NATURSTEIN – LABOR

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Examination report on SAPI – low pressure – cleaning of natural stones by means of vortex stream technique.

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Preliminary notes

Buildings and components made of stone show over the years/decades according to material and exposition always a more or less heavy pollution of the surfaces.
This pollution, often also referred to as „patina“, can be a thin surface coating but also a millimetre thick hard surface crust.
Depending on the situation, these contaminations have different causes and constitutions:

- Deposits of dust, soot
- Emissions out of the air
- Microbiological mucus
- Natural cover of moss and lichen
- Sinter formation through leaching of the construction material
- Crust formation through the combination of the individual, mentioned above, parameters.

The complex composition of such contaminations and crust formations can only be resolved by appropriate scientific examination.

Examinations

In addition to a macroscopic/microscopic expertise of the contaminations and respectively crust formations at the property at least the following examinations have to be executed:

- Salt/mineral analyses by means of x-ray diffractometry (XRD-diagram)
- Quantitative analyses by means of spectro-photometry
- Testing of the water intake of the natural stone surfaces before and after the cleaning.

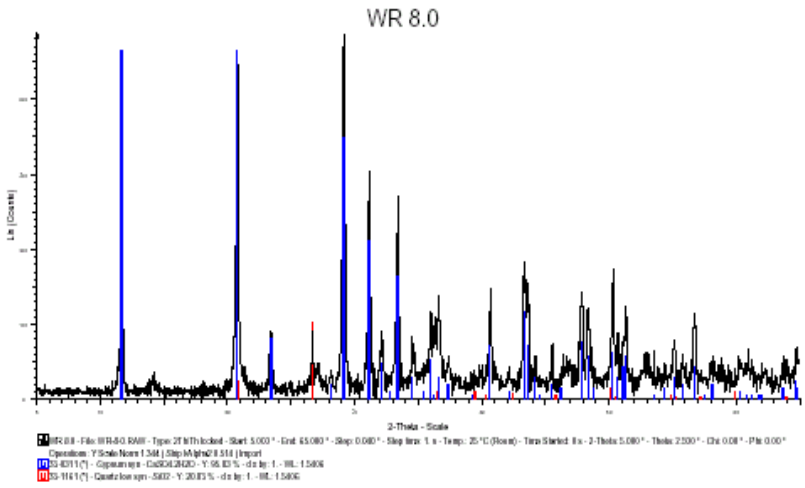


Fig. 1 XRD-diagram of a gypsum crust

Tab. 1 Wet chemical spectral analysis
(indication in %)

Sample No.	Cl	NO_3	SO_4	NH_4	pH
KS. 5	0,25	0,87	6,46	0,002	6,5

This wet chemical quantitative spectral analysis shows that in this case besides calcium sulphate (gypsum) salts also can be contained in surface crusts that are below the limit of the XRD-detection!

These are only two examples of the conducted examinations.
According to object and problem situation, it has to be decided if even more detailed examinations, for example with the scanning electron microscope (SEM/EDX), are necessary.

Cleaning

The surface pollution/crust formations on the masonry surface have in the rarest cases the protecting character of „real patina“!

In most cases they are the cause for damages or favour even consequential damages.

Sometimes crust formations seem to provide an efficient surface protection (?), but already small cracks provoke a consolidated destruction of the structure of the stones underneath.

Therefore, in case of renovation- and restoration tasks, always a corresponding cleaning has to be done.

This has to be carried out, adapted to the object, as gentle as possible so that the original building fabric is not affected or even endangered.

On this account the low pressure vortex stream method and the corresponding nozzles have been developed.

In the past years these nozzles have been continuously improved
⇨ Vario--vortex-stream nozzles

Brief description of the „Vario“ low pressure vortex stream cleaning technique“

The „Vario“ low pressure vortex stream cleaning technique“ is a modified low pressure mild blasting technique for object- and substance conserving cleaning of historical and delicate objects and surfaces, basing on a especially developed „Vario“ low pressure vortex nozzle technique.

The low-pressure blasting unit method can be adjusted exactly to the corresponding cleaning demand, for example air pressure, granulate amount and kind of “Vario”-nozzles.

By means of the new „Vario“ low pressure vortex stream nozzle technique exceptionally material conserving cleaning results can be obtained.

The fundamental part of the vortex blasting nozzle is a fixed vortex body with 4 coaxial boreholes.
The pressure air stream is conducted through the 4 inclined boreholes in an angle of 15^0 degrees through the vortex body whereby the linear pressure air stream is transformed into a highly rotating pressure air stream.
A venturi nozzle head that is connected immediately at the vortex stream body accelerates the pressure air stream through its conic narrowing flow channel and produces, when leaving the nozzle port, a cone - like highly rotating cleaning stream.

