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# THE ORDOVICIAN PALAEOKARST ON THE EASTERN MARGIN OF ORDOS BASIN

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The first submember of the fifth member of the Lower Ordovician Majiagou Formation (M5<sub>1</sub>) on the eastern margin of Ordos Basin, which is located on the uppermost palaeokarst, and mainly consists of mudstone limestone, microcrystalline dolostone, and karst breccia and conglomerate. The M5<sub>1</sub> was deposited in shallow and restricted epicontinental environments with high salinity and is the main reservoir of the Ordos Gas Field. The M5<sub>1</sub> is overlain pseudo conformably by Middle Carboniferous Benxi Formation.

Sedimentation, karstification and burial diagenesis have controlled the geochemical contents of the carbonate rocks. The karstification has played the most important role. As a result of combination of three actions, there are high contents of SiO<sub>2</sub>, Al<sub>2</sub>O<sub>3</sub>, Fe<sub>2</sub>O<sub>3</sub>, Na<sub>2</sub>O, Ba, Ti, Ce, Li, moderate contents of Th, Ni, Cu, Cr, La, and low contents of MgO, K<sub>2</sub>O, Sr, P, Mn in the M5<sub>1</sub>.

Leaching of meteoric water in the micrite dissolved CO<sub>2</sub> from organic carbon, therefore most micrite is characterized by low  $\delta^{13}\text{C}$  values, which range -10.5 to -14.4‰ PDB with a mean of -5.4‰ PDB. The unaltered marine  $\delta^{18}\text{O}$  composition of -4.3‰ PDB for micrite is heavy under influence of sedimentary environments. Leaching and burial diagenesis, particularly the latter, have made the  $\delta^{18}\text{O}$  values of micrite obviously low. The lowest value of  $\delta^{18}\text{O}$  for micrite is -13.1‰ PDB and the mean of  $\delta^{18}\text{O}$  for micrite is -7.1‰ PDB.

During the karstification, meteoric and subsurface water, which was unsaturated with carbonate dissolved carbonate rocks, creating abundant solution pores, caves, fissures and fractures in the M5<sub>1</sub>. The smallest pores can be seen only under an electroscan microscope. The biggest caves have diameter of 2 m. Fracture widths range 0.05 mm to 25 cm, while fracture lengths range <1 mm to 66.3 m. The porosity ranges 0.5% to 13.58% with a mean of 1.99%. The permeability ranges  $0.00003 \times 10^{-3} \text{ mm}^2$  to  $1224 \times 10^{-3} \text{ mm}^2$  with a mean of  $5.85 \times 10^{-3} \text{ mm}^2$ . The reservoir carbonate rocks, which have been reformed by the karstification, show a great heterogeneity.

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# HILLSLOPE FORMS OF TOWER KARST IN THE SAMPLED AREAS OF SOUTHWEST CHINA

An Interpretation using Geographic Information System (GIS)  
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Karst terrains in southwest China have been heavily dissected because of neo-tectonic uplift. Two groups of positive karst features are distinguished by Chinese researchers. These are "fenglin" or "peak forest" and "fengcong" or "peak cluster". The former are individual isolated residual hills rising from flood or corrosion plains. The latter comprise a group of residual hills emerging from a common bedrock basement and often incorporating closed depressions between the clusters of peaks.

Currently, researchers proposed two different hypotheses regarding the origin of the towers. One is sequential development, which considers that isolated towers represent a more advanced stage of evolution than link-based ones. While, the other is parallel development, which believes that both isolated and link-based towers developed independently during the geological period.

This research is designed to measure the slope angle and observe the slope forms of towers in order to supply some evidences to explain how they are developed. Two pieces of topographic map along the North 56 degree West transect in southwest China with 1:10,000 scale were digitized into Arc/Info GIS system for analysis. Each of them covers roughly 1.5 square kms on the ground. These are: (1) Fengcong-Depression Area near Guiyang on the Yunnan-Guizhou Plateau; and (2) Fenglin-Plain Area of Guilin in the lowland flood plain region. The contour interval of these topographic maps is 5 meters.

Digital terrain models were built by using Arc/Info sub-module TIN. Within the capacity of TIN, we were able to calculate slope angles of 13,600 slope segments for Fengcong-Depression sampling area, and 13,942 slope segments for Fenglin-Plain sampling area. Querying the TIN Arc Maps with data base, we were able to locate every single slope segment with its slope angle and distinguish the patterns of spatial distribution of a particular slope angle.

