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Geomechanical characterisation of fault rocks in tunnelling: The Brenner Base Tunnel (Northern Italy)

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ABSTRACT

The goal of this study is to characterise the rock faults involved in the excavation works of the Brenner Base Tunnel, which crosses one of the main tectonic alignments of the alpine area, the Periadriatic fault. The characterisation was carried out at different scales from macro (through drillings and geomechanical surveys) to meso (lab tests on specimens) and micro-scale (through thin sections), in order to find a correlation between the different scales properties of the rock masses. Finally, a relation between the voids ratio at the micro-scale and the fault rocks conditions at the meso and macro-scale was pointed out. As a result, by means of the Hoek–Brown method, an estimation of the fault rock strength was achieved, tending to avoid quite a typical overestimation arising from the use of literature values.

1. Introduction

The increasing demand of underground infrastructure means that over the last decades tunnels have been built in more and more difficult geological conditions. In particular, in the alpine area they often have to be constructed in highly tectonically deformed rocks, bearing important cataclastic fault zones. The main challenges to be faced when an underground excavation crosses fault rocks are: very short stand-up time, face instabilities, high radial convergences and potential squeezing, especially if stresses and/or water inflows are high.

Obviously, to enable a rigorous design of deep alpine tunnels, it is essential to achieve a proper knowledge concerning the geomechanical properties of these fault rocks. Yet, the mechanical behaviour of fault rocks is hard to characterise because of the many difficulties arising in getting undisturbed samples during field investigations, in specimen preparation, and in performing appropriate laboratory testing. Therefore, the mechanical behaviour of such rocks is still not entirely understood, even if they influence directly the excavation method (Süleyman, 2003), the safety of the working site, the choice of tunnel support (Mete and Turgay, 2013), their long-term behaviour and the final cost of the infrastructure. Consequently, it is a preeminent interest of designers to take into account the occurrence and properties of these fault rocks at a very early stage of the underground construction.

The engineering practice for tunnel design has widely applied the Hoek and Brown's failure criterion (Hoek et al., 2002) to describe the behaviour of fractured rock masses. This method allows an estimate of the strength of jointed rock masses, based on an assessment of the interlocking of rock blocks and the condition of the surfaces among these blocks. The main input parameters of this method are: the Geological Strength Index (GSI), arising from the geological–technical survey of the rock mass; the uniaxial compressive strength (σ_{ci}), obtained by lab tests on hand-specimens of intact rock, and the intact rock material constant (m_i), depending on the rock type and its texture. As it is quite evident, the assessment of these parameters involves the characterisation of the rock mass at different scales, from macro to meso and micro-scale. This is especially true in the presence of fault rocks, because of their great variability of behaviour near and far from the fault core.

For the micro-scale characterisation, in the present paper, thin sections of fault rocks will be analysed in order to find a correlation between microscopic characteristics and rock strength, and therefore to assess the intact rock constant m_i, which is nowadays the most difficult parameter to be estimated in the Hoek–Brown method. Previous studies showed that thin sections can give information useful in quantifying the degree of alteration by means of

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the ratio of neoformation minerals, which in turn can be put in relation to the m_i value (Gattinoni and Scesi, 2003).

Thin sections will now be processed to find out the voids in the microstructure of the rock; these voids will be characterised in terms of their percentage, shape and distribution, and they will be put in relation to the main meso and macro-scale features of the rock mass (i.e. fracturing degree and compressive strength). Previous studies on similar data showed a positive correlation between the porosity at the microscale and the geomechanical strength of a hand specimen (Gattinoni et al., 2014). The main goal of the present study is to define a method for the characterisation of rock masses useful for design purposes in fault areas, especially concerning the assessment of the parameters involved in the Hoek & Brown criterion.

The proposed method for fault rocks characterisation will be applied to a case study: the pilot tunnel of the Brenner Base Tunnel in the stretch where it crosses the Periadriatic fault, which is one of the main tectonic alignments of the alpine area (Fig. 1).

