附件1：名词图解
Appendix 1: Visual Glossary

石材
Stone

木材
Wood

抹灰
Plaster

金属
Metal

瓦
Tile

生物生长 Biological Growth

生物入侵导致外观变化，并可能导致脆化易碎及腐蚀

Biological attack resulting in change in surface appearance and possibly erosion or loss of surface material

会乘殿，南侧台阶，垂直阶面
红砂岩
石材表面的生物生长导致了污迹和侵蚀

Huicheng Hall, S Stair, riser
Red Sandstone
Biological growth on stone surface resulting in staining and erosion

会乘殿，南侧台阶
红砂岩
石材表面的生物生长导致了污迹和侵蚀

Huicheng Hall, S Stair
Red Sandstone
Biological growth on stone surface resulting in staining and erosion

会乘殿，西侧台基，
红砂岩
昆虫巢穴（及片状剥落）

Huicheng Hall, W Platform
Red Sandstone
Insect nests (and flaking/scaling)

开裂 Cracking

出现在表面的线状开裂，可能延伸至石材内部

Linear breaks visible at surface which may also penetrate into the material

挑头
红砂岩
沿岩石层面开裂

Scupper
Red Sandstone
Cracking along bedding planes

墁地石
红砂岩
开裂

Paving
Red Sandstone
Cracking and splitting

会乘殿，西北角
鹦鹉岩
裂缝（带有表面碎裂）

Huicheng Hall, NW Corner
Tuff (*yingwuyan*)
Crack (with surface chipping)

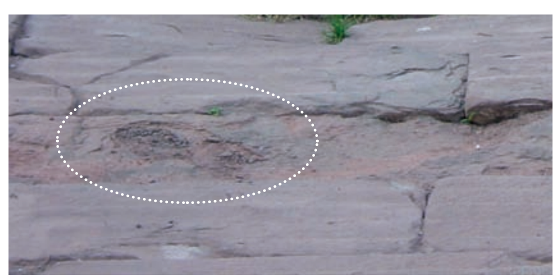
分解，粉化 Disintegration/Powdering

石材颗粒间结合力丧失，以外表易碎及极小机械作用即可造成材料破坏为特征

Loss of cohesion between grains of stone material characterized by friability of the surface and loss of material through minimal mechanical action

墁地石
红砂岩
表面瓦解及严重的材料缺失

Paving stones
Red Sandstone
Disintegration of surface and severe loss of material



墁地石
红砂岩
石材瓦解

Paving stone (S of Tianwang Hall)
Red Sandstone
Disintegration of one stone

盐霜 Efflorescence

由于蒸发作用与毛细作用带出盐分沉积物

Surface salt deposits due to capillarity within the stone facilitated by evaporation

会乘殿，室外东北槛墙
鹦鹉岩
盐霜凝结

Huicheng Hall,
NE Exterior sill wall
Tuff (*yingwuyan*)
Salt efflorescence

会乘殿，室内东北角槛墙
鹦鹉岩
盐霜凝结

Huicheng Hall, NE Interior sill wall
Tuff (*yingwuyan*)
Salt efflorescence

侵蚀 Erosion

磨损及物质缺失，导致不平坦表面及圆滑边缘

Surface loss of material resulting in uneven surface and rounded edges

会乘殿，南侧台阶
红砂岩
外表侵蚀

Huicheng Hall, S Stair, riser
Red Sandstone
Surface erosion

会乘殿，南侧台阶，细部
红砂岩
侵蚀及不均匀表面侵蚀

Huicheng Hall, S Stair, Tread
Red Sandstone
Differential erosion

吐水嘴
红砂岩
边缘脱落及被侵蚀

Scupper
Red Sandstone
Eroded edges following loss

山门，台基东南角
红砂岩
被侵蚀的角部埋头石

Shanmen
SE Platform corner
Red Sandstone
Eroded corners

粉碎 Fissuring

大量深入材料内部的平行裂缝，通常走向一致，导致材料结合力的丧失（常发生在鹦鹉岩上）

Deep parallel cracks throughout bulk of stone, often along same plane, resulting in loss of cohesion (common in local tuff)

清凉楼
鹦鹉岩
粉碎的石墙

Qingliang Building
Tuff (*yingwuyan*)
Fissuring wall

倚云楼
鹦鹉岩
粉碎的石块

Yiyun Building
Tuff (*yingwuyan*)
Fissuring block

倚云楼
鹦鹉岩
粉碎的石块

Yiyun Building
Tuff (*yingwuyan*)
Fissuring block

起甲/剥落 Flaking/Scaling

石材小片或大片剥离，剥离层平行于石头表面但不一定与层面平行

Detachment and lifting of thin layer(s) of stone material in small pieces (flaking) or large sheets (scaling), parallel to surface of stone, but not necessarily along bedding planes

会乘殿，台基西台帮
红砂岩
起甲及剥落

Huicheng Hall, W Platform
Red Sandstone
Flaking and scaling

会乘殿，南侧台阶垂带石
红砂岩
起甲并剥落

Huicheng, S Stair splay
Red Sandstone
Scaling with loss

涂写 Graffiti

由油漆或其它材料造成的人为表面污迹，通常被视为故意破坏的行为

Anthropogenic staining or surface deposit due to deposit of paint or other material on surface, considered as an act of vandalism

会乘殿，北立面
鹦鹉岩
油漆或墨水的涂写痕迹

Huicheng Hall, N facade
Tuff (*yingwuyan*)
Graffiti written with paint or ink

山门，北立面
鹦鹉岩
油漆或墨水的涂写痕迹

Shanmen, N facade
Tuff (*yingwuyan*)
Graffiti written with paint or ink

石狮子，山门前面
鹦鹉岩
油漆的涂写

Stone Lion, S of Shanmen
Tuff (*yingwuyan*)
Graffiti (paint)

不和谐人工干预 Incompatible Interventions

处理原来的石质构件，导致外观明显改变及状况退化

Treatments of original stone fabric resulting in evident changes in aesthetics or degradation of condition

山门，南立面，墙
红砂岩条石
水泥填充

Shanmen, S Facade, sill wall
Red Sandstone ashlar blocks
Cement infill

围墙，南立面
虎皮石墙
使用水泥做不和谐的重新勾缝

Perimeter Wall, S Facade
Rubble “tiger skin” masonry
Incompatible repointing with cement

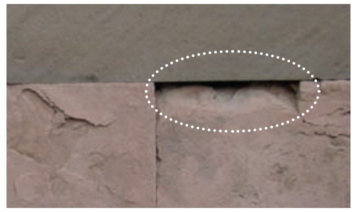
缺失 Loss

石构件或部分构件失落或已不存

Condition in which stone components or parts thereof are missing or no longer extant

山门，南立面，台基
毛石砂岩及凝灰岩砌面
毛石缺失

Shanmen, S Facade, platform
Rubble Sandstone and tuff masonry
Loss of rubble fill



会乘殿，台基西侧
红砂岩
石材边缘局部缺失

Huicheng Hall, W Platform
Red Sandstone
Partial loss of edge of stone

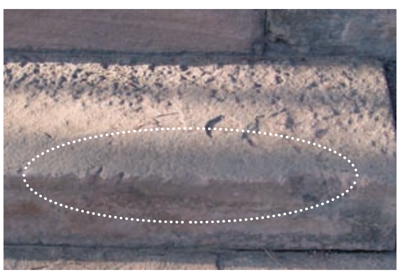
会乘殿，台基北侧踏步
红砂岩
侵蚀造成部分石材缺失

Huicheng Hall, N Platform step
Red Sandstone
Partial loss of stone, with erosion

机械损伤 Mechanical Damage

由动物、自然或人为造成的石材残损，通常表现出来的现象为磨损、切口或凿口

Damage to stone through animal, natural, or anthropogenic means most often in the form of abrasion, cuts or chipping



会乘殿，南踏步石
红砂石
石材边缘的切口

Huicheng Hall, S Stair tread
Red Sandstone
Edge cuts in stone

会乘殿，南踏步石
红砂石
搭脚手架所造成的损害

Huicheng Hall, S Stair
Red Sandstone
Scaffolding damage

盐分腐蚀及剥离 Salt-fretting

表面呈刻蚀状残损，通常伴有下层盐分析出，最终导致表层缺失

Deterioration of surface in etching pattern, often with subflorescence, often leading to surface loss

会乘殿，东北角下碱
鹦鹉岩
底部伴随盐分析出的表层缺失

Huicheng Hall, NE Sill wall base
Tuff (*yingwuyan*)
Basal surface loss with subflorescence

会乘殿，东部台基底部
红砂岩
底部伴随盐分析出的表层缺失

Huicheng Hall, E Platform base
Red Sandstone
Basal surface loss with subflorescence

会乘殿，东北角
下碱
鹦鹉岩
石材起甲剥落与严重外表残损及可见盐分

Huicheng Hall, NE Sill wall base
Tuff (*yingwuyan*)
Flaking/scaling of stone with severe surface deterioration and visible salts

