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Petrography of roofing slates

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ABSTRACT

Roofing slate is one of the world's most popular dimension rock products. This special type of slate can be split into regular and thin tiles forming an exceptional covering material. Many historical heritage buildings along Europe use slate covers. Although slate has been quarried worldwide for centuries, in the second half of the past century the production of roofing slate increased hugely, especially in Europe, where the largest outcrops known to date are located.

Despite its importance as a construction material, roofing slate has not been the target of a proportional number of scientific publications, as compared to other materials such as granite, sandstone, marble or limestone. This could be due to the general perception that roofing slate is a rather simple rock with a relatively unvarying mineralogy consisting of quartz, chlorites and mica, and having a monotonous structure dominated by the slaty cleavage and various fracture planes.

This paper deals with the main features of the roofing slate industry, i.e. petrological and mineralogical characterization, and their application on slate production, as well as additional phenomena and significant factors affecting quality which are rarely considered, such as weathering and durability.

Contents

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1. Introduction

The group of stone products referred to as roofing slate is a popular construction material that is widely used worldwide, both in modern architecture and in historical buildings. Most of the rocks used for roofing belong to the low-grade metamorphism of the green schist facies (Arkai et al., 2007) with a well-defined slaty cleavage and high fissility. These characteristics facilitate the slate split into thin and regular tiles used for roofs and façades, as well as for flooring and paving. The technological requirements for construction materials in the European Community (EC) are defined in the European Norm (EN) for roofing slate EN 12326 (Blanchard and Sims, 2007), whereas for the United States they are defined in the standards of the American Society for Testing and Materials (ASTM) C 120–90, C 121–90, C 217–94 and C 406–00 (Hicks, 2008). The ultimate goal of each normalised test is to give a prediction of the service life of a slate tile (Walsh, 2002).

1.1. Brief history of roofing slate mining

Mankind has used slate for construction since the very beginning of architecture. From the point of view of construction, slate is a rock that can be split into continuous tiles and slabs, which are naturally standardised construction materials. Some of the first evidences of slate in constructions (Bendala, 1990) and other uses (Cordero and Martin, 2012) are found during the Neolithic in the Iberian Peninsula. The Romans also used slates as constructing material (McWhirr, 1988; De Clercq, 2011). Slate was used for roofing, walls and flooring, but also as grinding stone or millstone—in short, for almost everything. During the following centuries, slate was mainly used as a building material in areas within just a few kilometres of an outcrop, until the 18th and 19th centuries, when slate mining appeared on a large scale in Western and Central Europe (Fig. 1) and in the United States. However, the golden age of slate mining did not begin until the second half of the 20th century, with the mechanisation of the production processes.

There were two important developments that changed the slate market. The first was that Spain began to produce large amounts of rather cheap high-quality slate, breaking into the market and forcing many quarries across Europe to close (García-Guinea et al., 1997). Nowadays there are still a few quarries in some of these countries which continue to produce slates with an extra value, used for the restoration of historical heritage or in unique new buildings (Hunt, 2006). The second was the introduction of diamond wire technology in the quarrying process. Before this, slate blocks were extracted with explosives, causing extensive fracturing and reducing the volume of usable slate. With the introduction of diamond wire cutting, large blocks could suddenly be extracted cleanly, without damage. This method, together with improvements in borehole technology, brought with it an unexpected advantage: for the first time, the relationships between the main structures in slate (sedimentation S_0 and slaty cleavage S_1) were clearly visible. This was a great help for geologists, who could now better understand the local and regional structure of the outcrops. The slate market subsequently boomed until the global economic crisis of 2008.

At present, many European quarries, most of them in Spain, are facing closure. The world's slate production is being displaced to emerging countries like Brazil, China, India and Vietnam. Other countries, such as the Russian Federation, have an unexplored potential for slate outcrops. Russian exportations of slate went from 15 T in 2008 to 676 T in 2011, still very far from the production level of the leading countries, but a sign that the Russian slate industry is clearly growing.

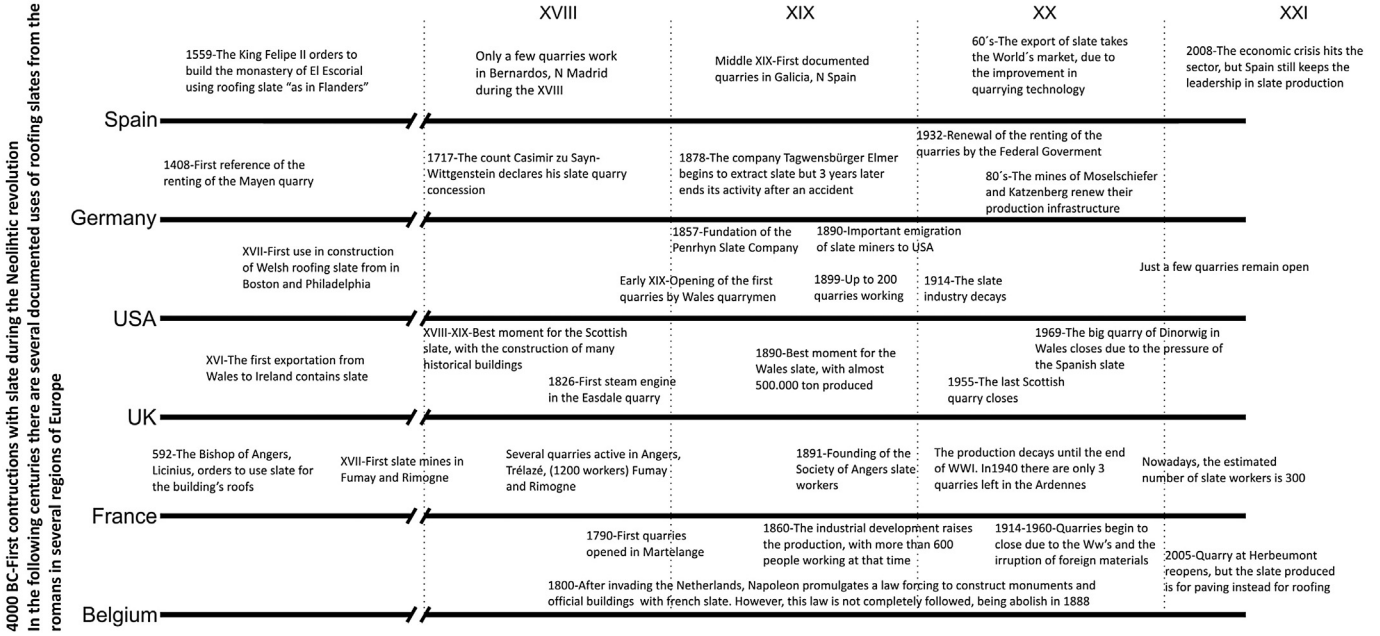

Fig. 1. Timeline of the history of roofing slate mining in the most representative countries.

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