2. State of the art on fault rocks characterisation

Fault rocks are typically weak rocks, which means that they are characterised by a compressive strength ranging from 2 to 20 MPa

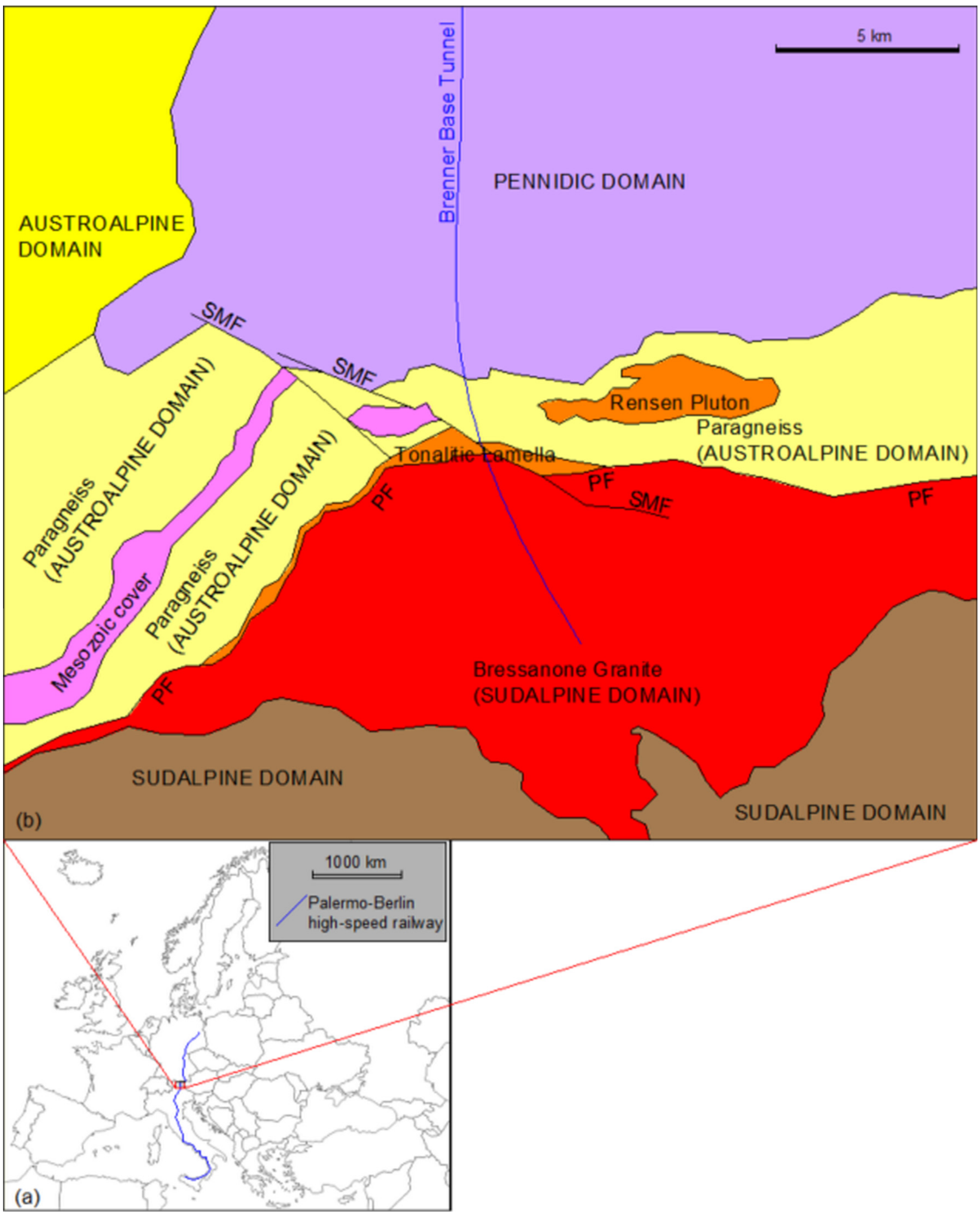

Fig. 1. (a) Location of the study area; (b) geologic and tectonic setting.