污迹 Staining

由局部变色造成的外表特征的改变

Change in appearance of surface due to localized discoloration

山门，室内西墙下碱
红砂岩
潮气上浸引起的水迹

Shanmen, W Interior sill wall
Red Sandstone
Staining attributed to rising damp

会乘殿，西立面，台基南角
红砂岩
避雷针引起的污迹

Huicheng Hall, W Facade, S corner of platform
Red Sandstone
Rusting of lightning rod resulting in staining

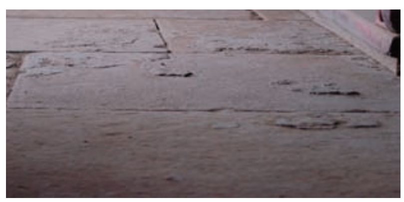
表面沉积/残迹 Surface Deposit / Residues

各种材料（如颜料、鸟粪、污垢等）在表面的沉积，包括早期的不和谐的人工干预

Accumulations of a wide variety of materials or residues (e.g. paint, droppings, dirt) on surface, including previous incompatible interventions

会乘殿，北立面
鹦鹉岩
鸟粪

Huicheng Hall,
N Facade
Tuff (*yingwuyan*)
Bird droppings



山门，室内地面
红砂岩
石墁地上的堆积物，推测来自以前屋顶的维修

Shanmen, interior
Red Sandstone
Deposit on paving stones, presumably from prior work on roof

山门，北侧下碱
红砂岩
残迹

Shanmen, N Sill wall
Red Sandstone
Residue staining

生物活动 Biological Activity

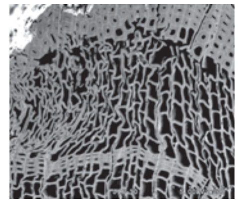
生物侵入木材造成外观改变（如蛀洞、表面堆积）或木材强度的改变（如真菌腐败）
Biological attack resulting in change of appearance (e.g. holes, surface deposits) and/or strength of wood (e.g. fungal rot)

会乘殿，南立面
柱
虫蛀洞（与腐朽）

Huicheng Hall, S Facade
Column
Exit holes of insects (and erosion)

会乘殿，南立面
柱
蜘蛛洞及蜘蛛网
（及片状开裂）

Huicheng Hall, S Facade
Column
Spiders resident in hole with spider webs (and splintering)



会乘殿，北立面，柱
电子扫描电镜图像（300倍）
由真菌侵蚀造成的木细胞残损
（褐色残损）

Huicheng Hall, N Facade, column
SEM image (300x)
Wood cell deterioration due to fungal attack (brown rot)

退色 Bleaching/Greying

因风化侵蚀（紫外线照射及频繁的干湿变化），木材自然色泽消失，造成表面外观退色
Loss of natural color of wood due to weathering (UV deterioration and frequent wetting/drying) resulting in washed out appearance of surface

会乘殿，北立面
柱
东半部柱子颜色泛白

Huicheng Hall, N Facade
Column
Bleaching of E half of column

会乘殿，南立面
铁箍
退色

Huicheng Hall, S Facade
Enclosure frame
Greying

线状开裂，劈裂 Cracking and Splitting

因机械的应力或风化引起的木材线状破裂（开裂），裂缝贯穿材料（劈裂）
Linear breaks in wood due to mechanical stress or weathering (cracking); cracks occurring through entire thickness of wooden element (splitting)

会乘殿，南立面
隔扇门
劈裂

Huicheng Hall, S Facade
Door baffleboard
Split

会乘殿，南立面
大额枋
裂缝中有地仗填充物

Huicheng Hall, S Facade
Architrave
Crack with original plaster infill

会乘殿，南立面
大额枋
发展中的开裂

Huicheng Hall, S Facade
Architrave
Progressive cracking

腐朽 Erosion

木材磨损导致外表形态改变和强度降低
Loss of wood resulting in change in surface morphology

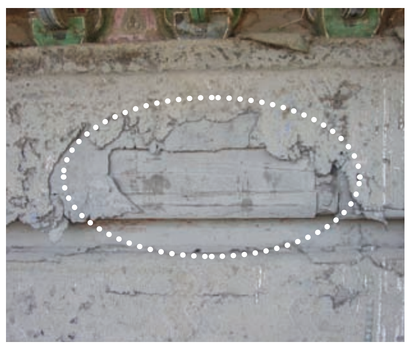
会乘殿，北立面
柱脚
腐朽
Huicheng Hall, N Facade
Base of Column
Erosion

会乘殿，北立面
柱脚
腐朽
Huicheng Hall, N facade
Base of Column
Erosion

木质暴露 Exposed Wood

原有的地仗或油漆已不存，木材无保护地暴露的状况
Condition of wood in which it is unprotected by plaster and/or paint coatings originally present

会乘殿，北立面
门、窗、枋
木质暴露
Huicheng Hall, N Facade
Doors, windows, architrave
Exposed wood



会乘殿，东立面上檐
大额枋
木质暴露
Huicheng Hall, E Facade,
Upper Eave
Greater Architrave
Exposed wood

机械损伤 Mechanical Damage

由动物、自然或人为造成的表面残损，通常表现出来的现象为磨损、切口或凿口
Loss of surface through animal, natural, or anthropogenic means most often in the form of abrasion, cuts or gouges

会乘殿，北立面
柱及门抱框
凿口痕迹及蚀洞
Huicheng Hall, N Facade
Column and enclosure frame
Gouge marks and scoring

会乘殿，北立面
抱框及门扇
凿口痕迹及蚀洞
Huicheng Hall, N Facade
Enclosure frame and door
Gouge marks and scoring

纹理凸出 Raised Grain

木材表面由于质软的早材和较硬的夏材受腐蚀的程度不同，而造成脊状延伸的图案，夏材组成脊状部分

A ridged pattern on the surface of wood due to differential erosion of soft earlywood and harder latewood, the latter forming the ridges

会乘殿，南立面
纹理凸起

Huicheng Hall, S Facade
Raised Grain

会乘殿，南立面
纹理凸起

Huicheng Hall, S Facade
Raised Grain

片状开裂 Splintering

薄片木材层状剥离，通常导致优先腐朽或剥离部分的木质缺失

Detachment of slender pieces of wood, in layers, often resulting in preferential erosion and/or loss

会乘殿，南立面
柱
片状开裂及腐朽

Huicheng Hall,
S Facade
Column
Splintering and erosion

会乘殿，南立面
柱
片状开裂及其结果——木质缺失

Huicheng Hall,
S Facade
Column
Splintering with resultant loss

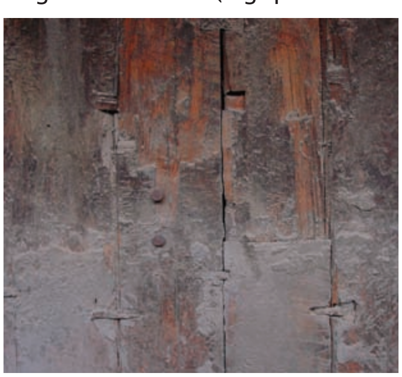
会乘殿，南立面
柱脚及其邻近的门抱框
片状开裂及腐朽

Huicheng Hall, N Facade
Base of column and adjacent door frame
Splintering and erosion

表面堆积 Surface Deposit / Residues

多种物质（如油漆、鸟粪、污垢）在表面的累积，包括原有材料的残迹（如地仗残迹）

Accumulations of a wide variety of materials (e.g. paint, droppings, dirt) on surface, including remnants of original materials (e.g. plaster residue)



会乘殿，室内，北廊
扇面墙
表面堆积（大片地仗脱落后的少部分地仗遗存）

Huicheng Hall, Interior,
N corridor
Wood panel wall
Surface deposit (remnant plaster after significant plaster loss)

会乘殿， 北立面
小额枋
表面堆积（鸟粪）

Huicheng Hall,
N Facade
Lesser Architrave
Surface deposit (bird droppings)

弯曲 Warping

各种类型的木构件变形

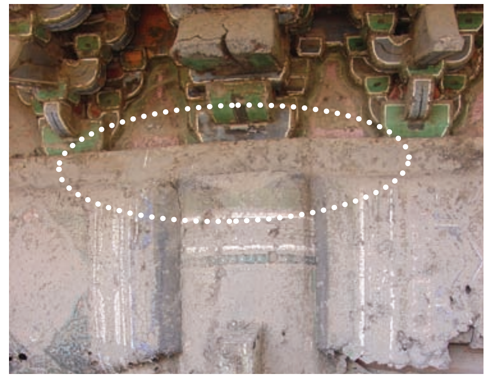
Distortion of wood member in the form of a variation from its true plane