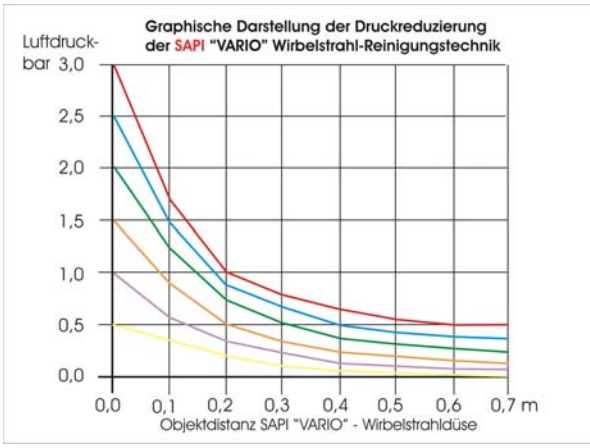
By means of the transmission of the kinetic energy from linear into rotating pressure air current the air pressure is reduced almost proportionally to the square. This means that a pressure air stream of 3 bar is reduced when leaving the vortex stream nozzle at a distance of approx. 40 cm to 0,5 bar.

This effects that small blasting particles impinge at an extremely low pressure on the surface and glide by means of the rotating movement of the pressure air stream in a very flat angle, smoothly grinding or erasing, tangentially over the surface to be cleaned and thus guarantee a highly conserving degradation of the contamination respectively the incrustation and the original surface structure remains.

The intensity of the degradation of the contaminations respectively the incrustations can be operated extremely well by means of the corresponding cleaning substrate varieties and the corresponding grain size.

Graphical demonstration:
Low-pressure vortex stream cleaning technique

Air pressure graphical demonstration of the pressure reduction of the SAPI
bar 3,0 “Vario” vortex stream cleaning technique



object distance SAPI “Vario” vortex stream nozzle

Test cleaning

Primarily to a cleaning, test areas should respectively have to be created.

Only by means of corresponding cleaning tests on the object, the necessary parameters for the respective rock, surface, as well as kind and degree of contamination can be detected.:

- Cleaning dry or wet
- Pressure
- Kind and size of the nozzle
- Kind of blasting material

Natural stones but also the born crusts show by means of their mineralogical composition a different hardness.
Exactly therefore the blasting material, according the Mohs' grade and the grain size, has to be adequately chosen to obtain a cleaning as gentle as possible.

Data sheet: blasting material for the cleaning

Mineral name	Formula	Mohs' grade	gross density in g/cm^3
Calcite	$CaCO_3$	3	2,7
Dolomit	$CaMg(Co_3)_2$	3,5 - 4	2,85 - 2,95
Glass/slag i.e. window glass	$Na_2O\ CaO\ 6\ SiO_2$ *	approx. 5	> 2,2
Quartz	SiO_2	7	2,65
Granate/Almandin	$Fe_3Al_2(SiO_4)_3$	6,5 - 7,5	approx. 4,2
Olivin/Peridot	$(Mg,Fe)_2(SiO_4)$	6,5 - 7	approx. 3,4
Corundum	Al_2O_3	9	3,9 - 4,1

* also $K_2O\ \ CaO\ \ 8\ SiO_2$
as well as other additives whereby the gross density can amount distinctively!

Application to the object

During the last years I have accompanied scientifically the most various objects with a corresponding survey, cleaning and restoration tasks.

As an example here is only singled out the gothic capital sacristy at the cathedral in Eichstätt. (further objects, see list in the attachment)

The two-storied capital registry was attached between 1460-80 by Roritzer, the cathedral master builder of the Regensburg cathedral, to the gothic cathedral of Eichstätt with its romanesque pre-constructions.

The capital sacristry is built of fine-grained dense jurassic limestone ("jurassic-marble").
With this very fine-grained limestone it was possible to produce respectively carve out of the limestone extremely delicate adorning elements, such as Wimperg with *crabs* and pinnacles with *milkworts*.

Former the limestone surfaces were framed with lime sludge (in terms of colour?).
In the course of time again and again damaged spots were touched up or replenished with corresponding crossings.
During the last extensive restoration (1962/63?) the supplements were made of "stone substitute mass" containing cement as well as the whole capital registry was provided with a brownish-grey coat of paint.
In the meantime, this paintwork is again extensively worn.

At the moment of the expertise, the surfaces of this object were generally very intensely contaminated, that is to say, the pale limestone was "black" (!) and partially covered with a thin sinter crust (see photo documentation in the attachment)

These black gypsum crusts (see fig. 1 XRD-diagram) but also contained considerable concentrations of chloride- and nitrate salts. (see tab 1)

Partially, the surfaces, especially in the upper areas and the roofage, were overgrown extensively with lichen and moss.

