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Selected quaternary building stones (spring tufas, breccias) in western Austria – quarries, use and petrophysical properties

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In the inner Alpine region, the walls of many historical buildings such as churches, castles and monasteries are murated of natural stone that, in most cases, was derived from the local environs.

In Western Austria, at many locations, the Quaternary system provides building materials such as lithic breccias of alluvial fans and talus slopes, or calcareous spring tufas. These rock types are easily workable, and even small occurences had been quarried for local use mainly in architectural and ornamental elements, in particular for columns, cornices and pilasters. Some of the building stones attained regional distribution, like the spring tufa from Thiersee or the Höttinger Brekzie near Innsbruck, the latter an interglacial succession that accumulated from alluvial fans and talus slopes. During Roman times, spring tufa had been used as corner stone in settlements (Aguntum/Eastern Tyrol, Roman villa Rankweil/Vorarlberg). In the Middle Ages calcareous tufa was used for the masonry of castles and churches (e.g. St. Martin near Ludesch/ Vorarlberg; ruin Kropfsburg/Northern Tyrol, Neuburg/Vorarlberg). During the past few centuries, tufa was quarried for purpose of both construction and ornamention in churches (e.g. Stiftskirche Wilten/Northern Tyrol).

Advantages of spring tufa as a building stone include that it is easy to quarry, is lightweight, can easily be handled and, most strikingly, is obviously highly resistant to physical weathering (frost cracking). The Höttinger Brekzie, in turn, has been quarried in two larger and several smaller quarries near Innsbruck, Northern Tyrol, until the

beginning of the 20^{th} century. A major portion of the old towns of Innsbruck and Hall in Tyrol are built of this decorativ type of stone.

The goal of our study was to locate and sample abandoned quarries, and to document use and change, over time, of their materials within buildings. For purposes of conservation, restaurators often have a vital interest in re-locating abandoned quarries.

A striking observstion is that despite hundreds of years of exposure to weathering, damage by physical weathering is very limited to absent. This holds for both spring tufas and Höttinger Brekzie. Where Höttinger Brekzie, however, is used for horizontal building elements, such that standing water may freeze, however, it is subject within a few years to severe damage by frost cracking; such a faulty application of this building stone is observed in a modern construction about 15 few years in age.

In the Alpine region, the main destructive mechanism affecting buildings of natural stone is cycles of wetting-drying and of freeze-thaw.

To better understand the physical weathering of spring tufas and Höttinger Brekzie, we determined the petrophysical properties of these rock types, including mineralogical composition and fabric of the materials, porosity measurements by BET and Hg-porosimetry, water uptake, drying behaviour, and behaviour under freeze-thaw cycles.

These stone types show outstanding petrophysical properties: while the Höttinger Brekzie shows an average porosity of about 15 % and a capillary water uptake coefficient (A coeff.) of about 1.7 kg/m^2*h$^{0.5}$, porosities of 50 % can often be documented for spring tufas, their A coefficient can easily reach 20 kg/m^2*h$^{0.5}$and more.