会乘殿，西立面，上檐
平板枋
端头弯曲

Huicheng Hall, W Facade,
upper eave
Flat tie beam
Warped ends

会乘殿，东立面
平板枋
弯曲

Huicheng Hall,
E Facade,
Lower Eave
Flat tie beam
Warping



开裂 Cracking

表面可见的线状破裂，可能穿透入材料内部

Linear breaks visible at surface which may also penetrate into the material

会乘殿，西立面
红色抹灰
开裂

Huicheng Hall, W Facade
Red-colored stucco
Cracking

山门，北立面
红色抹灰
开裂

Shanmen, N Facade
Red-colored stucco
Cracking

空鼓 Detachment

抹灰/地仗与下层介质粘性消失

Loss of adhesion of stucco/plaster to substrate

会乘殿，西立面
红色抹灰
空鼓与附近的裂缝
及脱落

Huicheng Hall,
W Facade
Red-colored stucco
Detachment with
adjacent cracking
and loss

会乘殿，西立面
红色抹灰
从邻近的脱落部分看空鼓

Huicheng Hall,
W Facade
Red-colored stucco
Detachment, as seen
through adjacent loss

涂写 Graffiti

以油漆或其它材料造成的表面污迹或刻划，人为故意破坏的行为

Anthropogenic vandalism in the form of deposit of paint or other material on surface or incising/carving of surface

会乘殿，西立面
红色抹灰
涂写及凿痕

Huicheng Hall,
W Facade
Red-colored stucco
Graffiti and gouging

会乘殿，西立面
红色抹灰
涂写及凿痕

Huicheng Hall,
W Facade
Red-colored stucco
Graffiti and gouging

不和谐人工干预 Incompatible Interventions

人为处理原来的构件导致外观的明显改变或状况退化
Anthropogenic treatments of original fabric resulting in evident changes in aesthetic or degradation of condition

山门，南立面
红色抹灰
名牌周围不和谐
的重新抹灰

Shanmen, S Facade
Red-colored stucco
Incompatible replastering
around new sign

山门，南立面
红色抹灰
不和谐的新加抹灰

Shanmen, S Facade
Red-colored stucco
Incompatible replastering

脱落 Loss

抹灰/地仗完全或部分脱落，露出下层介质
Complete or partial loss of plaster/stucco, exposing substrate

会乘殿，西立面，北端
红色抹灰
脱落区域

Huicheng Hall, W Facade, N end
Red-colored stucco
Area of loss

会乘殿，西立面，南端
红色抹灰
脱落区域

Huicheng Hall, W Facade, S end
Red-colored stucco
Area of loss

天王殿，室内西部
抹灰
脱落区域

Tianwang Hall,
E interior
Plaster
Area of loss

机械损伤 Mechanical Damage

由动物、自然或人为造成的表面残损，经常表现出来的情形为磨损、切口或凿口
Deterioration of surface through animal, natural, or anthropogenic means most often in the form of abrasions, cuts or gouges

会乘殿，东立面
红色抹灰
凿及子弹造成的小坑

Huicheng Hall, E Facade Red-colored stucco
Holes caused by gouging
and projectiles

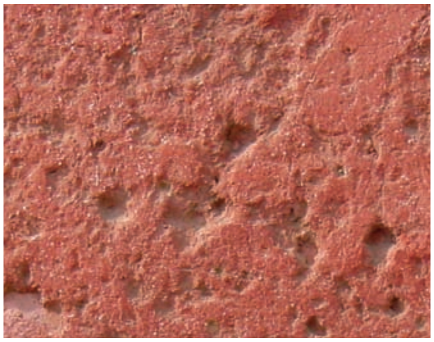
会乘殿，南立面，西端
红色抹灰
凿痕及划痕

Huicheng Hall,
S Facade, W end
Red-colored stucco
Gouges and scratches

孔状脱落 Pitting

表面点状脱落，以许多密集的直径通常为几毫米的小孔为特征

Point-like loss of surface characterized by many close small cavities with diameter generally of a few millimeters



山门，室外南
红色抹灰
孔状脱落及凿痕

Shanmen, S Exterior
Red-colored stucco
Pitting and gouging

山门，室外南
红色抹灰
孔状脱落及凿痕

Shanmen, S Exterior
Red-colored stucco
Pitting and gouging

污迹 Staining

由局部变色造成表面外观的改变

Change in appearance of surface due to localized discoloration

围墙，山门以西，内侧
红色抹灰
带状受潮痕迹

Site wall, W of Shanmen, Interior
Red-colored stucco
Band of staining from moisture

山门，北立面
红色抹灰
带状受潮痕迹

Shanmen, N Facade
Red-colored stucco
Band of staining from moisture

表面堆积 Surface Deposit

多种物质（如油漆、鸟粪、污垢）在表面的累积，包括早期不和谐的人工干预

Accumulations of any of a wide variety of materials (e.g. paint, droppings, dirt) on surface, including earlier incompatible interventions

会乘殿，北立面
红色抹灰
污垢堆积及鸟类粪便

Huicheng Hall, N Facade
Red-colored stucco
Dirt accumulation and bird droppings

山门，南立面，西尽间
红色抹灰
灰尘堆积以及滴落的油漆痕迹

Shanmen, S Facade, W bay
Red-colored stucco
Dirt accumulation with paint drips

锈蚀 Corrosion

由于与环境状况（污染、相对湿度、氧气等）反应造成的电化学残损，导致颜色改变和材料缺失
Electrochemical deterioration due to reaction with environmental conditions (pollution, RH, oxygen, etc.) that results in color change and loss of material

会乘殿，北立面
柱子铁箍， 铁金属
锈腐及脱落

Huicheng Hall, N Facade
Column hoop, ferrous metal
Rust with loss

会乘殿，南立面
门扇青铜配件，铜氧化（铜绿）

Huicheng Hall, S Facade
Door fitting, cuprous metal
Oxidation (patina)

会乘殿，南立面
避雷针扣，
铁锈

Huicheng Hall, S Facade
Attachment for decorative fitting, ferrous metal
Rust

开裂 Cracking

材料上的线性破裂，可能贯穿也可能不贯穿整个材料宽度
Linear breaks in material that may or may not pass through entire width of material

会乘殿，北立面
柱上铁箍
开裂及铁锈

Huicheng Hall, N Facade
Column hoop, ferrous metal
Cracking and rust

会乘殿，南立面
门扇青铜配件开裂

Huicheng Hall, S Facade
Door fitting, cuprous metal
Cracking

生物生长 Biological Growth

在瓦里面及附近有生物的活动（如树木、微生物、真菌），其结果可以造成构件裂缝、位移和失落

Presence of biological activity (e.g. plant, microbiological, fungal) in or around tile, which can result in cracking and/or displacement or loss of elements

会乘殿，北立面
下檐
琉璃瓦顶
植物生长

Huicheng Hall,
N facade
Lower eave
Glazed roof tiles
Plant growth

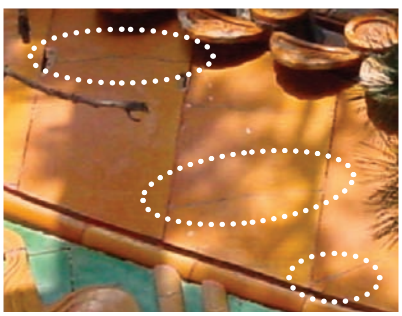
会乘殿，北立面
上檐
琉璃瓦顶
植物生长

Huicheng Hall,
N facade
Upper eave
Glazed roof tiles
Plant growth

开裂及破损 Cracking and Breakage

釉质或瓦胎上的线形开裂，可造成瓦件的整个分离，破损为多个碎片

Linear breaks in glaze and/or fired tile that may result in complete separation (breakage) of tile into multiple pieces



会乘殿，西山墙
琉璃瓦
开裂

Huicheng Hall, W gable
Glazed tiles
Cracking

会乘殿，北立面，西侧
下檐
琉璃瓦
开裂及破损（两个不同部位）

Huicheng Hall, N facade,
W side
Lower eave
Glazed roof tiles
Cracking and Breakage (in two areas)

位移 Displacement

瓦件从原位被移动

Movement of tile from its original location

围墙，山门西侧
顶瓦
一片瓦位移

Enclosure wall, W of Shanmen
Roof tile
Displacement of one tile

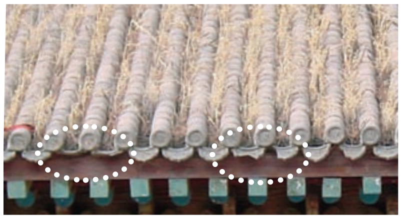
脱落 Loss

瓦

Tile

整片瓦或部分瓦构件或釉的部分缺失或完全脱落

Condition in which a complete or partial component of fired tile or its glaze is missing or no longer extant



山门，南立面
瓦顶
部分脱落

Shanmen, S Facade
Roof tiles
Partial loss

会乘殿，北立面，
东侧
下檐
琉璃装饰物
屋顶构件部分脱落

Huicheng Hall,
N facade, E side
Lower eave
Glazed ornaments
Partial loss of
roof elements

会乘殿，东立面
下檐
琉璃瓦
脱釉

Huicheng Hall,
E facade
Lower eave
Glazed tile
Loss of glaze

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附件2：建筑材料试验报告
Appendix 2: Architectural Materials Testing Reports

下面的文件是从殊像寺建筑材料的采样、分析与试验所产生的全部档案记录的部分摘录的样本。这些报告的全文及其它的档案记录都收录在分析报告的文件夹中。

The following documents are partial examples of the full documentation generated by the sampling, analysis, and testing of architectural materials from Shuxiang Temple. Complete versions of these reports, as well as additional documentation, is included in the full Analytical Binder.