To prevent further damages and to be able to carry out appropriate restoration procedures, thus a general and gentle cleaning was urgently necessary.

Therefore different test areas were carry out at a column and at the small delicate construction adorning elements, to identify the appropriate parameters regarding the blasting material and the pressure.

The best results were obtained here with the Vario low pressure vortex stream technique and calcite respectively stone powder as blasting medium.

It was agreed upon with the obligee, that also during the cleaning procedures, the defined parameters had to be controlled again and again.

In the attachment a small photo documentation is assembled to show the capital registry before and after the successful cleaning.
Especially with the delicate adorning parts the extremely gentle cleaning with the "Vario" vortex stream technique could be demonstrated.

Final remark

The “Vario” vortex stream technique is especially qualified for a material conserving removal of various contaminations/encrustings, as well as discolourations on sand- and limestone, brick, terracotta etc.

Material conserving removal of hard encrustings on weathered stone surfaces.

The desired degree of cleaning, that means the removal of contaminations and encrustings can be adjusted individually to the object.

If necessary and desired also the conservation of old paint covers and “patina” is possible.

A cleaning can be carried out dry or wet, that means with only 10 – 30 l water per hour.

The “Vario” vortex stream technique offers another good application possibility for the removal of soot condensation after fires.

Note:

As a matter of principle it is always recommendable to create test areas at the respective object to determine the corresponding parameters concerning blasting material, pressure etc.

The sample areas at the object shall also serve as a rule as reference areas for the performing specialised company to guarantee the quality of the cleaning.

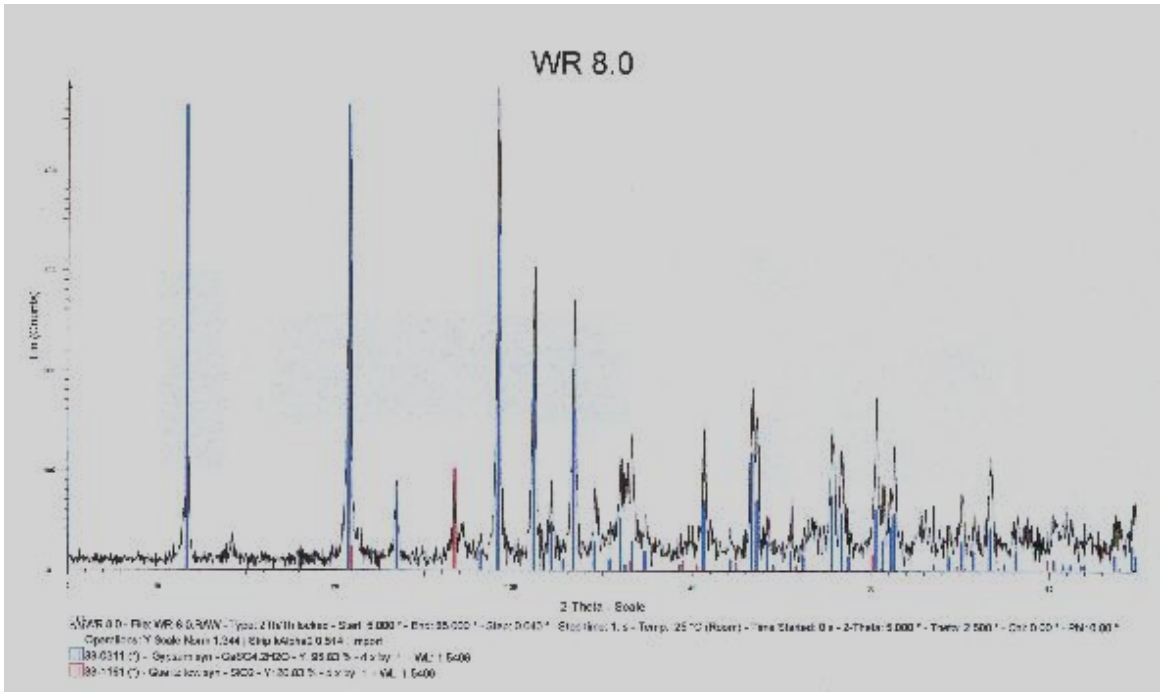
The SAPI “Vario” low pressure vortex stream cleaning technique is one of the most gentle cleaning methods for stone, brick and other mineral building material.

