Coal Fires of Northern China

Burning lignite being excavated from the Kuitunbayingou opencast coal mine in Xinjiang Province, China. *Photo by Sherong Hu, 2013.*
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A lignite fire, possibly started by spontaneous combustion (Zhang, 2011), in a 200 by 300 m² open pit mine in the Shaerhu Colliery, Xinjiang Province, China.

Photo by Yu Zhang, 2017.

Introduction

China has the second large coal reserves (21.4%) after the United States (22%), and it is the biggest coal producer (3.41 Gt in 2016) and consumer (2.7 Gt in 2016) in the world (China information industry network, 2017; National Bureau of Statistics of China, 2017). Coal provides 61.8% of China’s energy needs (China information industry network, 2017) and 72.2% of the electricity produced in China is from coal (National Bureau of Statistics of China, 2017).

Coal in China formed during the Devonian, Carboniferous, Permian, Triassic, Jurassic, Cretaceous, Eogene, and Neogene (Dai and Finkelman, 2018; Figure 1). The coal is mainly distributed in the northern Chinese provinces of Xinjiang, Shanxi, Inner Mongolia, Shaanxi, Ningxia, Gansu, Qinghai, Henan, Anhui, Shandong, Liaoning, Jilin, and Heilongjiang. These provinces have serious problems with coal fires including the loss of coal as a valuable resource, environmental pollution, and health problems (Finkelman, 2004; Gielisch H, 2018; Hower et al., 2013; Kuenzer and Stracher, 2012; Kuenzer et al., 2012; Kuenzer et al., 2007; Song and Kuenzer, 2014; Stracher, 2004; Stracher, 2005; Stracher and Taylor, 2004).
Figure 1. The distribution of coal and coal-fire regions in China. Adapted from Guan et al. (1998, p. 7), with permission of J.L. van Genderen.

**Xinjiang**

Xinjiang is a provincial autonomous region in northwest China. It is the largest province in China and has an area of 1.66 million square kilometers, which accounts for one sixth of the total area of China. Xinjiang is located at 34°25' - 48°10' north latitude and 73°40' - 96°18' east longitude. Most of the coal in Xinjiang is Jurassic in age, although there are some Carboniferous and Permian deposits. The earliest record of coal fires in Xinjiang can be traced back to the Pleistocene (de Boe et al., 2001; Zhang et al., 2004).

Four reports about coal fires in Xinjiang were submitted to the Chinese Government in 1981, 2000, 2008, and 2013. The areas of combustion and the amount of coal lost as a consequence are discussed in Song and Kuenzer (2014), Zeng (2012), and Zhang (2008). In 1981, the State Council of China identified 42 coal-fire zones in Xinjiang and five key areas for fire control.
(Zhang, 2008). In 2000, a second coal-fire investigation report about Xinjiang was submitted to the Chinese government. The report indicated that there are 35 coal-fire zones, the total burn area is 8.26 km², and 10 million tons of coal are lost each year because of coal fires (Zeng, 2012).

According to a 2008 Xinjiang Coal Fire Fighting and Engineering Bureau report, 49 firefighting areas exist in the Xinjiang coalfield and 22 of these occurred since 2000. The firefighting area was reported to be 9.061 km², with 8.13 million tons of coal lost to fire each year. This amounts to an economic loss of 1 billion RMB (Zeng, 2012). The forth coal-fire report, completed in 2013, said that there are 47 uncontrolled coal fires in Xinjiang, these occur in an area of 7.0 million km², and the coal lost to fire each year is 4.7 million tons (Cai, 2015).
Figure X1. Lignite coal fire in the Jiangjungebi open pit coalfield, Qitai, Xinjiang. The coal is thought to have been mined during the Tang and Song Dynasties. a) Cracked and collapsed sandstone from the coal fire. The length and width of the crack are 15 m and 1 m, respectively. b) Six meter long crack caused by the coal fire. c) White mineral(s) encrusting the top of gas vents (5-20 cm in diameter) in a coal waste heap. d) A white mineral (possibly mirabilite) nucleated in association with coal-fire gas. Photos by Sherong Hu, 2013.
Figure X2. Products of coal combustion. a) Smoke exhaled from a gas vent in the Dahonggou Colliery, Qitai. The horizontal field of view is 4 m. b) A blue substance mixed with white ash as a consequence of coal combustion in the Bayingou Colliery, Kuitun (Zhang et al., 2016). The area shown here measures 16 by 18 m. Photos by Sherong Hu, 2013.

