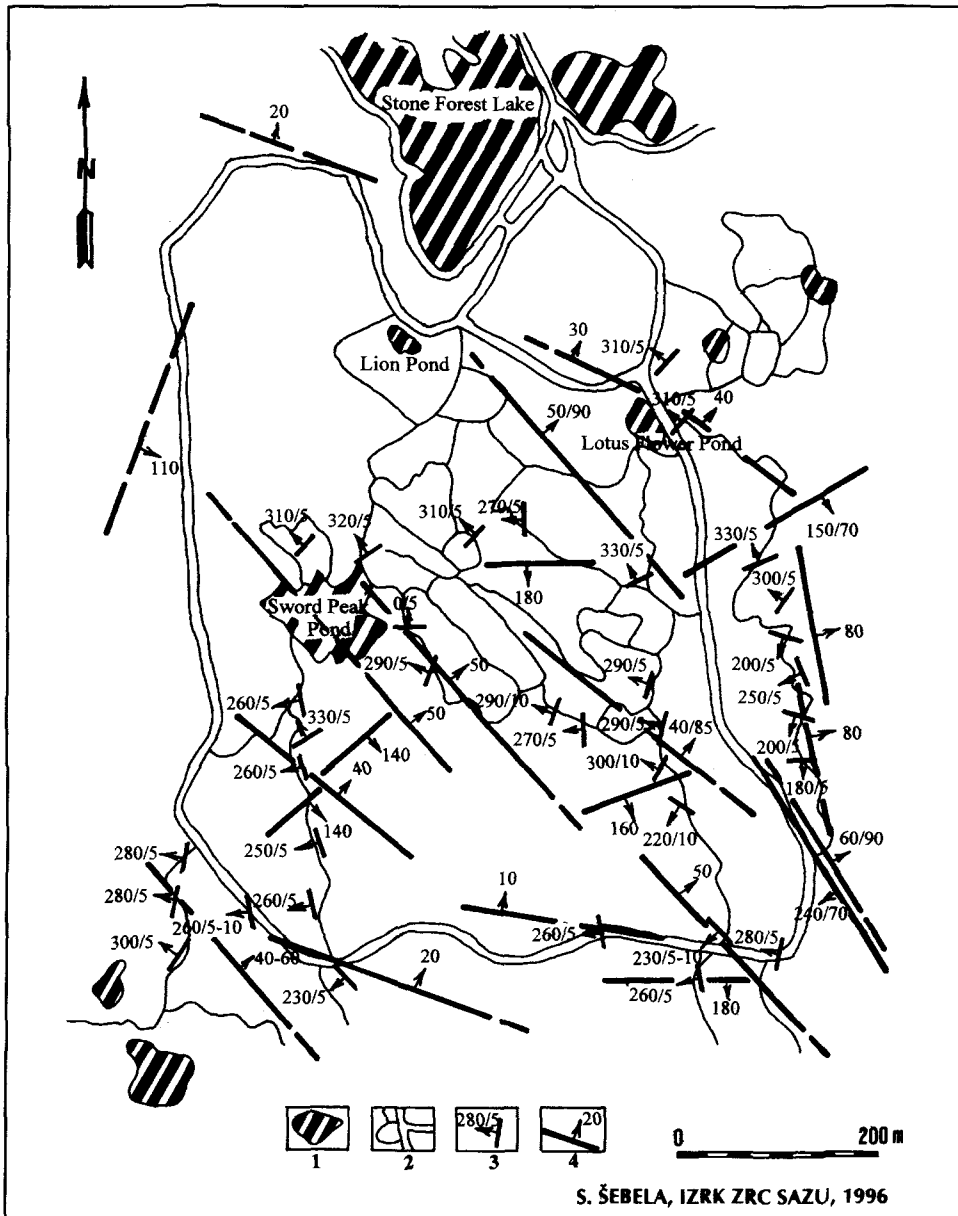


Fig. 5: Structural-geological sketch of the Lunan Stone Forest. 1-lake or pond, 2-touristic pathways, 3-strike and dip of strata, 4-strike and dip of structural zones