Munich, 07.04.2004

Dr. W. Schneider

Attachment

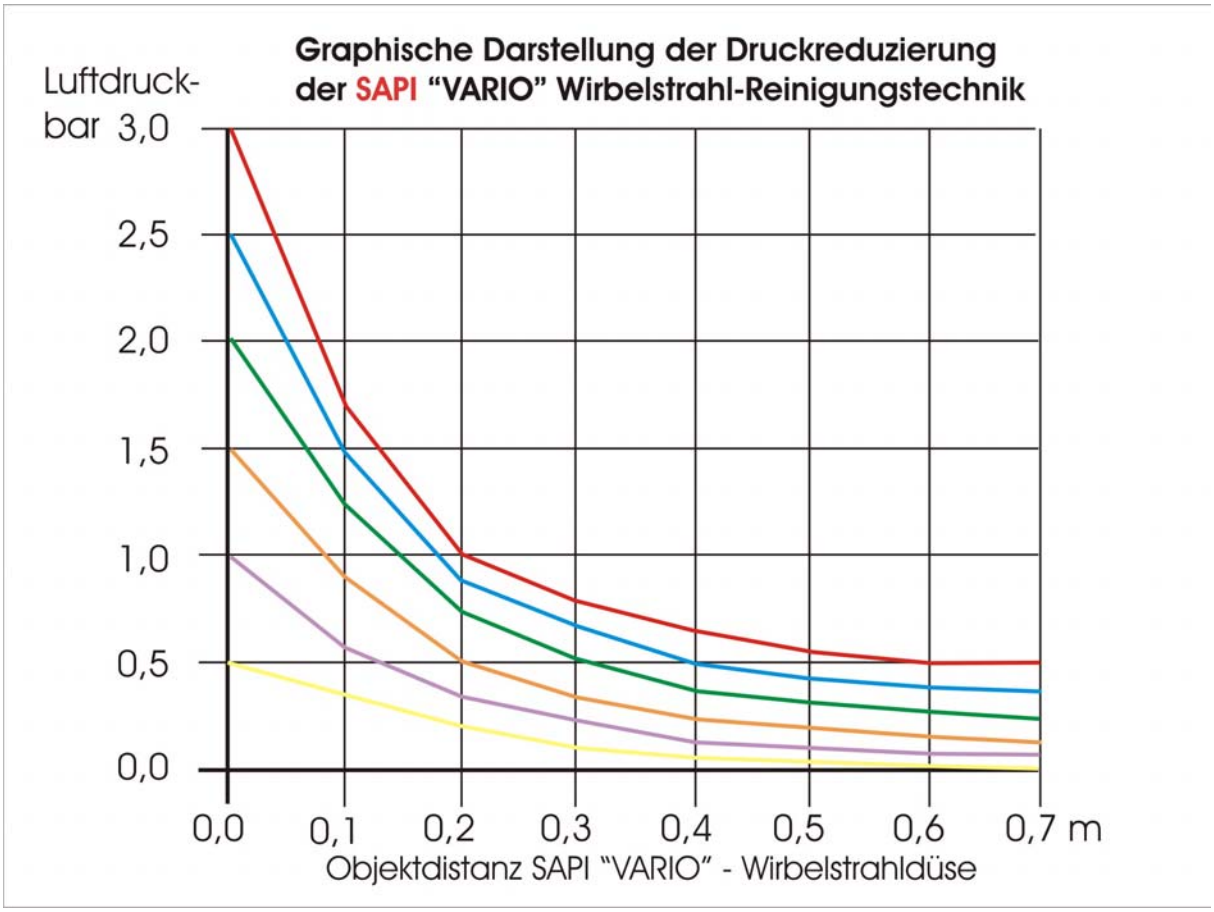
- XRD - diagram of a gypsum crust
- Graphical demonstration of the pressure reduction with the „Vario“ vortex stream
- Photo documentation
- Reference list



XRD-diagram of a gypsum crust

Air pressure
Bar 3,0

Graphical demonstration of the pressure reduction
of the SAPI “Vario” vortex stream cleaning technique