Figure X3. Coal seam, coal ash, and rock in the Bayingou Colliery, Kuitun (Zhang et al., 2016). Photos by Sherong Hu, 2013.
Figure X4. An underground coal fire in the Daquanhu Colliery, west of Urumqi. a) Pipes were put in the ground and water and grout injected into them for fire control. The length of the road is about 10 m. b) The temperature at the opening of the pipe was 90.2 °C. c) Smoke and water vapor exhaled from a crack that is about 20 m long and 16 m wide. d) Equipment used for firefighting. Photos by Yu Zhang, 2017.
Figure X5. Lignite coal fires in the open pit Shaerhu Colliery, Shanshan. a) Smoke exhaled from coal seams in a 20 by 80 m open pit. b) Coal with a surface temperature of 67 °C. Photos by Yu Zhang, 2017.
Figure X6. Combustion metamorphic rocks. a) Buchite with gas vesicles, found in the Baiyingou Colliery, Kuitun. b) Slag in the Hongshaquan Colliery, Qitai. c) Clinker with the original sandstone texture in the Hongshaquan, Colliery, Qitai. d) Breccia in the Xishan Colliery, Changji. Photos by Sherong Hu (a,b,c), 2013 and Yu Zhang (d), 2017.

Inner Mongolia

Inner Mongolia is another province in China affected by coal fires. These occur in the Dongsheng, Zhuozishan, Wuda, and Gulaben coalfields. Wuda has experienced especially serious fires. It was mined in 1958, and spontaneous combustion occurred there in 1961. In the
early 1990s, Wuda coal seams No. 1, 2, 4, 6, 7, 9, 10, and 12 spontaneously combusted. An investigation of the Wuda coalfield in 2002 revealed 26 coal fires occurring in an area of over 3.07 km². As of 2011, firefighting dramatically reduced the number of coal fires in Wuda.

Figure IM1. An open-pit coal fire in the Maoda Colliery, Ordos, Inner Mongolia. The trench is about 40 m wide. Its extends toward the front of the photo and outside the field of view for a total length of about 80 m. Photo by Sherong Hu, 2011.
In Ningxia, coal-fires encompassing an area of 0.81 km² were extinguished in 1999. They occurred in the following coalfields: Dongfanghong, Xianggendalei, Hongliang, Western Hongliang, Yushugou, Naner, Beiyi, Hongwan, and Rujigou. In Rujigou, twenty-two coal fires in twelve locations were extinguished in 2006 (Zhang, 2008). A firefighting engineering project investigated and extinguished additional coal fires in Ningxia in 2012.

**Figure N1.** Collapsed breccia mixed with combustion metamorphic rocks in the Rujigou coalfield, Ningxia. Photo by Sherong Hu, 2012.
**Figure N2.** An extinguished coal fire in the Rujigou coalfield. Combustion metamorphic rocks (sandstone protolith) are in the foreground. The area shown is about 50 m long and 20 m in height. Photo by Sherong Hu, 2012.

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**Qinghai**

Coal-fires are known to occur in the Datong, Dameigou, Xiaomeigou, and Gaoquan collieries in Qinghai Province. The Datong Colliery was closed by the Chinese government in 2017 (National Coal Mine Safety Administration, 2018). A minor coal fire was found by the first two authors at the bottom of an open pit in Dameigou. At Xiaomeigou, burnt rock was found in the absence of active combustion. At the Gaoquan Colliery, active coal fires were found by the first two authors.
Figure Q1. A coal fire in the bottom of an open pit mine that is about 50 m wide and 30 m deep in the Dameigou Colliery, Haixi, Qinghai. Photo by Sherong Hu, 2014.
Figure Q2. A coal fire in a waste pile in the Gaoquan Colliery, Haixi. The temperature, measured immediately in front of the waste pile with an infrared thermal gun, varied from 500 - 805.7 °C. Photo by Sherong Hu, 2014.
Figure Q3. Burning subbituminous coal being excavated from a coal dump in the Gaoquan Colliery, Haixi. Photo by Sherong Hu, 2014.

Shanxi

According to a Chinese government project in 2014, entitled “Study on Geological Exploration and Control of Spontaneous Combustion of Coal Seams in Shanxi Province,” 167 coal-fire locations were identified in Shanxi. The area burning was 56.59 km². The fires occurred in the Datong, Ningwu, Hedong, Xishan, and Qinshui coalfields. Fires in a 38.21 km² area are extinguished and others are still burning (People's network, 2014).
Figure S1. Coal fire in the Ningwu coalfield, Ningwu, Shanxi. a) A coal fire in a sub-bituminous open pit mine. The trench varies in width from 10 to 15 m and is hundreds of meters long. b) A burning coal seam at the same coal mine as in a). Photos by Yu Zhang, 2017.

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