Background to subsurface ventilation and environmental engineering

1.1 INTRODUCTION

Ventilation is sometimes described as the lifeblood of a mine, the intake airways being arteries that carry oxygen to the working areas and the returns veins that conduct pollutants away to be expelled to the outside atmosphere. Without an effective ventilation system, no underground facility that requires personnel to enter it can operate safely.

The slaughter of men, women and children that took place in the coal mines of Britain during the eighteenth and nineteenth centuries resulted in the theory and art of ventilation becoming the primary mining science. The success of research in this area has produced tremendous improvements in underground environmental conditions. Loss of life attributable to inadequate ventilation is now, thankfully, a relatively infrequent occurrence. Falls of ground rather than ventilation-related factors have become the most common cause of fatalities and injuries in underground mines. Improvements in ventilation have also allowed the productivity of mines to be greatly improved. Neither the very first nor the very latest powered machines could have been introduced underground without an adequate supply of air. Subsurface ventilation engineers are caught up in a continuing cycle. Their work allows rock to be broken in ever larger quantities and at greater depths. This, in turn, produces more dust, gases and heat, resulting in a demand for yet better environmental control.

This opening chapter takes a necessarily cursory look at the long history of mine ventilation and discusses the interactions between ventilation and the other systems that, jointly, comprise a complete mine or underground facility.

1.2 A BRIEF HISTORY OF MINE VENTILATION

Observations of the movements of air in underground passages have a long and fascinating history. Between 4000 and 1200 BC, European miners dug tunnels into...
chalk deposits searching for flint. Archaeological investigations at Grimes Graves in the south of England have shown that these early flint miners built brushwood fires at the working faces—presumably to weaken the rock. However, those Neolithic miners could hardly have failed to observe the currents of air induced by the fire. Indeed, the ability of fire to promote airflow was rediscovered by the Greeks, the Romans, in medieval Europe and during the Industrial Revolution in Britain.

The Laurium silver mines of Greece, operating in 600 BC, have layouts which reveal that the Greek miners were conscious of the need for a connected ventilating circuit. At least two airways served each major section of the mine and there is evidence that divided shafts were used to provide separate air intake and return connections to the surface. Underground mines of the Roman Empire often had twin shafts, and Pliny (AD 23–79) describes how slaves used palm fronds to waft air along tunnels.

Although metal mines were worked in Europe during the first 1500 years anno Domini, there remain few documented descriptions of their operations. The first great textbook on mining was written in Latin by Georgius Agricola, a physician in a thriving iron ore mining and smelting community of Bohemia in Central Europe. Agricola’s *De Re Metallica*, produced in 1556, is profusely illustrated. A number of the prints show ventilating methods that include diverting surface winds into the mouths of shafts, wooden centrifugal fans powered by men and horses, bellows for auxiliary ventilation and air doors. An example of one of Agricola’s prints is reproduced in Fig. 1.1.

Agricola was also well aware of the dangers of ‘blackdamp’, air that has suffered from a reduction in oxygen content—‘miners are sometimes killed by the pestilential air that they breathe’—and of the explosive power of ‘firedamp’, a mixture of methane and air—‘likened to the fiery blast of a dragon’s breath’. *De Re Metallica* was translated into English in 1912 by Herbert C. Hoover and his wife, Lou. Hoover was a young American mining engineer who graduated from Stanford University and subsequently served as President of the United States during the term 1929–1933.

From the seventeenth century onwards, papers began to be presented to the Royal Society of the United Kingdom on the explosive and poisonous nature of mine atmospheres. The Industrial Revolution brought a rapid increase in the demand for coal. Conditions in many coal mines were quite horrific for the men, women, and children who were employed in them during the eighteenth and nineteenth centuries. Ventilation was induced either by purely natural effects, stagnating when air temperatures on the surface and underground were near equal, or by fire. The first ventilating furnaces of that era were built on surface but it was soon realized that burning coals suspended in a wire basket within the upcast shaft gave improved ventilation. Furthermore, the lower the basket, the better the effect. This quickly led to the construction of shaft bottom furnaces.

The only form of illumination until the early nineteenth century was the candle.

**Figure 1.1** A print from Agricola’s *De Re Metallica*. (Reproduced by permission of Dover Publications.)