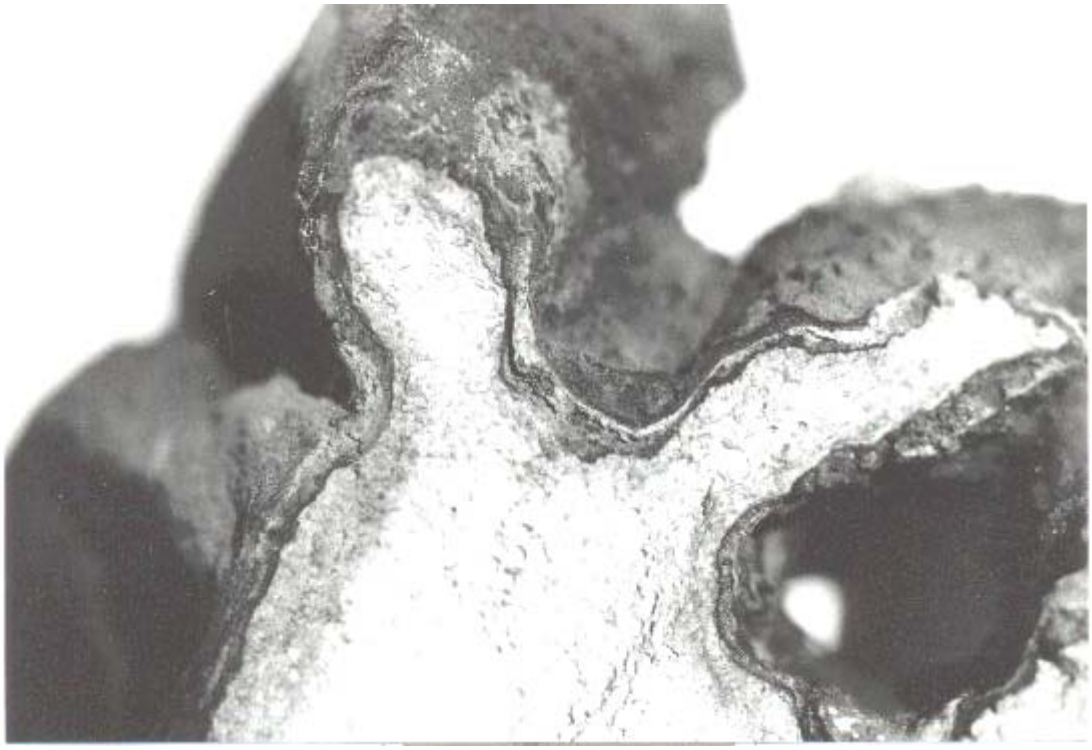


Object distance SAPI “Vario” vortex stream nozzle

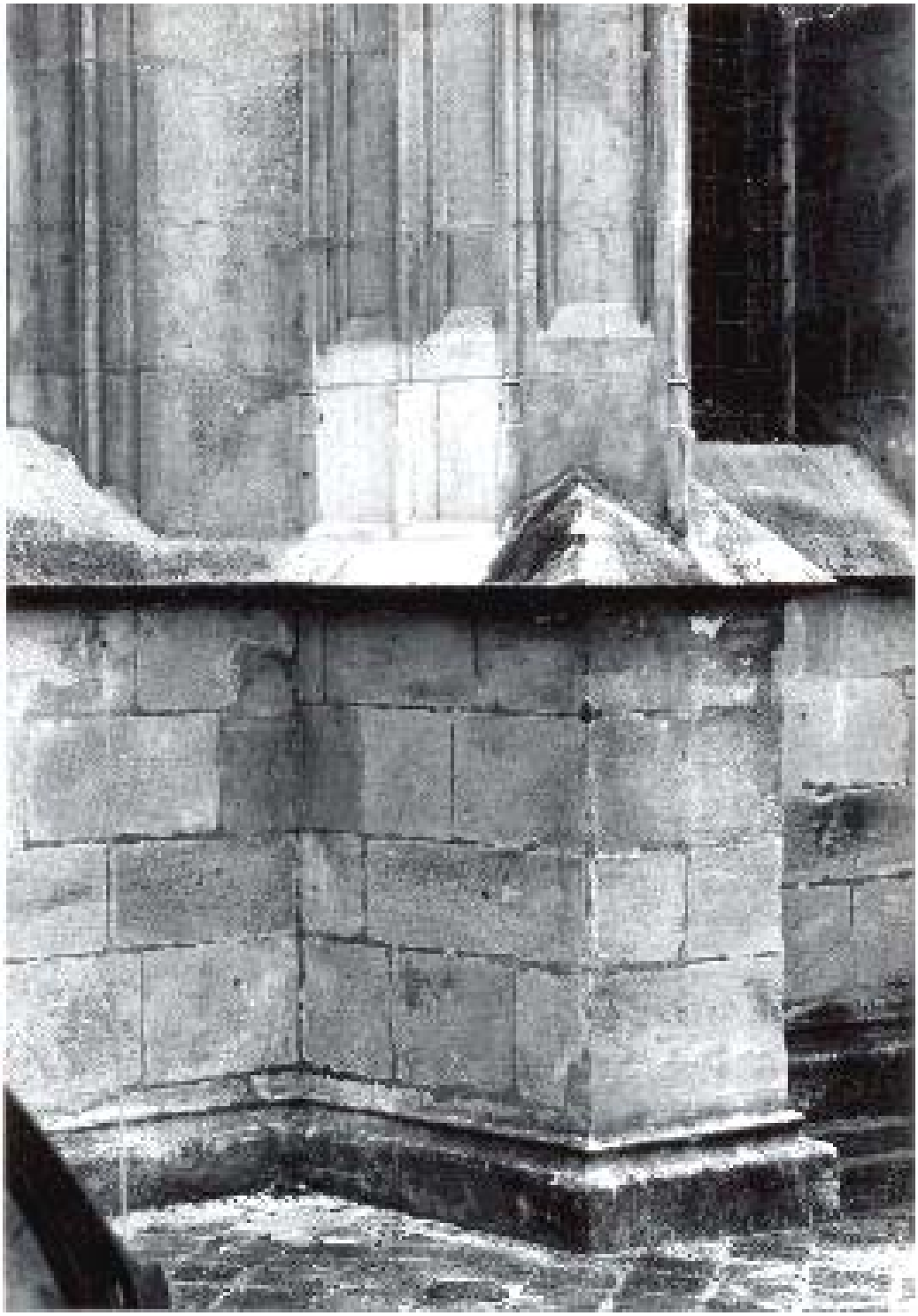
By means of the transmission of the kinetic energy in the inside of the “Vario” vortex stream nozzle from linear into rotating pressure air flow, the air pressure is reduced almost proportionally to the square. This means that a pressure air stream of 3 bar is reduced when leaving the vortex nozzle at a distance of approx. 50 cm to 0,5 bar. The fine cleaning particles are lead in a very flat angle tangentially over the surface to be cleaned and thus provoke a very fine abrasive cleaning effect whereby the textures of the stone surfaces are not being damaged.

