Mechanism And Prevention Techniques Of the hazardous Burst of Interlayer-sagging Water Body

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Abstract

The sagging water outburst was firstly noticed in China in 1980s. On the basis of actual cases happend in China, the paper investigated the mechanism and prevention measures of this kind of hazards. The prerequisites to form a sagging void space include: upper hard rock strata, lower soft aquifuge and long water accumulating process. Static water head/pressure and rockbursting energy are the two main forces to trigger the ourburst of 'sagging wate bulb'. It was summarized that the patterns/passages of sagging water outburst included rockburst-induced passage, extra-high water-connected zone passage, re-activated faults passage and Neozoic faults passage. The comprehensive prevention measures involve in: pre-dewatering the interlayer-sagging water body via underground drilling, pre-dewatering the aquifers which may potentially recharge the sagging water body, increasing the size of working face to limit the development of sagging strata, etc.

Keywords: mining-induced sagging water, mechanisms, diversion-based drilling, roof

Introduction

As the movements of coal roof are controlled by full caving mining at a coal mine, the normal tensile may cause the overburden, which are composed of hard and soft formations, to yield uncoordinated sagging deformations, or even to leave a large interlayer lenticular-like void space. Further, when the interlayer void space in the sagging zone is continuously expanded and water accumulates to a certain amount, the rock-burst of the upper hard rock might cause a suddent outburst of the interlayer sagging water into the stope, causing a mine water accident like what the goaf water inrush usually does.

Initially, this kind of inrush was noticed in China in 1980s. It was with the aids of a paper by a former Suviet expert that the Chinese practitioners first knew the concept of sagging and futher inferred that, under a certain curcumstance, the sagging zone might form a huge void space, gradually be flooded by neighbour aquifers and finally induce an unexpected inrush hazard. They judged that the inrush occurred at a Nantong coal mine (Sichuan, China) in 1980s were actually the ourburst of flooded sagging void. From the year of 1990 to 2000, there were some Chinese investigating the occurrence, mechnism, prevention of sagging zone. However, not all sagging zone might leave enough void space and not all void space could get flooded. It happened under a certain conditions. The accidents of sagging water outburst were not fairly common.

But after 2000, this kind of accidents were frequently reported in China again. For example, on May 21 of 2005, a sagging water inrush accident happened at the Haizi coal mine (An'hui, China) and caused a huge property and safety loss. The void sagging space were formed under the thick intrusive sill. Especially in the recent years, this kind of accidents were more reported occurring in the Ordos Jurassic coalfields. In general, sagging water burst was always being neglected and easily being misjudged. So, the purpose of the paper is to investigate the mechanisms of and precaustions against sagging water outburst…

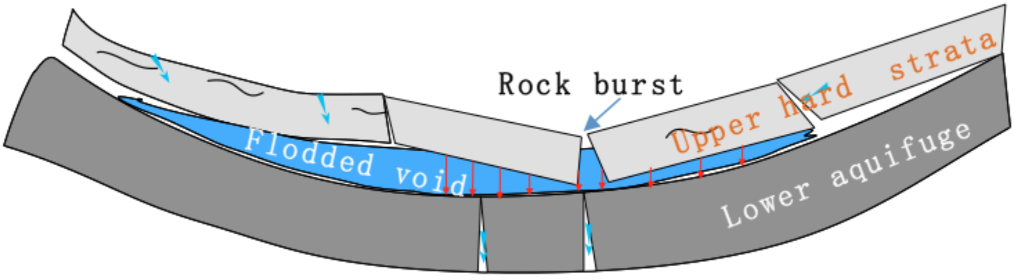

Figure 1 conceptual model of flooded sagging void.

Interlayer sagging void

As the caving method being adopted, there will be developing the caving zone, fractured zone and sagging zone in the overburdens at the goaf side. For the roof pattern of soft strata overlain by hard strata (shortly as 'upper hard and lower soft'), the normal tensile may cause uncoordinated sagging deformations, or even to leave a large interlayer lenticular-like void space. In caving zone and fractured zone, the deformation void is soon damaged again; but in the sagging zone, the void may be remained, expanded and enlarged(Figure 1).

The prerequisites to form a sagging void space include:

(1) Upper hard rock strata

Indispensibly, in the vertical upper part of the sagging zone, there must be a certain thickness of hard igneous, sedimentary, metamorphic rocks, like limestone, sandstone, conglomerate, intrusive sill, etc. In most cases, this kind of hard rocks carry almost no groundwater, and are always ignored their potential threat.

