THE KARSTIC SINKING-COLUMNS IN PERMO-CARBONIFEROUS COAL FIELDS OF NORTH CHINA

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ABSTRACT

The Permo-Carboniferous series are the principal coal-measures in north China. Such so called "karstic sinking-columns", which can usually be exposed in drilling holes during the geological exploration of coal or in pit-system in the course of mine construction and production, are not identical both in magnitude and in height. But they all take the shape of irregular cone whose the upper section is rather smaller than its lower section. Their axes are vertical to the strata. The karstic sinking-columns get begged down from that position responding to the stratigraphic level of the tip layers of the cones through the lower part of the coal-measures in the interior of the Middle Ordovician limestone.

Inside these columns they are disorderly and unsystematic filled with lumps and crubs of various dimension and powders of rock. We can discover lumps of rock belonging to different ages of geology on the same stratigraphic level. Always there is an unfilled space locating above the tip of each sinking-column.

It is brought to light by the developing of many the coal mines in north China that the lump or crumb sediments in most of the sinking-columns are accumulated closely together. Thereby, they are not water-bearing and impermeable. Just the exploitation of coal is of influence when the face fall leads to unmark the sinking-column, but no water disaster would be happened in general. It is hard to avoid that the lump or crumb sediments in some of the sinking-columns are loosely accumulated. Certainly they are water-bearing and permeable, and become to be the natural passageway favourable to the hydraulic relationship between the water of the Middle Ordovician aquifer and among the water of these aquifers interleaved in the upper part of the coal-measures. Once the excavation meets one of the aforesaid sinking-columns under the piezometric level of the Middle Ordovician aquifer, it would result in a sudden water incursion into the mine and make an emergency. For example, the maximium yield of water incursion

from the karstic sinking-column in Middle Ordovician limestone amounted to 2053 cubic metres per minute on June 2, 1984 in the Fan Gezhuang Mine of the Kailuan coal field. So the water incursion from the karstic sinking column is one of the principal water emergencies during the exploitation of the Permo-Carboniferous coal-measures in north China.

It is well known to the form and structure of karstic sinking columns some experts have already approached. But nobody ever discusses on the divergences of their contributing factors and of their hydrogeological conditions. Some knowledge of the author, on which never being discussed, has been advanced in the paper for reference.

Just as some of the dormant volcanoes sometimes turn into active and erupt again, some of the karstic sinking-columns formation in the course of endless geological evolution are also bearing such a cycle of development from extinct to steady and oppositely from steady to extinct. The course of geological evolution in north China is about 300 000 000 years and can be divided into the following four stages:

1. Stage of subsidency. The overlying strata of coal-measures fall down into the huge karstic caves extending among the tip of Middle Ordovician limestone aquifer.

2. Stage of lump accumulation. The artesian water of the Middle Ordovician limestone aquifer intrudes into the subsidency space and enlarges the volume of the space. And the lumps or crumbs of rock accumulate in the space simultaneously.

3. Stage of column extrusion and displacement caused by tectonic movement.

4. Stage of the influence of the later water circulation, alternation and karst generation on the sediments of the sinking-column in the Middle Ordovician limestone.

It would be better to name the colume as karstic sinking-column according to its occurrence and formation. Most of the karstic sinking columns after the first three above-mentioned stages become to be such columns in which the lumps or crumbs are closely accumulated and to be no water-bearing and impermeable geological masses. Only a few karstic sinking-columns have changed into otherwise appearence in the period of the forth stage. The sediments is sinking-columns had been removed away by corrosion.

The artesian water in the Middle Ordovician limestone has intruded into the columns again and the columns have turned into water bearing and permeable as a result of the anew movement of the karstic sinking-columns.

The Permo-Carboniferous series are the principal coal-measures in north China. In drilling holes during geological exploration of coal fields or in pit-systems in the course of mine construction and production, a rock-column body, namely, karstic-sinking column, is usually exposed inside intergreted

rock strata, which distributes both in fragment and in family. It seems like the intrusion of igneous magma into the strata, but it is a typical sedimentary body rather than an igneous magma.

The karstic sinking-column, whose upper section being much smaller than lower section, takes the shape of an irregular circle or ellise on the horizontal plane and the shape of cone, sometimes, the shape of bee-waist on the vertical section. Its axis is always vertical to the strata without respect of the varieties of the strata's occurrences. The magnitude and height of the column have a wide range of change, its diameter being from several hundred meters to several meters and height being from no less than 250 meters above the Middle Ordovician limestone roof throught the strata of Shihezi group of Permian Period to only several decades meters beloning to the Taiyuan group of Carboniferous Period. But, all the columns get begged down into the Middle Ordovician limestone with large depth and get connected with large filled depth carverns. The shape of the contact surface of the column with the rocks around it is just like the dog's teeth rather than smooth. The column is filled with disorderly and unsystematic lumps and crumbs of various dimensions and powders of rocks, which come from upper strata with different ages. But, there often appears an unfilled space locating in the tip of each column, while the roof of the space is usually made of solide rocks.