F 1 Cathedral Eichstätt / choir of the capital sacristry
Stone surfaces intensely polluted and encrusted
Upper areas, especially roofage is overgrown with green algae and moss.
Condition before the cleaning

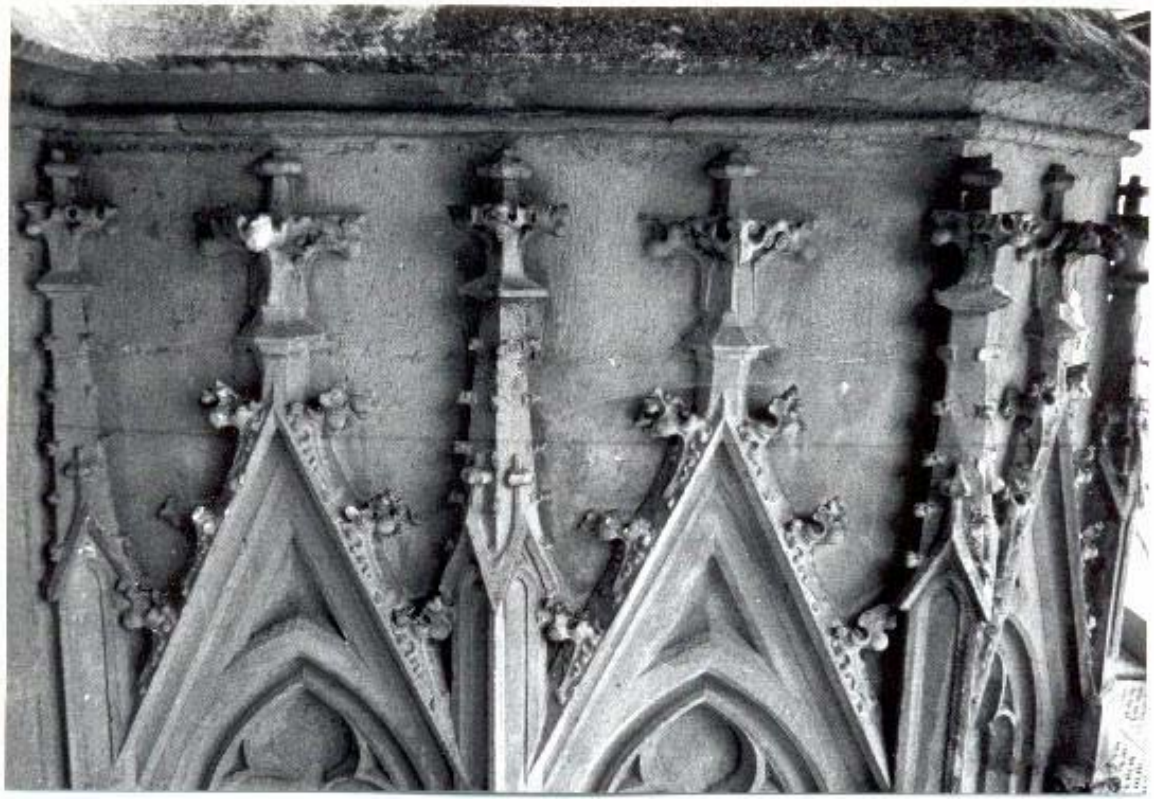
F 2 Cathedral Eichstätt / choir of the capital sacristry
Result after the cleaning with the "Vario" vortex stream technique.
The restoration is not yet finished at the lower wall area