建筑材料样品 Architectural Samples:

木材（5个样品）

样品报告.HC.F02.S09, SX.HC.F03.S12, SX.HC.Su01, SX.HC.Su02, SX.HC.Su03， 图片及描述由 Robert Blanchette 博士提供。会乘殿包镶柱外包层木材经分析认定为云杉，木料来自生长非常缓慢的树木，可能生长于高海拔或是不利生长的环境中。在两个木钻芯样本中均发现由于真菌活动所造成的褐腐。一个样品取自严重腐蚀的木柱根部，通长（3厘米）表现出严重的腐朽；而另一个样品取自相对健康的部位木质样本仅腐朽1毫米的深度。在木材中出现的完整菌丝可能仍具活性。因此木材的腐烂仍可能是活跃，或有可能在有湿度的情况下再次活跃。

Wood (5 Samples)

Sample reports: SX.HC.F02.S09, SX.HC.F03.S12, SX.HC.Su01, SX.HC.Su02, SX.HC.Su03, images and descriptions submitted by Robert Blanchette.

Huicheng Hall column cladding wood samples have been identified as Picea (Spruce). The wood appears to be from a tree that was very slow growing, possibly growing at a high elevation or in adverse conditions. Fungal activity in the form of brown rot was identified in two wood cores taken. One core, from the badly eroded lower portion of a column, showed significant decay throughout its length (3cm), while another from healthier wood, 1.5m above the column base in the same column, showed decay to only 1mm of depth. Intact hyphae are present in the wood samples and may still be viable. Therefore, the decay could still be active or could possibly reactivate in the presence of moisture.

石材：鹦鹉岩（采自采石场的新样品）（两个样品）

样品报告：SX.HC.Su04.S04, SX.HC.Su04.S05, 见盖蒂保护研究所对鹦鹉岩的报告（该报告收在卷二，《**建筑和建筑构件状况评估**》，附件2）。

Stone: tuff (new samples from quarry) (2 Samples)

Sample reports: SX.HC.Su04.S04, SX.HC.Su04.S05, GCI science reports on tuff (see Vol. 2, *Condition Assessment of Architecture and Architectural Elements,* Appendix 2)

石材：绿色和红色的砂岩 （样品采自破碎的墁地石和建筑基址）(四个样品)

样品报告：SX.HC.Su04.S06, SX.HC.Su04.S07, SX.HC.Su04.S08, SX.HC.Su04.S09，见盖蒂保护研究所对砂岩的报告（该报告收在卷二，《**建筑和建筑构件状况评估**》，附录2）。

所有石材样品表现出“天然的易退化性”的特征。石材的粘土含量显示出当石材暴露在高湿度的情况下，湿生质的扩张会产生剪力，导致石材破碎。此外，显微镜下的肉眼观察看出所有样本有较高的孔隙率，并有网状细微破碎。对鹦鹉岩进行的冻融实验显示出这种岩石至少可以分成两类：一类易受冻融影响，而另一类对冻融有一定的抵抗力。

Stone: green and red sandstone (samples collected from broken stone fragments of pavers and architectural ruins in situ) (4 Samples)

Sample reports: SX.HC.Su04.S06, SX.HC.Su04.S07, SX.HC.Su04.S08, SX.HC.Su04.S09, GCI Science report (October 2004), GCI science reports on sandstone (see Vol. 2, *Condition Assessment of Architecture and Architectural Elements,* Appendix 2)

All stone samples showed signs of inherent susceptibility to deterioration, as clay content of all stones suggests hygric expansion will result in shear stress and fracturing when exposed to elevated moisture content. Furthermore, visual examination under the microscope shows high porosity in all samples, with microfracture networks present. Freeze-thaw testing of tuff has revealed that at least two qualities of tuff exist, one susceptible to freeze-thaw, the other somewhat resistant.

室外隔墙抹灰（一个样品）

样品报告：SX.HC.F02.S05 由盖蒂保护研究科研部提供（2003年6月18日）

为了确定抹灰的特征（胶结剂、骨材等）对样品进行分析。发现样本分为2层：粘土抹灰层及其上的红色抹灰层。可以看到纤维。在抹灰层的下层中发现黏土和石英，上层石灰质抹灰含有白云石质石灰骨材，并可能有砖灰。

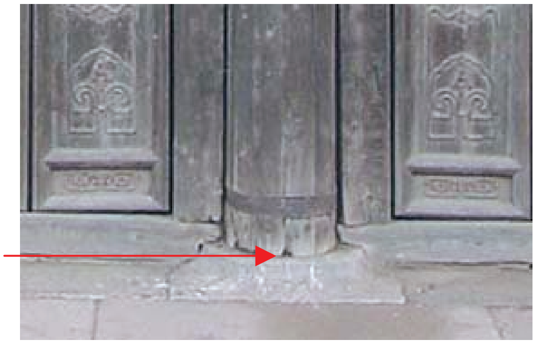
Exterior Masonry Wall Stucco (1 Sample)

Sample reports: SX.HC.F02.S05, report by GCI science (June 18, 2003)

The sample was investigated to characterize exterior stucco and identify the principal components, such as binder and aggregates. The sample contains two layers: a red-colored lime-based stucco on an earthen plaster base. Fibers are visible. In the lower plaster, clay and quartz components were identified. The upper stucco layer contains dolomitic limestone aggregate and possibly crushed brick. The source of the characteristic red color has not been categorically identified, though it is thought to be due to an inclusion of hematite.

Huicheng Hall, Shuxiang Temple, Chengde

Sample #: SX.HC.F02.S09 (SXEW02-1)



Sample location: wood sample from exterior north facade, base of column of Huicheng Hall. Sample was collected in September 2002.

Sample description: deteriorated piece of wood

Sampling rationale: to identify wood species and understand decay

Analysis: Optical microscopy (Professor Robert Blanchette)

Comments (Robert Blanchette – February 2003):

The wood appears to be Picea (Spruce) or Larix (Larch). The sample is so fragile that it is hard to get a good section for light microscopy to see the type of ray pitting needed to make a definite determination. The wood also appears to be from a tree that was very slow growing - maybe from high elevation since the growth rings are very narrow (indicating a very short growing season or one where the tree is growing under adverse conditions).

Some selectivity has occurred in the attack of the wood. The slow growing trees used for the wood have produced thick-walled latewood cells that resisted attack more than the early wood cells. Since intact hyphae are present in the wood and they may be still viable, the decay could be still active or can reactivate if moisture is present.

Sample location: wood sample from exterior north facade, base of column of Huicheng Hall.