Case 1: At Haizi coal mine (An'hui, China), it was the intrusive sill 76.3-88.7m in thickness that cantilevered in the sagging zone and left a huge void space full of water. On May 21 of 2005, the sagging void space suddently bursted, the violent inrush of water mixed with debris instantly peaked at 4000 m3/h, and the process last for 3.5 hours.

Case 2: At Xinji coal mine (An'hui, China), it was the excessively thick and expaisive gneiss nappe that hung over the upper part of sagging zone to yielded a big void space. As the gneiss cantilever eventually was broken, the big 'water bulb' in sagging zone suddently bursted. At an inrush rate of 400m3/h, the longwall face was soonly inundated.

(2) Lower soft aquifuge

Beneath the upper hard rocks, a lower soft aquifuge is needed to wrap up the void space to hold seepage water. It could be either the inact aquifuge in the sagging zone or the re-united aquifuge in the fractured zone.

For example, from September of 2009 to March of 2010, there happened 4 times of inrush accidents at the Hongliu coal mine in the Ordos Coalfield (Ningxia, China), the maximum inrush rate rose up to 3000 m^3/h and the working face was twice flooded. It was judged that strata of silt enriched in expansible clay re-formed a layer of secondary aquifuge in the fractured zone, which formed a kind of secondary sagging water body.

(3) Long water accumulating process

The sagging void space usually got recharged by a traditionaly neglectable aquifer. A long water accumulationg process was always observed. It could be reasonably inferred that the harder the upper rock is, the longer the cantilever of hard strata hanged over, the larger the void space develpe, the more the water is accumulated and the more serious the outburst hazard would be. At the case of the Guojiahe coal mine (Shanxi, Chine), the longer water accumulating time at the 3rd sagging water inrush led to a total drainage of $22.6 \times 10^4 m^3$, much larger the former two inrush accidents.

Forces to trigger sagging water outburst

There are two kinds of forces to trigger the ourburst of 'sagging wate bulb'. One is static water head/pressure of the recharging aquifers and the other is the rockbursting energy of the upper hard rocks. The magnitude of rockbust energy depends on the strength, fissures, thickness and cantilever of the upper hard rock strata. Most of the sagging water ourbust were triggered by a mixture of them.

Patterns of sagging outburst

On the basis of actual cases happend in China, we sum up the patterns/passages of sagging water outburst as:

(1) Rockburst-induced passage. For this pattern, common forces of rockburst and static water pressre directly pierce through the 'water bulb' in the sagging zone. Most of the sagging water outburst accidents in China, like the ones in Haizhi coal mine, Hongliu coal mine, Jining coal mine, Dafuosi coal mine, Yuhua coal mine, Huoshizui coal mine, Cuimu coal mine, etc., belong to this pattern.

(2) Extra-high water-connected zone passage. For this pattern, water interconnected zone elevates surprisingly higher than as expected to induce the outburst of flooded sagging void. For cases where the multi-coal-seams are sequentially excavated, the water connected zone would reach an extra-height. The sagging water outburst happened in the Nantong coal mine in 1996, Yutianbao coal mine in 1985, Datong coal mine in 2008, etc., were all induced by extra-water-connnetcted height.

(3) Re-activated faults passage. For example, the sagging water outburst sequently occurred at Xinji coal mine in December of 2001 and in January of 2003. It was due to the under fault being re-activated by the rockburst of the upper hard rock, which resultantly damanged the flooded 'water bulb' in the sagging zone.

(4) Neozoic faults passage. The cases of this kind of pattern include: the sagging water outburst at Guojiahe coal mine with a total inrush of $22.6\times10^4 m^3$ and the one at Daliu coal mine with a maximum inflow rate of 430 m_3/h. Apart from the 'flooded bulb' in the sagging zone, the Neozoic faults even pierce up into the regional Cretaceous water-enriched sandstone aquifers, thereupon causing a big and steady inrush flow rate.

Precautions against sagging hazards

A comprehensive preventions measures involve in: (1) pre-dewater the interlayer-sagging water body via underground drilling; (2) Pre-dewater the aquifers which may potentially recharge the sagging water body;(3) Increasing the size of working face to limit the development of sagging strata; (4) strengthen the capacity to buffer and eliminate water inrush in a short time. Practice proves that the method is correct and the effect is great.Occur.

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