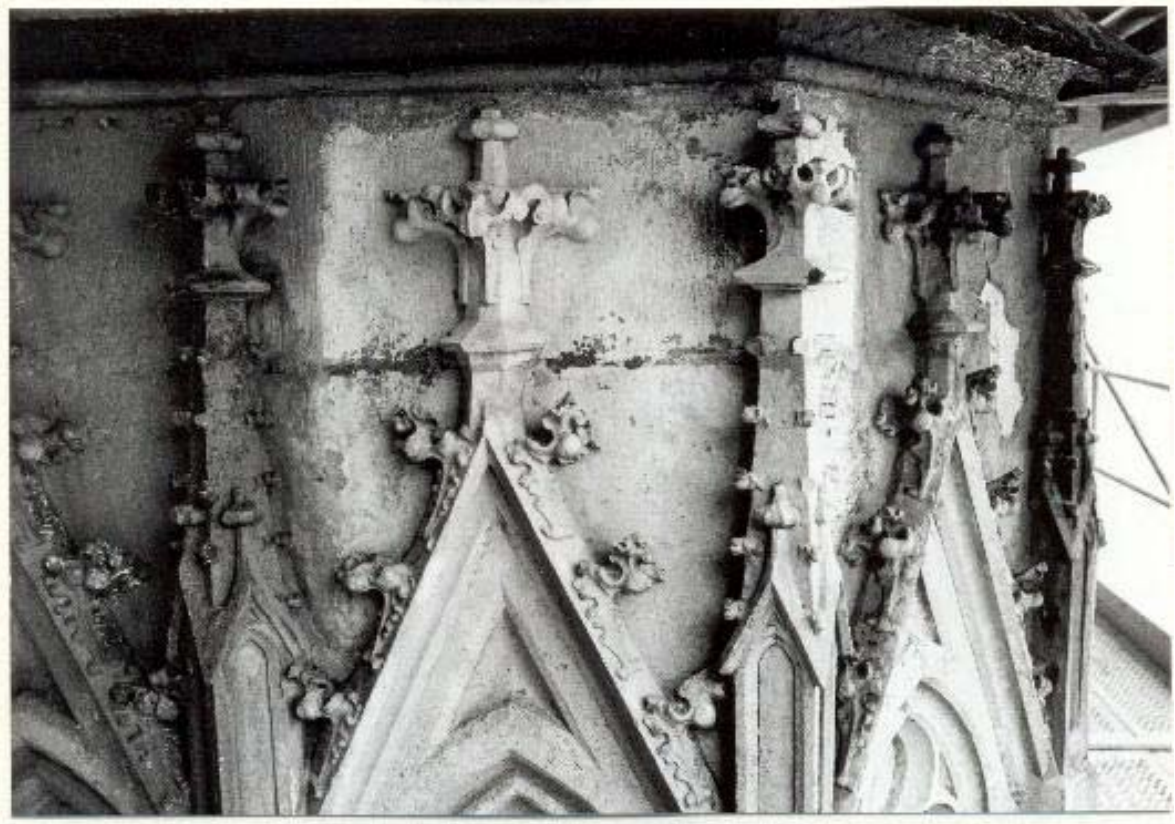
F 3 This factured surface demonstrates clearly a 1 mm thick pollution / gypsum crust on the limestone surface