SX.HC.F02.S05

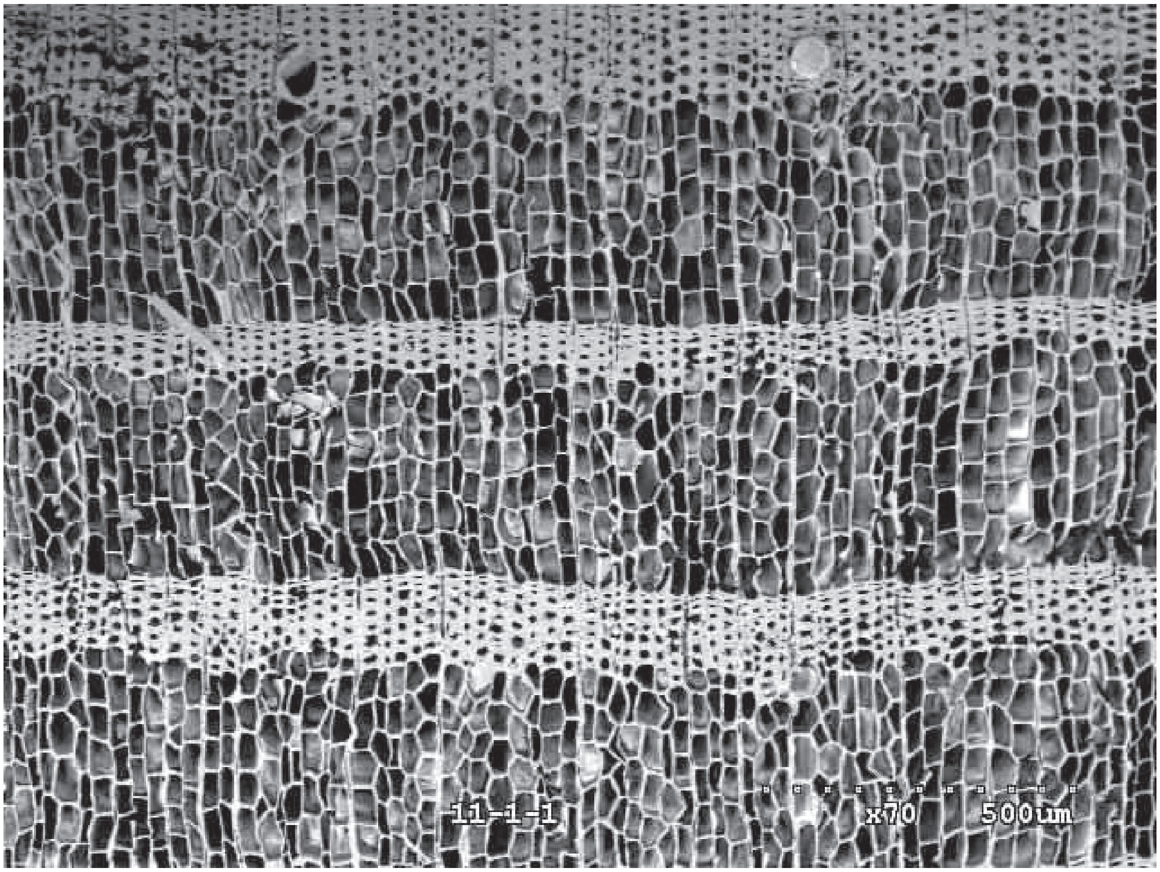
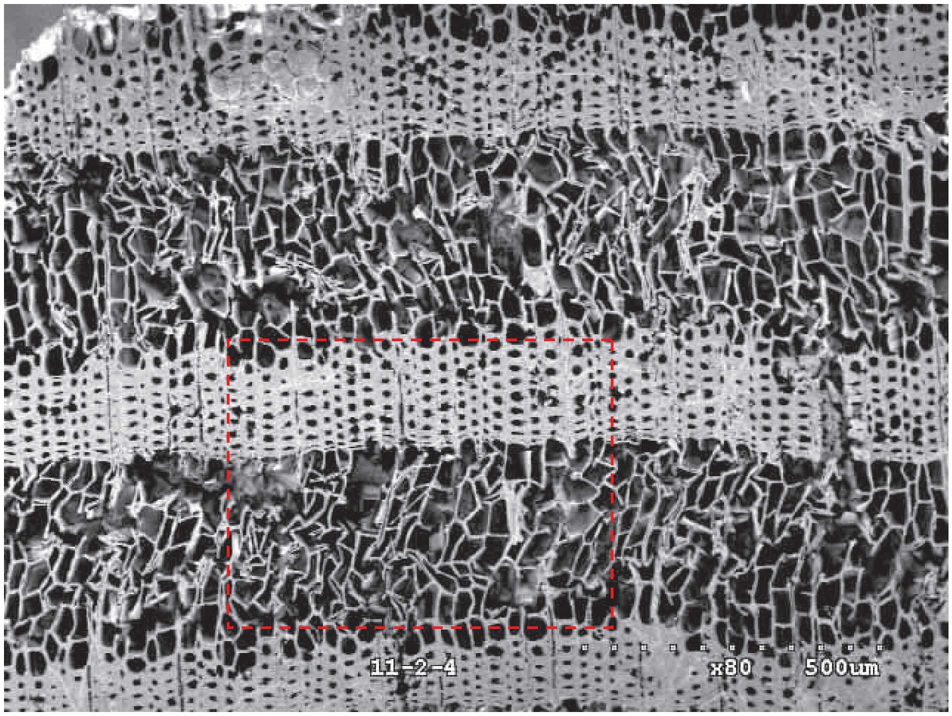
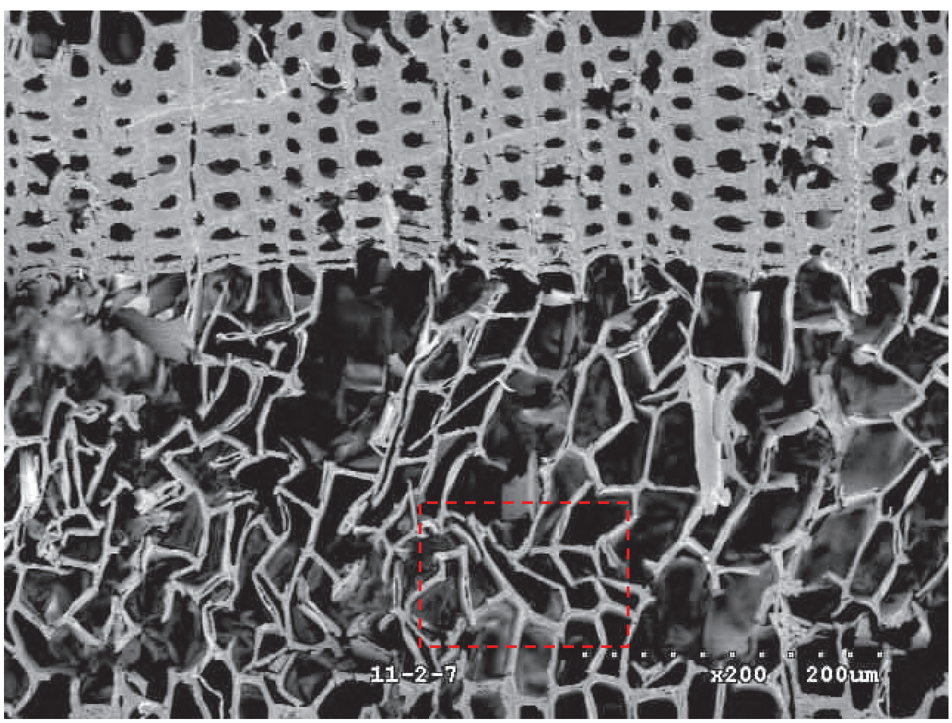


Photo J11-1-1 shows 3 annual layers over a very small area. The wood appears to be attacked by a brown rot fungus that has degraded the early wood cells more than the late wood. This type of decay causes very severe strength losses to occur and the weakened early wood cells can be seen fragmenting (see Photo's J11-2-3 and J11-2-4, J11-2-4a, J11-2-6 (high magnification of the fragmented cells, J11-2-7). Note all of the micrographs from J11-1-1 to J11-2-7 are transverse sections of the wood sample.