The result indicates that slopes on the tower karst of Fenglin-Plain area are much steeper than those on the towers of Fengcong-Depression area. For instance, only 95 slope segments in the Fengcong-Depression area have slope angle more than 45 degrees, and only 15 of them exceed 60 degrees. While, the slope segments in Fenglin-Plain area with slope angle more than 45 degrees are 2,073, and 653 of them are more than 60 degrees.

In combination with field measurement of both surface and subterranean dissolutions, the evidences suggest:

- (1) the steeper the slope is, the lower the surface dissolution.
- (2) currently, subterranean dissolution is much more intensive than surface dissolution on the towers.

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# Criogenic metamorphization of isotopic composition of ground water on the permafrost territories

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The formation (in the past) and degradation (in the condition of present-day climate) of the permafrost strata are accompanied by criogenic metamorphization of not only chemical (Anisimova, 1971; Kononova, 1974), but also isotopic composition of ground water. The investigations of subpermafrost water in Yakutia (Lena-Angamskoye Interfluvium) have revealed a tendency of latter to lighten its isotopic composition with nearing to the bottom of degraded part in the permafrost strata. The thickness of this strata in this region is now not more than 300 m, whereas 20 000 years ago it amounted to 600 m and deeper (Fotiye, 1978). The degradation of permafrost rocks in Holocene with a velocity of waning the lower edge equal approximately to 2 cm/year (Bolobayev, 1973) at an average porosity of 5% leads to the formation of approximately 1000 cub.m of free "endogenic" water per one sq.km. Thus, 10 mln.cub.m of such water could be formed during the Holocen period. The availability of "revived" water should be taken into account in the interpretation of isotopic and hydrochemical data. The separation of hydrogen and oxygen isotopes between ice and water leads to the lightening of the rest liquid water as compared with initial composition. The ice, being in equilibrium with liquid phase, is enriched by  $^{18}\text{O}$  approximately by 3‰, and by D - 18‰. The deeper are rocks frozen, the greater are the changes in the isotopic composition. The link of values is described by Eq.  $\delta\text{D} = 6\delta^{18}\text{O} - 30\text{‰}$ , and the experimental points are shifted downwards relative to the meteoric water line. The isotopic composition of subpermafrost water on the studied territory varied from -130 to -172‰ for D and from -17.5 to -23.4‰ for  $^{18}\text{O}$  depending on the depth of sampling. The "revived" water shows also high values of activity ratio of even isotopes of Uranium ( $\gamma = \frac{^{234}\text{U}}{^{238}\text{U}}$ ), varying from 2.1 (water of present-day recharge) to 7.2 in "ancient" water. In the conditions of migration closeness, that are real in permafrost medium, the daughter  $^{234}\text{U}$ , due to release energy, transfers into defects of crystalline grid of rock-forming minerals, and it is accumulated in potentially mobile form. With degradation of permafrost rocks the accumulated  $^{234}\text{U}$  transfers into liquid phase, which is just reflected in high values of the above-given  $\gamma$ -ratio in the "revived" water.

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# The modern dynamics of the Upper Ribeira Karst, southeastern São Paulo State, Brazil

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The hydrology and hydrochemistry of the Perolas-Santana karst drainage system has been monitored for one hydrological year in order to estimate the chemical denudation rate of a subtropical humid karst system. This paper presents the first net solution rate of a karst area in Brazil.

The Perolas-Santana system belongs to a karst area in dolomitic and calcitic metalimestones of the Mesoproterozoic Açungui Group in the Upper Ribeira river valley, between Apiai and Iporanga, southeastern São Paulo State, Brazil.

The following hydrochemical facies have been defined: allogenic surface runoff, fluvio-karstic runoff, vadose autogenic fissure seepage, vadose autogenic conduit flow, deep phreatic conduit flow and karst resurgence flow. The hydrochemistry indicates that the karstification is basically controlled by meteoric water enriched in carbonic acid.

The modern erosive dynamics of the studied karst has been quantified according to the following parameters: saturation rate in calcite and dolomite of allogenic rivers entering the limestone surface, the seasonality of the saturation index of the main hydrochemical facies and the rate of limestone surface lowering through dissolution. The calculated mean chemical denudation rate for the Perolas-Santana basin is  $31 \pm 6 \text{ mm/ky}$ , based on a one year water budget of the basin and water hardness variation with respect to the spring discharge.