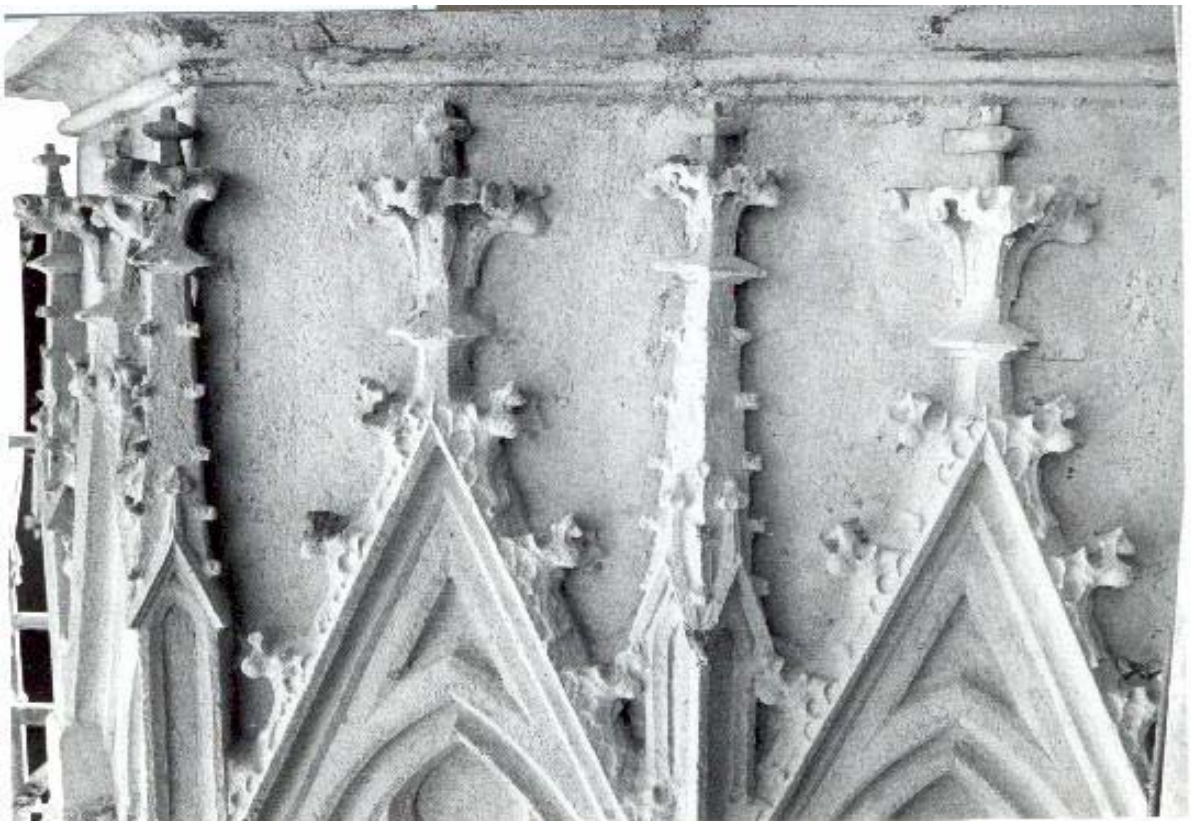
F 4 Test cleaning on column 6 of the capital sacristry
The pale area shows clearly the successful and gentle cleaning with the “Vario” vortex stream technique.



F 5 Very intense contamination of the delicate abonding parts (gothic Wimperg with crabs, as well as pinnacles with milkworts/ height of a milkwort 15 cm !)
These adorning elements have been carved out of the limestone behind.
Condition before the cleaning



F 6 Test cleaning of this wall with delicate adorning elements.
The good and gentle cleaning with the vortex stream technique is in evidence.
Blasting material was calcite / stone powder with a graining of 200 µm.



F 7 Wall after the cleaning
The cleaning with the “Vario” vortex stream technique was carried out as careful and

As gentle so that no damages occured to the delicate adorning elements and partially even rests of a “patina” were conserved.

Reference list

Gumbertuskirche, Ansbach
Pfarrkirche St. Alban, Wallerstein
Spitalkirche, Weißenburg
Liebfrauen-Münster Wolframs-Eschenbach
Pfarrkirche St. Antonius Mörsach

Ulmer – Münster, Ulm
Nürnberger Burg, Nürnberg
Nürnberger Oper, Nürnberg
Kaufhof, Nürnberg
Kaufhof, Rosenheim
Kaufhof, München
Glaspalast, Augsburg
Wohnsiedlung, Bad Soden
Asylantenwohnheim, Kassel
Opernhaus, Wiesbaden
Musikhochschule, Mannheim
Kaufhaus Whörl, Würzburg
Pfarramt, Andechs
Finanzamt, Offenbach
Krankenhaus Haar, München
Iduna Haus, München
Senatsverwaltung für Finanzen, Berlin
Finanzamt, Offenbach
Schiller Denkmal, Salzburg

Universität, Ljubljana, SL
The British Museum, London UK
The Ayyubid Wall, Cairo
Massachusetts Historical Society, Boston, MA
The First Baptist Church, Newton, MA
High Point Monument, Sussex, NJ
Princeton Chapel, Princeton, NJ
Rockefeller Center, New York, NY
The Atlantic Bank, New York, NY
The Church of St. Vincent Ferrer, New York, NY
The Federal Reserve Bank, New York, NY
The Helmsley Building, New York, NY
Grey Towers National Historic Landmark, Milford, PA
The Historical Society of Pennsylvania, Philadelphia, PA
The Mellon Bank, Philadelphia, PA
Arlington National Cemetery, Arlington, VA