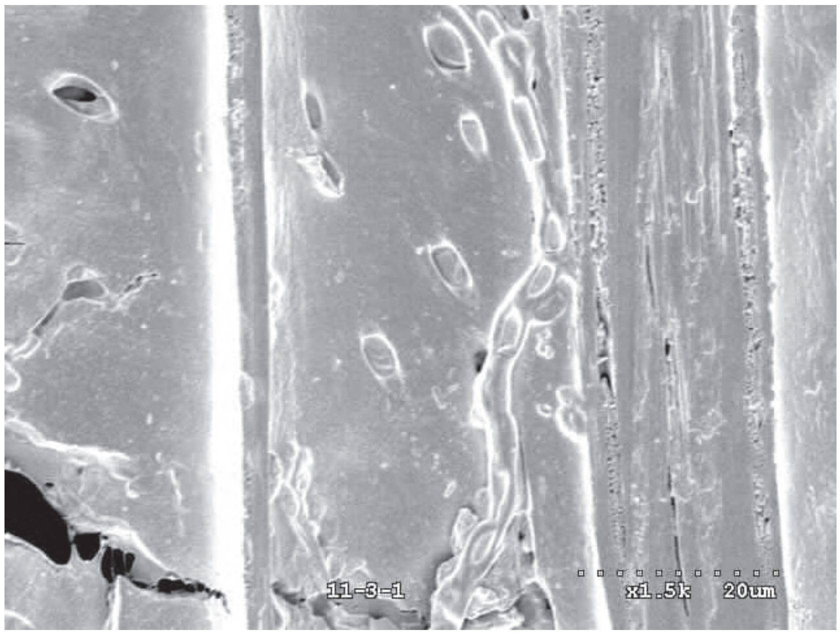


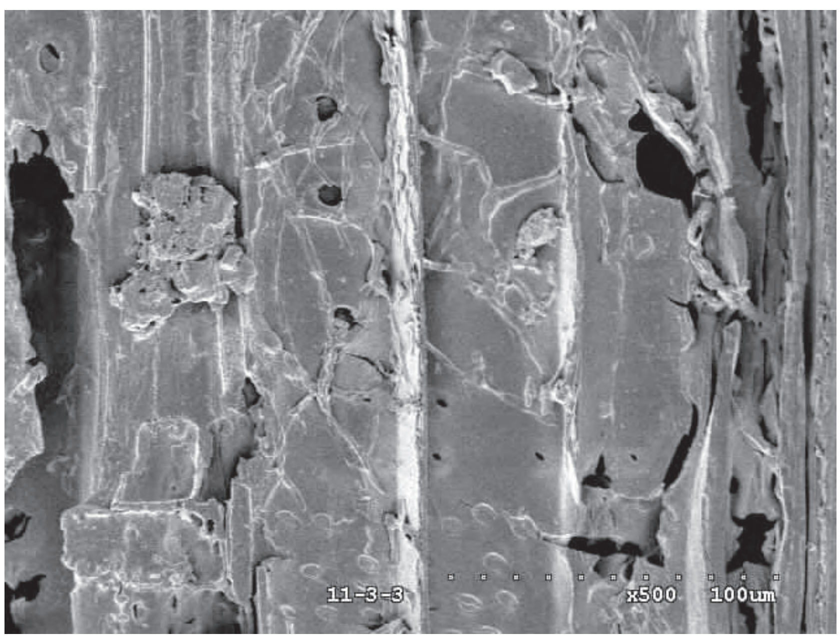
J11-2-4a



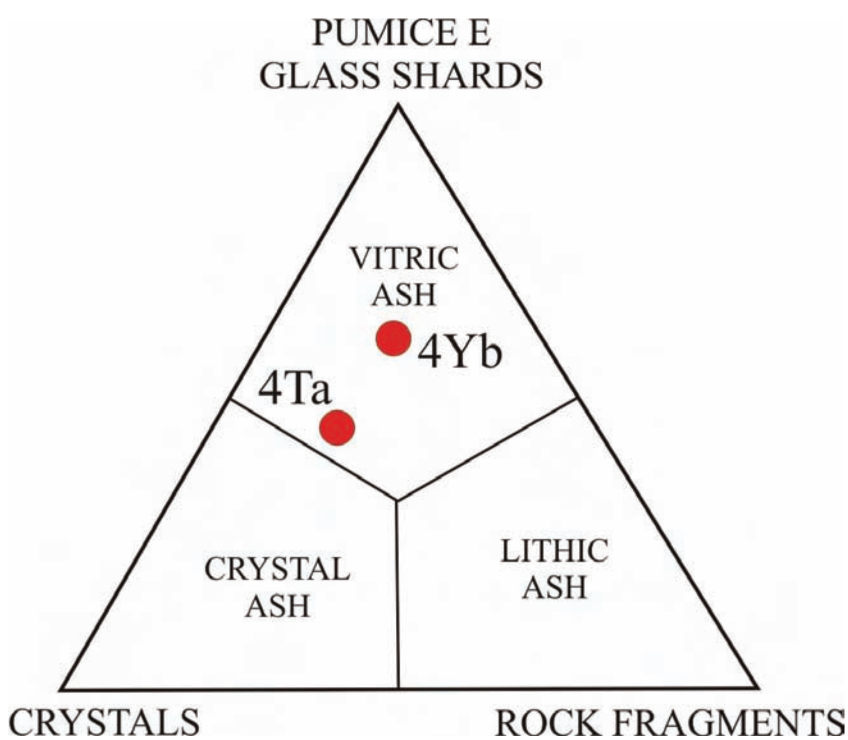
J11-2-7, high magnification of the fragmented cells

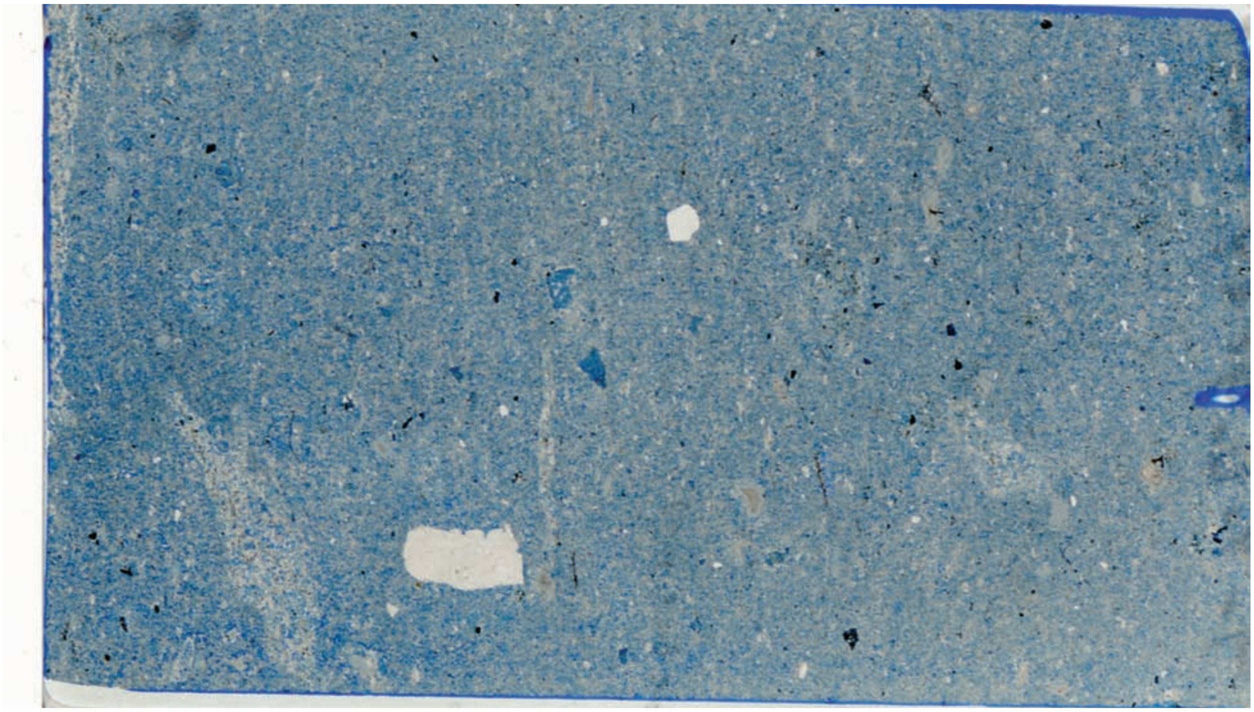
Micrographs J11-3-1 to J11-4-4 are radial sections showing fungal hyphae in the cells and some ray parenchyma anatomical detail that is used to identify the wood. The fungi that colonized the wood are found throughout the cells of the samples. The structurally weak cells are evident by the fractured cell walls around the mycelium. Typically, brown rot fungi will degrade the cellulose and hemicellulose from the wood leaving lignin behind. Without cellulose, the cells have little integrity left.



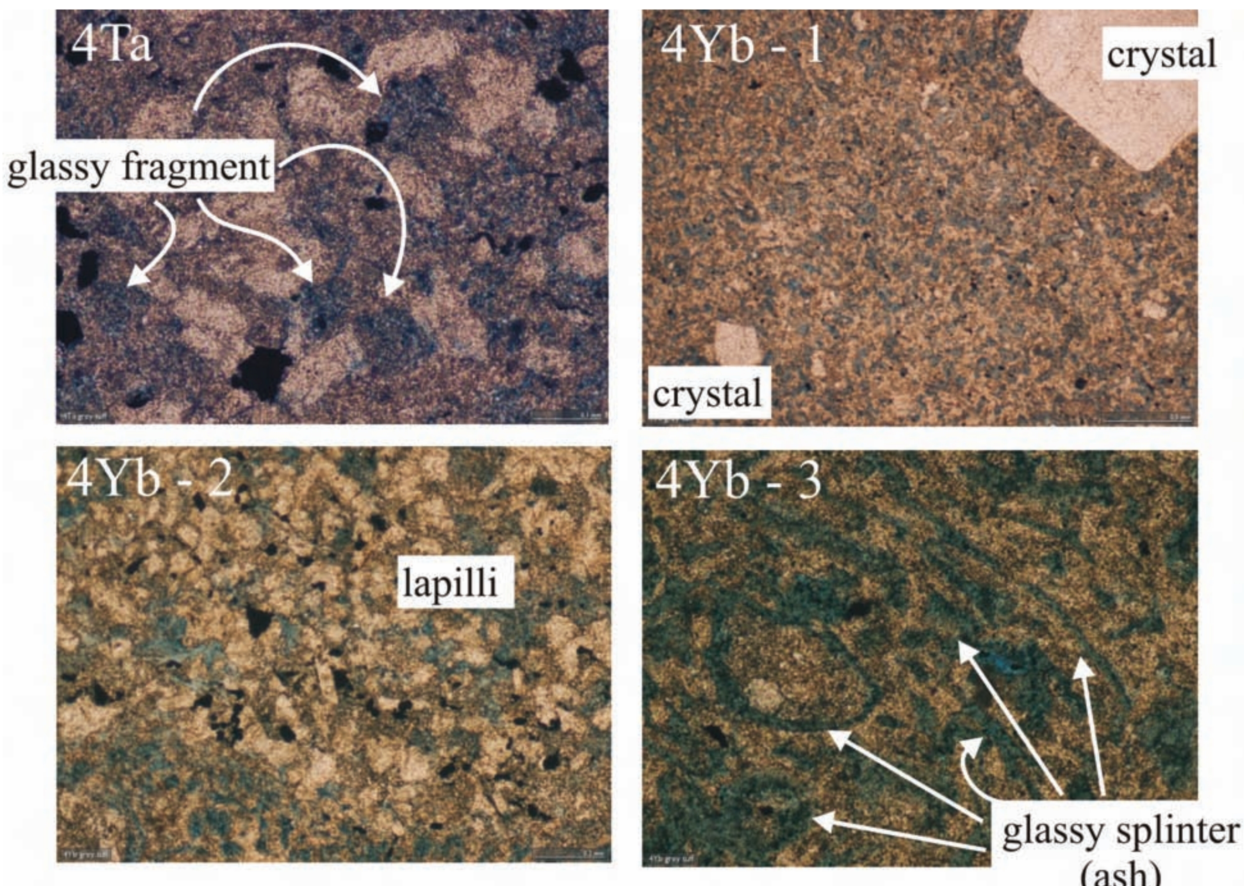


GREY TUFF	
Volcanic fine-ash tuff with vitrophiric matrix	
fine-grain matrix	quartz and feldspar grains with abundant glassy splinter (ash) - (Fig. 4Yb-3)
crystal	rarely quartz and feldspar crystal (millimeter- submillimeter size) - (Fig. 4Yb-1)
rock fragments	rarely lapilli (millimeter - centimeter size) well oriented; this fragment are porphiric texture with abundant fenocrystal (feldspar and subordinate plagioclase) - (Fig. 4Yb-2)
porosity	micro-porosity well distributed in fine-grain matrix; Secondary porosity is due to devetrification of glass splinters - (Fig. 4Ta)
	VITRIC ASH TUFF





