Mechanism of instantaneous coal outbursts—Supplementary materials

GSA Data Repository item 2009229

This supplementary data repository includes the following:
1. Table DR1 lists some deadly coal outbursts in the last 130 years.
2. Experimental apparatus and procedures.
3. Figure DR2 shows six continuous frames of outburst exp 102.
4. Two video clips, one for exp 5 (Figure 1) and one for exp 102 (Figure DR2).

1. Table DR1

TABLE DR1. SOME DEADLY COAL OUTBURSTS IN THE LAST 130 YEARS

Year	Country	Mine	Outburst coal (ton)	Outburst gas (m^3) F	atalities	Ref.
1879	Belgium	Agrappe	–	–	141	1
1930	Poland	Wencelaus	5000	28,000 CO_2 151		1
1941	Poland	Nowa Ruda			187	2
1958	Canada	Springhill	–	–	74	a
1960	China	Songzao #2, Chongqing	1000	–	125	3
1978	China	Yaojie #3, Gansu	1030	240,000 CO_2 90		3
1981	Japan	Yubari-Shin	6500	600,000 CH_4 93		1
1985	China	Meitian #3, Guangdong	3200	720,000 CH_4 56		3
1992	Turkey	Kozlu	–	–	263	1
2007.04.19	China	Dashucun	1200	–	17	b
2007.05.24	Russia	Yubileynaya	–	–	35	c
2008.05.23	Ukraine	Donetsk	–	–	8*	d
2008.07.31	China	Zigui, Hubei	–	–	6	e

References: 1—Beamish and Crosdale, 1998; 2—Lama and Bodziony, 1998; 3—Wang and Li, 2002; a—http://www.gov. ns.ca/nsarm/virtual/meninmines/disasters.asp?Language=English; b—http://www.yzsafety.gov.cn/neirong.php? newsid=2229; c—http://www.regnum.ru/english/832640.html; d—http://mns.gov.ua/daily/showdailyarchive.php?day =1&month=6&year=2008&l=en; e—http://news.xinhuanet.com/newscenter/2008-08/04/content_8953817.htm.

*Three were missing in addition to the eight deaths.

More complete summaries of outburst occurrences can be found in Bodziony and Lama (1996), Beamish and Crosdale (1998), and Wang and Li (2002).

2. Experimental Apparatus and Procedures

The apparatus (Fig. DR1) consists of mainly a Lexan (polycarbonate) test cell and a large tank above it. The test cell is 50 mm in diameter and either 400 or 200 mm long. Thin-wall test cells (3 mm thick) were used in earlier experiments and they rupture at ~3.2 MPa. A customer-fabricated thick-wall (10 mm thick) test cell was used in later experiments to reach higher pressures. At 4 MPa, the solubility of CO_2 in coal is ~5 wt% (Cui et al., 2007). This is a very high concentration of gas. (In comparison, for explosive volcanic eruptions, the pre-eruptive H_2O content in magma is often 4-7 wt%.) The base of the test cell is made of steel. Above the test cell is a large cubic tank (~1 m on each side). Inside the tank, there is an electromagnetically driven knife. The test cell is separated from the large tank by layers of aluminum foil (the number of layers of aluminum foil depends on the test cell pressure), which can be cut by electromagnetically driven knife blades inside the tank.

Figure DR1. Experimental apparatus for coal outbursts. A coal cylinder is inside the test cell.

The starting coal samples were large chunks of coal we collected from coal mines. Long cuboids were cut from the chunks and then were ground to quasi-cylinders of 10–20 mm in diameter and ~0.1 m long.

In an experiment, the base of the coal cylinder was glued to the base of the test cell, which was then connected to the large tank. The cell was evacuated to remove air. Then CO_2 was let into the test cell at a desired high pressure (such as 2.5 MPa). The test cell was maintained at high CO_2 pressure for a couple of days to allow CO_2 diffusion into coal and reach rough equilibrium. The duration at high CO_2 pressure was estimated from $t = r^2/D$ where t is time, r is the radius of the coal cylinder and D is CO_2 diffusivity in coal (Saghafi et al., 2007). To achieve sudden decompression, the knife in the tank was triggered to come down to cut open the

aluminum foil. The high gas pressure in the test cell then completely opened the aluminum foil, leading to a loud noise similar to gunshot sound. (Sometimes, only a tiny hole was open in the aluminum foil, leading to slow decompression. These experiments were not counted.) Most experiments were recorded by a video camera. Observation was made on whether the coal sample stayed as one piece or fragmented into pieces.