Sl. 5: Strukturno-geološka skica lunanskega Kamnitega gozda. 1-jezero ali ribnik, 2-turistične poti, 3-smer in vpad plasti, 4-smer in vpad tektonskih con

Table 2. Statistical evaluation of the direction of layers in Lunan Stone Forest. N=52

| direction (smer) | no. of measurements (št. meritev) | % | position (zaporedno mesto) |
|----------------------|---|------|----------------------------------|
| 1-15 ⁰ | 5 | 9.6 | 4 |
| 16-30 ⁰ | 11 | 21.2 | 1 |
| 31-45 ⁰ | 4 | 7.69 | 6 |
| 46-60 ⁰ | 8 | 15.4 | 3 |
| 61-75 ⁰ | 2 | 3.8 | 8 |
| 76-90 ⁰ | 2 | 3.8 | 8 |
| 271-285 ⁰ | 0 | 0 | 12 |
| 286-300 ⁰ | 2 | 3.8 | 8 |
| 301-315 ⁰ | 1 | 1.9 | 11 |
| 316-330 ⁰ | 3 | 5.76 | 7 |
| 331-345 ⁰ | 5 | 9.6 | 4 |
| 346-0 ⁰ | 9 | 17.3 | 2 |

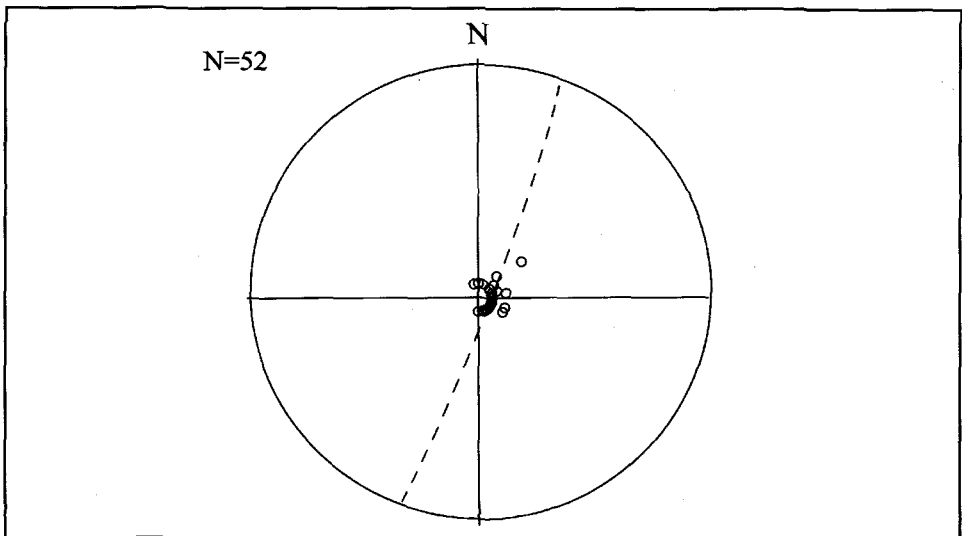


Fig. 6: Schmidt's net - the layers of limestone in the Lunan Stone Forest (N=52)
Sl. 6: Schmidtova mreža - plasti apnenca v lunanskem Kamnitem gozdu (N=52)

The layers of Permian limestones strike towards NW and W dipping for 5 to 20°, they are gently folded into several smaller anticlines and synclines.

To attain a more complex explanation of tectonic conditions it would be necessary to widen the researches over the borders of touristic part of the Lunan Stone Forest.

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Fig. 2: The Lunan Stone Forest (Photo by S. Šebela, July 1996)
Sl. 2: Lunanski Kamniti gozd (Foto: S. Šebela, julij 1996)



Fig. 8: Karst polje in Xichou (Yunnan) (Photo by S. Šebela, July 1996)
Sl. 8: Kraško polje v pokrajini Xichou (Yunnan) (Foto: S. Šebela, julij 1996)



Fig. 4: The fault zone in the Lunan Stone Forest (Photo by S. Šebela, July 1996)
Sl. 4: Prelomna cona v lunanskem Kamnitem gozdu (Foto: S. Šebela, julij 1996)