It has been brought to light with the development of coal mines, by whom a lot of karstic sinking-columns have been exposed that the lump or crumb sediments in most of the columns are accumulated closely together and the gaps between the rocks pieces are filled by powders of rocks. Thereby, they are not water-bearing and impermeable. When they are exposed directly no water disaster happens. The column has only a little influence on the excavation engineering and coal output. It must be noticed that there is an exceptional column, which should not be neglected. The accumulation of rocks pieces inside this column is very loose and the gaps are unfilled or partially unfilled. The column is certainly water-bearing and permeable, which becomes a natural passageway favourable to the hydraulic relationship between the water from the Middle Ordovician limestone aquifer and among the water from the Permo-Carboniferous thin limestone aquifers. Once the excavation engineering meets one of the aforesaid columns under the piezometric level of the Middle Ordovician aquifer, it would result in a sudden water intrusion into the mine and make an emergency. For example, the confinedwater from acolumn inrushed into the mine in 1978 in Tongzhi mine of Anyang Bureau, Henan province, the yield of intrusion water being 24 cubic meters per hour at first, and then increasing to 1500 cubic meters per hour rapidly. As a results, the mine is inundated. The afterward exploration of stopping up the column demonstrated that the karstificat ion is excellent. There appeared 17 caves, the largest of which is 2.58 meters high in No.1 drilling hole in which 50 meters was drilled down into the column, the porosity being as large as 28 percent in the vertical direction. The bottom of it was not reach ed in No.3 hole in which 200 meters was drilled down alone the column. As shown

in figure 1. As another example, we consider the Fangezhuang Mine of Kailuan Coal Field. In 1984, when the 2171 working plane on which no.7 coal seam was mined was 57 meters apart from a hiding karstic sinking-column, the confined water from the column broke down the coal wall into the mine. The largest yield of water intrution amounted to 2053 cubic meters per minute. The mine was inundated in 21 hours by groundwater from Middle Ordovician aquifer beneath the coal-measures. The afterward exploration of stopping up the column demonstrated that the column demonstrated that the column is as high as 280 meters, from Middle Ordovician Limestone to the roof of sandstone of no.5 coal seam. On the horizontal plane of no.7 coal seam, the karstic sinking-column takes the shape of ellipse with maximum axis of 74 meters and minimum axis of 64 meters. There exists an unfilled space of 8.72-32.12 meters in the tip of the column. As shown in figure 2.

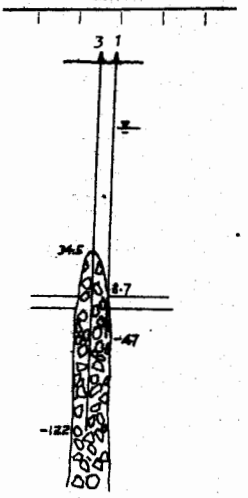

Fig.1. Illustration of Karstic Sinking-Column, Tongzhi Mine.

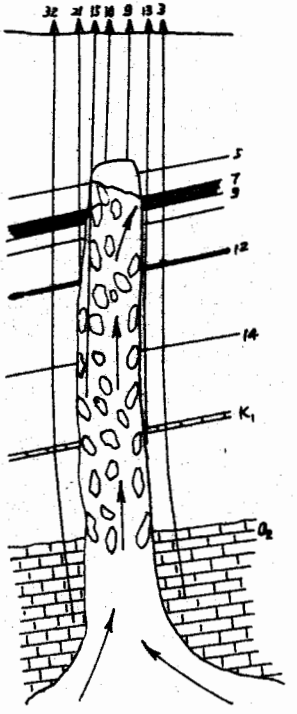

Fig.2. Illustration of Karstic Sinking-Column, Fangezhang Mine.

The example stated above ilustrate that the water intrusion from karstic sinking-columns is also one of the water sisaster in excavation of Permo-Carboniferous coal field in north China. The perniciousness of it is far much greater than its number.

It is well known that some experts have given reports about the Permo-Carboniferous karstic sinking-columns, especially the shape and structure. But nobody even discusses on the divergences of their contributing factors and of the hydrogeological condition especially on the reasons why some columns water-bearing and permeable while the others are not water-bearing and impermeable. Some knowledge of the auther, on which never being discussed, have been advanced in the paper for reference.

Just as the volcanoes have a course of from erupting to going out and some dormant volcanoes sometimes turn into active and erupt again, the karstic sinking-columns are also bearing such a general cycle in the course of endless geological evolution, from emerge through development to stability and, on the contrary, from stability through development to emerge for the second time. The course of geological evolution in north China is about 300 000 000 years and can be divided into the following four stages. As shown in figure 3.

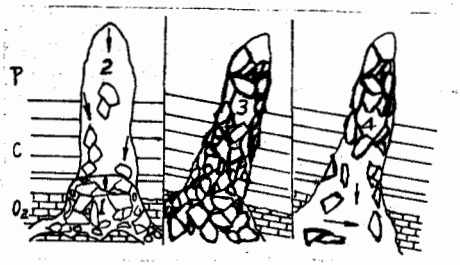

Fig. 3. Stages of Karstic Sinking-column Evolution.