3. Video Frames for Experiment 102

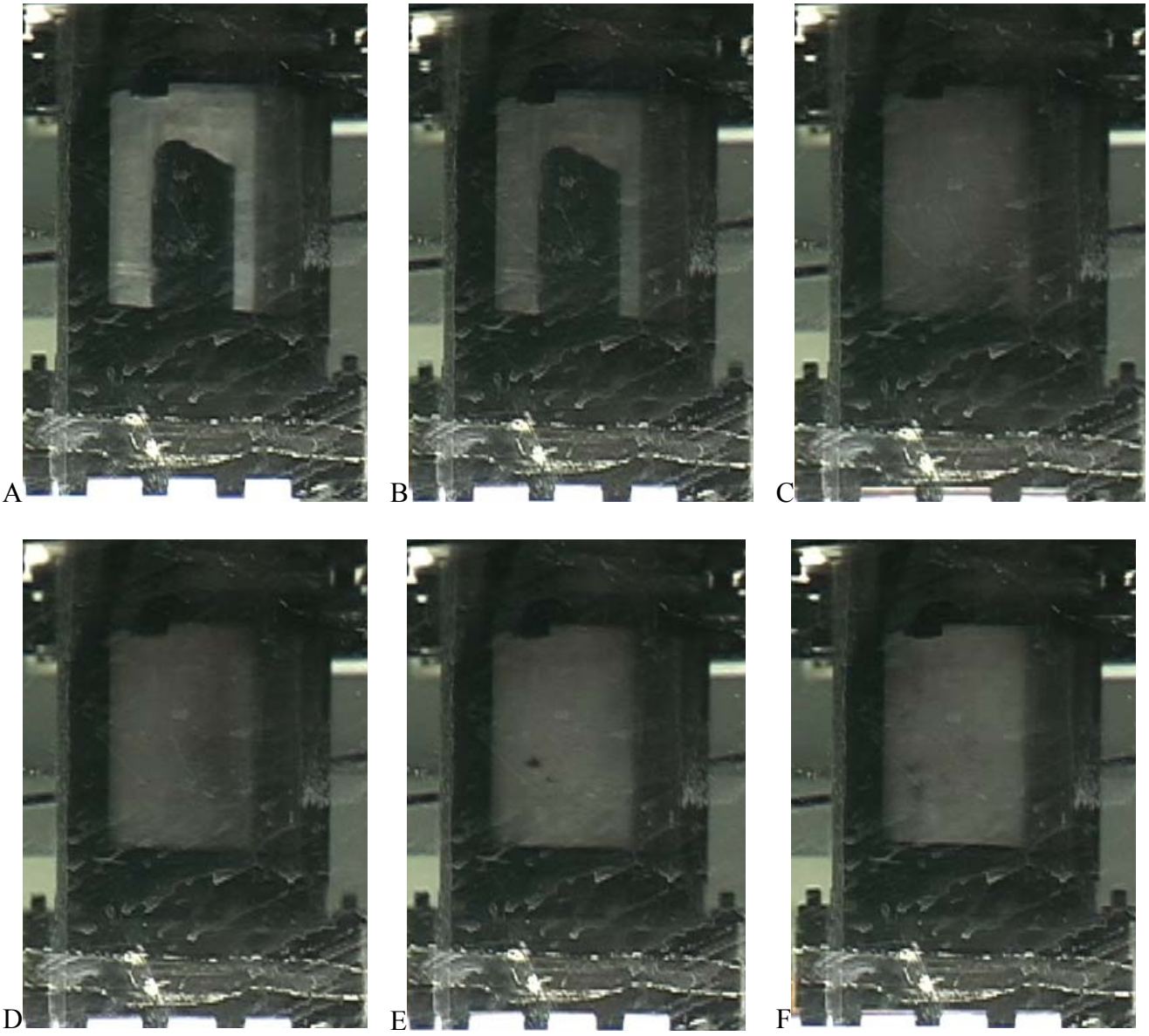

Figure DR2. Six continuous frames of video camera recording (representing 0.2 s) of outburst experiment 102. Coal fragmentation occurred between frame B and C (that is, in less than 0.033 s). Before sudden decompression shown in this figure, the coal sample was pressurized in CO_2 at 4.0 MPa for 2.9 days. After the experiment, degree of fragmentation is 72.6%. The QuickTime movie can be seen by clicking the link Experiment 102 below.

4. Video Clips for two Experiments

Video DR1: Experiment 5

Video DR2: Experiment 102

References Cited in This Supplement:

Cui, X., Bustin, R.M., and Chikatamarla, L., 2007, Adsorption-induced coal swelling and stress: implications for methane production and acid gas sequestration into coal seams: J. Geophys. Res., v. 112, p. doi: 10.1029/2004JB003482.

Saghafi, A., Faiz, M., and Roberts, D., 2007, CO_2 storage and gas diffusivity properties of coals from Sydney Basin, Australia: International Journal of Coal Geology, v. 70, p. 240–254, doi: 10.1016/j.coal.2006.03.006.

Wang, J.F., and Li, W.J., 2002, Collection of Reports and Comments on Coal Mine Accidents in China: Beijing, Coal Industry Press (in Chinese), 3032 p.