Thin section of grey tuff



PLM microphotographs of tuff

Chengde Tuff:
Physical characterization and Freeze-Thaw Resistance testing

I. Objectives

The objectives of the study are:

- To determine whether freeze-thaw cycles result in deterioration (cracking, splitting) of ornemental tuff from Chengde as seen in exposed architectural and sculptural tuff at the site.
- To determine whether tuff from different levels in the quarry near Chengde show different deterioration rates, as is believed by site staff.

Stone samples were taken at two different sequence levels, one on the lower level of the quarry, stone 1, and one at the upper level of the quarry, stone 2. Used as a building material, these two stones showed some difference in their resistance to freeze-thaw cycles.
Physical mechanical testing may help to understand the different behavior of these two samples.

II. Methods

All measurements including freeze-thaw cycles are reproduced three times for each sample type.

Porosity accessible to water (RILEM I.1)

After drying the samples to constant mass (M_1) at 60°C, they were placed in desiccators, under vacuum (20 mmHg) for 24 hours to eliminate the air contained in the pores. Water was slowly introduced into the vessel, while the vacuum was maintained for 24 hours. Finally the samples were left under water at atmospheric pressure for another 24 hours.
The samples were then weighed in water (hydrostatic weighing: M_2) and in air (M_3).
The porosity (N_t [%]) is expressed as the ratio of the volume of the pores accessible to water to the bulk volume of the sample:

$$N_t = \frac{M_3 - M_1}{M_3 - M_2} \times 100$$

Free porosity (N_{48}) RILEM II.1

Free porosity N_{48} (%) determines the open porosity accessible to water by capillarity under atmospheric pressure and is comparable to natural absorption and immersion conditions.

$$N_{48}\ (\%) = \frac{M_{48} - M_1}{V_t}$$

The sample first absorbs water slowly by capillarity during 2 hours at atmospheric pressure and then is immerged under water for 48 hours.
M_{48}: mass of the sample after 48h
M_1: mass of the dry sample
V_t: total volume of the sample

The free porosity is comparable with interconnected porosity. From this measurement the Hirschwald coefficient or Saturation coefficient can also be calculated, expressing the water saturation of the sample:

$$S_{48} = \frac{N_{48}}{N_t}$$

Bulk density and real density (RILEM I.2)

The bulk density (or apparent density): δ_{bulk} [kg/m^3] is the ratio of the mass to the bulk volume of the sample.
The real density (δ_{real} [kg/m^3]) corresponds to the volume mass of impermeable material. It is the ratio of the mass to the impermeable volume of the sample.
The bulk and real densities were calculated with the mass determined in the experiment for water accessible porosity:

$$\delta_{bulk} = \frac{M_1}{M_3 - M_2} \times 1000$$

$$\delta_{real} = \frac{M_1}{M_1 - M_2} \times 1000\,.$$

Specific surface area (BET)

The specific surface area in m^2/g is defined as the sum of the area developed by each particle composing a mass unit of the porous material.
The BET theory was originally elaborated by Brunauer, Emmett and Teller (Brunauer, E&T 1938). The determination of specific surface by means of the BET theory is based upon the phenomenon of physical adsorption of gases on the external surfaces of a porous material.
The volume of gas is determined as a function of partial pressure from the de-sorption branch of the isotherm after cooling to the liquid nitrogen temperature (BET Nitrogen Adsorption ASTM C1069-86, DIN 66131 modified). Knowing the area occupied by one adsorbed molecule the specific surface area of solids can be calculated.

$$\frac{Va}{Vm} = \frac{C\,(p/p_0)}{(1-p/p_0)\,(1+(C-1)\,p/p_0)}$$

Where V_a is the volume adsorbed at relative vapor pressure p/p_0 (p is the actual vapor pressure, p_0 is the vapor pressure at saturation) V_m is the volume of adsorbate forming a monolayer on unit mass of adsorbent and C is a constant related to the energy of adsorption in the first adsorbed layer and consequently its value is an indication of the magnitude of the adsorbent/adsorbate interactions.

Ultrasonic velocity measurements and dynamic modulus of elasticity

The aim of this measurement is to determine the velocity of ultrasonic longitudinal waves V_L as a ratio of the distance between a transmitter and a receiver to the corrected time (time going from the transmitter to the receiver). The velocity is related to physico-mechanical characteristics such as the mineralogical composition, intercrystalline connections, porosity, and moisture content. To

determine V_L a portable measurement device USG 20 (Fa. Krompholz Geotron Elektronik, FRG) was used with a 250 kHz emitter (USG -T) and receiver (USE-T).
Determining the Poisson-ratio the dynamic modulus of elasticity is calculated (from additional shear wave, resonance frequency).

$$Ed = \rho V_p^2 \frac{(1 + \upsilon)(1 - 2\upsilon)}{(1 - \upsilon)}$$

With:

$$\upsilon = \frac{1}{2} \frac{(V_p/V_s)^2 - 2}{(V_p/V_s) - 1}$$

ν = Poisson coefficient
ρ = apparent density
V_p = velocity of compressional wave
V_s = velocity of shear wave

<u>Water uptake coefficient and capillarity rise (ISO 15148)</u>

The water absorption coefficient is the mass of water absorbed by a test specimen per face area and per square root of time. The lower surface of the specimen is in contact with water (level of water 5 mm) and the change in mass of the specimen is measured over a period of time of 24 hours. The measurements are carried out perpendicular to the banding of the stone sample and taken after 1 min, 5 min, 10min, 15min, 30 min, 1 h, 2 h, 4 h, and 24 h.
The water uptake coefficient is calculated from the linear part of the curve, as:

$$W = \frac{m}{\sqrt{t}} \quad [kg/m^2/h^{0.5}]$$

with:
m: amount of water at time t

The capillarity rise or B-value, is also linear as a function of the square root of time, as:

$$B = \frac{h}{\sqrt{t}}$$

where:
h: the water height in cm

<u>Water vapor permeability and diffusion resistance coefficient μ-value (EN ISO 12572)</u>

The water vapor permeability is the quantity of water vapor passing per time unit and surface units through a porous material under isothermal conditions. Fick’s law describes this phenomenon:

$$\delta = A.d/S.\ P_{(v)}$$

where:
δ = water vapor permeabilty
d = thickness
S = surface area
$P_{(v)}$ = partial water vapor pressure
A = coefficient of proportionality between the weight loss and the time

Two units are used: δ = g/m.h.mmHg or the System International (SI) kg/m.s.Pa
With: 1 g/m.h.mmHg = $20.8.10^{-10}$ kg/m.s.Pa

The diffusion of the water vapor in the air is not direct and we can also determine the diffusion speed and the water vapor permeability of an air layer, with air pemeability at: 0.09 g/m.h.mmHg or $1.9.10^{-10}$ kg/m.s.Pa
The water vapor diffusion resistance coefficient of a material is the ratio of the air permeability to its own permeability:

$$\mu = 0.09/\delta$$

This ratio is dimensionless, a material with a μ coefficient close to 1 is a material very permeable to the water vapor, a waterproof material will be characterized by $\mu = \infty$.
The wet cup procedure is followed with the gradient of 100% RH water H_2O to 45% RH controlled room condition. The samples disk used has a diameter of 40 mm and a thickness of 5 mm.