1 - Stage of Subsidency, 2 - Stage of Lumps Accumulation, 3 - Stage of Column Extrusion and Displacement Caused by Tectonic Movement, 4 - Stage of Change of Later Hydrogeological Condition.

1. Stage of subsidency of the overlying strata of coal-measures falling down into the huge karstic caves in Middle Ordovician system. In the later period of Palaeozoic Era dating back to 300 000 000 years ago, the whole area of north China subsided. After bying weathered, eroded and karstified in a long period of about 100 000 000 years of Upper Ordovician System (O_3), Silurian System(s), Devonian System (D), and Lower Carboniferous System (C_1), the strata of Middle Ordovician System begined to load the sediments of Permo-Carboniferous Period on its weathered crust. Those caves connecting directly with the stratum surface are filled first, while in the upper section, the roof of other large, having bad connection with the surface gradually fall down into large caves with the increasement of overlying sediments, that is the increasement of layer pressure. In such a way, a collapsed space is formed beneath the coal-measures, whose size has something to do with the volume of the karsticcaves, the larger the karstic caves, the bigger the collapsed space.

2. Stage of lump accumulation. The artesian water of the Middle Ordovician limestone aquifer intrudes into the subsidency space and enlarge the volume of the space. And the lumps or crumbs of rocks accumulate within the space simutaneously.

At the same time when the Middle Ordovician limestone collapsed to make spaces the artesian water of the Middle Ordovician aquifer intrudes into the collapsed space to erod and crack the rocks around the space. The eroded and cracked rocks keep falling to the bottom of the space to accumulate with the space advancing towards the upper layers.

The cycle, collapsing, falling, accumulating, and enlarging would not stop slowly going until the main systems of the karstic caves and the collapsed space in coal-measures are filled by rock pieces, and apressure-preventing arch is left unfilled in the tip of the space. This course may take 1000 years. So far, an initial karstic sinking-column is formed.

3. Stage of karstic sinking-column extrusion and displacement caused by tectonic movement. The influence of Yanshan Movement in Mesozoic Era on the area of north China is to make mountains. The horizontal rock strata with a large scale are sqeezed forming a lot of folds and faults. The karstic sinking-columns are also extruded and displaced with the development of the strata. Extruding makes the accumulation of rock pieces closer and solid rock lumps are pressed into soft ones, forming acontact surface with the sharpe like the teeth of a saw. The axis of the column is always vertical to the strata without respect of the varieties of the strata's occurrences. There are some exceptional columns which are intercepted by faults.

4. Stage of influences of the later water circulation, alterration and karstic generation on the sediments of the karstic sinking-columns in the Middle Ordovician limestone. The bulge areas in north China underwent weathering and eroding during the period of Mesozoic Era and Triassic System (T), Jurassic System (J), Cretaceous System (K), Tertiary System (R), and Quaternary System (Q). As a result, a portion of the Middle Ordovician aquifer was concealed to the surface, with atomspheric precipitation penetrating down to recharge the aquifer ones more. The formed unconfined water flow goes through the local eroding plane of datum at the root of a mountain to discharge as a spring through outcrops of the Middle Ordovician aquifer or through a tectonic faults zone, which is favourable to the circulating conditions of rapid run-off in the Ordovician aquifer.

It is believed that the sedimentation is still going on in the east of north China, where being a subsidency zone. The aquifer of the Middle Ordovician limestone is deeply buried by the layers of Carboniferous System and Permian System, which is unfavourable to its discharge, circulation. The artesian groundwater is still in the state of stagnant.

It is well known that the circulation conditions of groundwater is the fundamental premise to karstification. The di-

fference of the conditions of the Middle Ordovician aquifer between mountain areas and plain areas results in the differences of karstification, being active in former and being inactive in latter. Rapid run-off and karstification not only make new karstic systems, but also make the dormant karstic caves, left over in geological history, turn into active again. The eroding and washing out bring away and hollow out the sediments at the bottom of the karstic sinking-column, forming a suspended karstic cave again. The artesian water of the Middle Ordovician aquifer intrudes the bottom of the column for the second time to erode the rock pieces.

The reviving of erosion made by artesian water makes the column gradually become less crowed, and be congested by water from the bottom to the tip. The hydrogeological conditions of the karstic sinking-column with not water-bearing and impermeable propert ies, formed by acculation, softening and sqeezing under static level, would be changed. That is the very reason why some column can cause water disaster when the Permo-Carboniferous coal field is mined in north China.

So, it would be better to name the column as karstic sinking-column according to the four stages of its occurrence and formation. Strictly speaking, in north China, all of the karstic sinking-columns have undergone the first three above-mentioned stages. The columns are characterized by their not water-bearing and impermeable hydrogeological properties. Only a few karstic sinking-columns in the mountain areas are changing into otherwise appearence in the period of the four stages.