Weathering of the lime sandstone used for building the farmhouse in Strtenica (Slovenia)

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The farmhouse in Strtenica, situated in the eastern part of Slovenia (Fig. 1), represents an important piece of cultural heritage. The seven stone buildings (Fig. 2) are unique in Slovenia, above all because of the sandstone, which is the prevalent type of building stone in this part of Slovenia. Buildings made from sandstone are mostly weathered after 170 years. The farmhouse is a typical example of Slovenian vernacular architecture from the nineteenth century.

Indigenous stones are needed for restoration work on weathered sandstone buildings. The original quarry of the Middle Miocene lime sandstone used is situated in the vicinity of the farmhouse.

Investigations were made by systematically mapping damaged objects (Fitzner *et al.*, 1992). The mineralogical composition and structure were determined by X-ray diffraction, SEM and optical microscopy. Particular changes in the mineralogical composition were found, starting on the surface and going into deeper parts of particular object in the damaged pieces of sandstone. The chemical composition of stone was determined at different distances from the surface, depending on the intensity of damage.

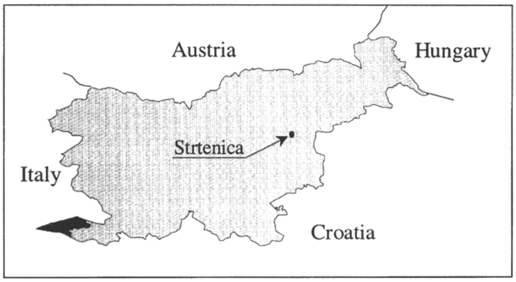

FIG. 1. Map of Slovenia, with the position of Strtenica indicated.

FIG. 2. View of the farmhouse in Strtenica.

Results and discussion

Lime sandstone is a grey-yellow coloured rock. The colour changes to brown-yellow according to atmospheric conditions and is thick-bedded. This is the reason why, in the most cases, it was built in parallel with the direction of the layers.

Lime sandstone is homogene rock made up of 75% particles, 15% cement and 10% pores. The allochem component, as well as fossil particles, intraclasts and glauconite prevails (50%); there are 25% terrigenous particles, represented by quartz, lithic particles, muscovite and feldspars (K-feldspars, plagioclase). Orthochemical components are represented by lime cement and pyrite (15%).

The pillar of stairs (Fig. 3) is used as the representative case of weathering. The pillar is built in such a way that its longer axis runs parallel with the direction of the layer. The crustation of layers is seen as the consequence of such a position. A 1-cm-thick layer of sandstone is weathered in the upper part of the pillar. Weathering continues with the appearance of relief with thin crusts. Weathering is most expressed in the lower part of the pillar as stone bursting, because of the crystallisation of gypsum.

Quartz, calcite, muscovite K-feldspar, plagioclase and gyps are found at the surface. Quartz, calcite, muscovite, and K- feldspar can be detected at a depth of 10 cm. The selective leaching of calcite (Fig. 4)

FIG. 3. Damaged stair pillar from the house used as the inn.

and crystallization of gypsum are seen at the surface.

Leached calcite reacts with the pyrite and crystallises in gyps. Crystals of gyps are seen in Fig. 5.

The leaching of feldspar is seen in Fig. 6.

The chemical composition of the pillar changes, depending on the distance from the surface. Changes can be seen in Table 1. Changes in chemical composition coincide with different mineral composition depending on the distance from the surface of the damaged pillar. Leaching of SiO_2 and Al_2O_3 and

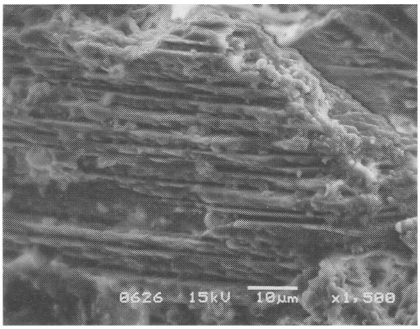

FIG. 4. The leaching of calcite crystal is seen as the lamellar surface of calcite crystal.

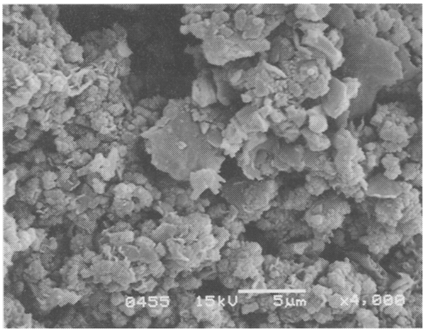

FIG. 5. Crystals of gypsum, SEM.

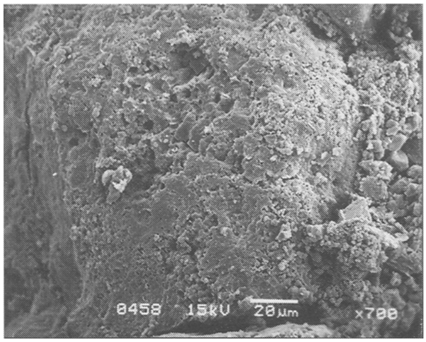

FIG. 6. Leached surface of feldspar.

TABLE 1. Chemical composition of the damaged stone pillar at a different distance (in cm) from the stone surface in wt.%

Distance	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	LOI
0 cm	24.60	2.56	1.71	0.70	35.10	34.0
3 cm	14.90	1.59	1.06	0.57	44.21	37.2
6 cm	39.96	3.61	1.87	0.58	26.86	24.8
10 cm	35.20	3.24	1.73	0.56	29.94	28.0
Original	46.33	3.88	1.71	0.48	24.23	21.3

enriching of MgO and CaO are seen at the surface because of gyps crystallisation near the surface of the pillar.

The substitution of the damaged parts of sandstone objects with original sandstone from the stone quarry in the vicinity of the farmhouse is suggested. Painting, similar to methods used in the past, should be used as the protection.