3 Rock mass structure and characterisation

3.1 Introduction

Rock differs from most other engineering materials in that it contains fractures of one type or another which render its structure discontinuous. Thus a clear distinction must be made between the rock element or rock material on the one hand and the rock mass on the other. **Rock material** is the term used to describe the intact rock between discontinuities; it might be represented by a hand specimen or piece of drill core examined in the laboratory. The **rock mass** is the total *in situ* medium containing bedding planes, faults, joints, folds and other structural features. Rock masses are discontinuous and often have heterogeneous and anisotropic engineering properties.

The nature and distribution of structural features within the rock mass is known as the **rock structure**. Obviously, rock structure can have a dominant effect on the response of a rock mass to mining operations. It can influence the choice of a mining method and the design of mining layouts because it can control stable excavation spans, support requirements, subsidence, cavability and fragmentation characteristics. At shallow depths and in de-stressed areas, structurally controlled failures may be the prime concern in excavation design (Figure 3.1). At depth and in areas of

![Figure 3.1 Sidewall failure in a mine haulage aligned parallel to the line of intersection of two major discontinuities (photograph by E. Hoek).](image)
high stress concentration, the influence of structure may be less marked, and limiting the induced boundary stresses or energy release rates may be more important considerations (Chapters 7 and 10).

This chapter describes the types and important properties of structural features found in rock masses, methods of collecting, processing and presenting data on rock structure, and the incorporation of such data into rock mass classification schemes. The uses of these data and rock mass classifications in selecting mining methods and designing excavations will be described in subsequent chapters.

3.2 Major types of structural features

Structural features and their origins are well described in several textbooks on general, structural and engineering geology. From an engineer’s point of view, the accounts given by Hills (1972), Hobbs et al. (1976), Blyth and de Freitas (1984), Price and Cosgrove (1990) and Goodman (1993) are particularly helpful. The reader who is not familiar with the elements of structural geology should study one of these texts. All that will be given here is a catalogue of the major types of structural feature and brief descriptions of their key engineering properties.

**Bedding planes** divide sedimentary rocks into beds or strata. They represent interruptions in the course of deposition of the rock mass. Bedding planes are generally highly persistent features, although sediments laid down rapidly from heavily laden wind or water currents may contain cross or discordant bedding. Bedding planes may contain parting material of different grain size from the sediments forming the rock mass, or may have been partially healed by low-order metamorphism. In either of these two cases, there would be some ‘cohesion’ between the beds; otherwise, shear resistance on bedding planes would be purely frictional. Arising from the depositional process, there may be a preferred orientation of particles in the rock, giving rise to planes of weakness parallel to the bedding.

**Folds** are structures in which the attitudes of the beds are changed by flexure resulting from the application of post-depositional tectonic forces. They may be major structures on the scale of a mine or mining district or they may be on a smaller local scale. Folds are classified according to their geometry and method of formation (Hills, 1972, for example).

The major effects of folds are that they alter the orientations of beds locally, and that certain other structural features are associated with them. In particular, well-defined sets of joints may be formed in the crest or trough and in the limbs of a fold. Figure 3.2 shows the typical development of jointing in one stratum in an anticline. During the folding of sedimentary rocks, shear stresses are set up between the beds where slip may occur. Consequently, the bedding plane shear strength may approach, or be reduced to, the residual (section 4.7.2). Axial-plane or fracture cleavage may also develop as a series of closely spaced parallel fractures resulting from the shear stresses associated with folding.

**Faults** are fractures on which identifiable shear displacement has taken place. They may be recognised by the relative displacement of the rock on opposite sides of the fault plane. The sense of this displacement is often used to classify faults (Hills, 1972, for example). Faults may be pervasive features which traverse a mining area or they may be of relatively limited local extent on the scale of metres; they often occur in