<u>Bi-axial flexural strength</u>

A slice of stone is placed between two steel rings. A load (F) is applied on the sample. First an elastic deformation takes place and allows determining the static E-modulus in kN/mm^2 (E = Young modulus) according to the equation [1]. E static is measured at one third of stress – strain curve The increase of the load results in microcracking in the sample until the breaking point is reached (maximum load); The bi-axial flexural strength (σ_{fb}) expressed in N/mm^2 can be calculated by using equation [2] (Wittmann, Prim, 1983)

$$E = 1.5\frac{F}{f_o}\frac{1}{h^3}(1-\nu^2)\left[b^2 \ln\frac{b}{a} + \frac{(a^2-b^2)(3+\nu)}{2(1+\nu)}\right] \qquad [1]$$

$$\sigma_{fb} = \frac{3F}{4\pi.h^2}\left[2(1+\nu)\ln\frac{b}{a} + \frac{(a^2-b^2)(1-\nu)}{a^2}\frac{a^2}{R^2}\right] \qquad [2]$$

ν = Poisson ratio (ν= 0.25)
a = Radius of the lower ring (a = 18 mm)
b = Radius of the upper ring (b = 6.5 mm)
f_o = Displacement (mm)
h = Thickness of the slice (mm)
F = Load (N)
R = Radius of the stone slice (mm)

<u>Freeze-thaw cycles (DIN EN 12373)</u>

Each cycle consists of a six hour freezing period at -20°C, followed by a six hour thawing period during which the specimen is immersed in water. The cycles are repeated until the specimen fails or a given maximum number of cycles is reached.

The control measurements to determine the freeze/thaw resistance are:

- Visual inspection, which rates the samples on the following scale is done after each cycle:
  - 0 specimen intact
  - 1 very minor change (minor rounding of corners and edges) which does not compromise the integrity of the specimen.
  - 2 one or several minor cracks (< 0.1 mm width) or detachment of small fragments (< 10 mm^2 per fragment).
  - 3 one or several cracks, holes or detachments of fragments larger than those defined for the "2" rating, or alteration of material in veins
  - 4 specimen broken in two or with major crack
  - 5 specimen in pieces and disintegrated

- Measurement of the apparent density (e.g.0)

Measurements of changes in apparent density during the freeze-thaw cycles makes it possible to calculate the total loss of material due to the deterioration. Deterioration is considered to have occurred on a specimen when the reduction in apparent density reaches 1 % of the original apparent density. This measurement is calculated every 12 cycles.

- Measurement of the dynamic modulus of elasticity (Young's modulus)

By measuring the change in the dynamic modulus of elasticity during the freezing-thawing cycles it is possible to detect some deterioration, such as microcracks. It is necessary to dry the samples to constant mass before performing the measurement. The percentage decrease in dynamic modulus of elasticity is calculated as follow:

$$\Delta E = \frac{(E_0 - E_n) \times 100}{E_0}$$

Where E_0 is the initial measurement in a dry condition performed before cycling starts and E_n the measurement in a dry condition after n cycles.
The number of cycles at which the decrease of dynamic modulus of elasticity reaches 30 % shall be noticed.

The test continues until two or more specimen are classed as failed using any of the following criteria:

- the score of the visual inspection attains 3;
- the decrease of apparent density reaches 1 %;
- the decrease of dynamic modulus of elasticity reaches 30 %.

For our study the total disintegration is not necessary and the score 2 or 3 at the visual inspection should be sufficient. Moreover the decrease of the dynamic modulus of elasticity appears to be the most accurate measurement to notice start of cracks in the specimen.

III. Results

III.1. Properties of the fresh tuffs

Table 1 summarizes the physical-mechanical properties of the two tuffs types.

Chengde Quarry	App Density (g/cm^3)	Real Density (g/cm^3)	Nt (%)	N48 (%)	S	Us parll. (km/s)	Us perp. (km/s)	E-Dyn (kN/mm^2)	W (kg/m^2/h$^{0.5}$)	B (cm/h$^{0.5}$)	μ	BFS (N/mm^2)	E-Static (kN/mm^2)
1 (lower)	2.1	2.6	18.5	11.6	0.6	3.1	3.1	20.5	3.6	3.4	34.5	14.5	24.8
1 (lower)	2.1	2.6	18.5	11.9	0.6	3.1	2.9	19.1	3.3	3.1	29.1	12.3	20.6
1 (lower)	2.1	2.6	18.5	11.7	0.6				3.6	3.4	31.8	13.8	28.5
2 (upper)	2.1	2.6	21.8	19.6	0.9	3.1	2.6	13.8	6.1	3.5	30.6	10	15.1
2 (upper)	2.0	2.6	22.3	20.0	0.9	2.6	2.5	14.5	6.2	3.4	29.4	7.6	13.8
2 (upper)	2.0	2.6	22.2	19.7	0.9				5.9	3.4	30.6	10.9	20.7

Table 1. Results obtained on the fresh tuff samples 1 and 2; (3 replicates for each tuff).

The two stones reveal a great difference in their porosities. Indeed, stone 2 (upper) showed a higher total porosity than stone 1 (lower) (Nt, measured under vacuum) and also a free porosity (N48, porosity open to water by capillary) (Figure 1). It demonstrates that stone 2 (upper) has higher pore connectivity, which allows the water to penetrate easily by capillary.

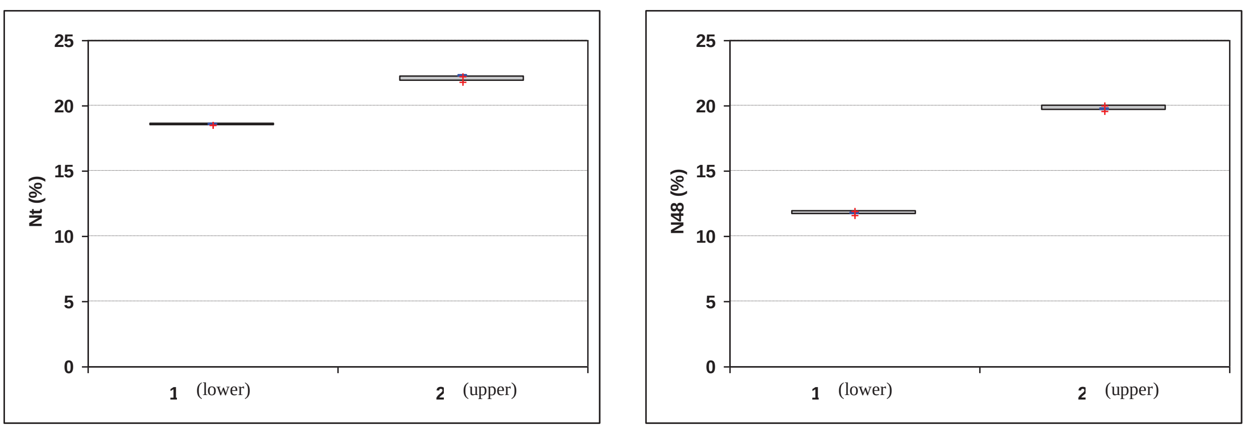


Figure 1. Total porosity and free porosity at 48 hours measured on stone 1 and 2.

These properties lead to a greater Saturation coefficient or Hirschwald coefficient, which potentially indicates susceptibility of stone to freezing damage (Figure 2).

Hirschwald coefficient ranges determine the susceptibility of a stone to frost:
$S > 0.85$ susceptible; $0.75 < S < 0.80$ moderate resistance; $S < 0.75$ frost resistant

As well, a coefficient at 0.9 might reveal a high susceptibility to frost damage, while a coefficient of 0.6 may show a stone resistant to frost damage (Hirschwald J., 1908).

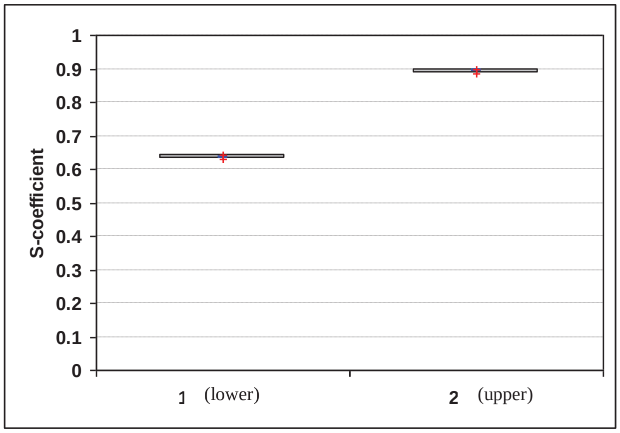
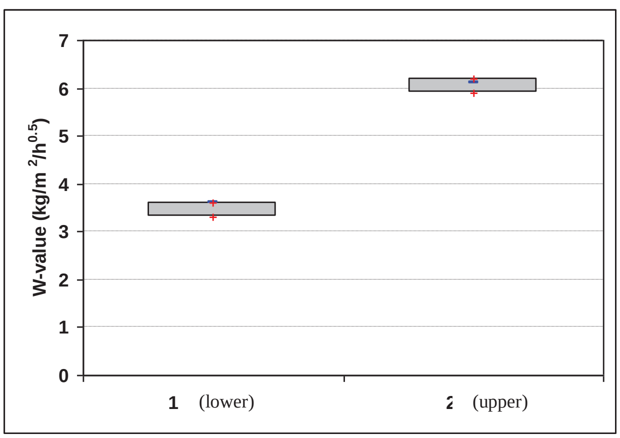


Figure 2. Saturation coefficient measured on stone 1 and 2.

Additionally, the stone 1 (lower) reveals also a lower water uptake coefficient, higher moduli of elasticity and strength (Figure 3 and 4), which explains its better durability.



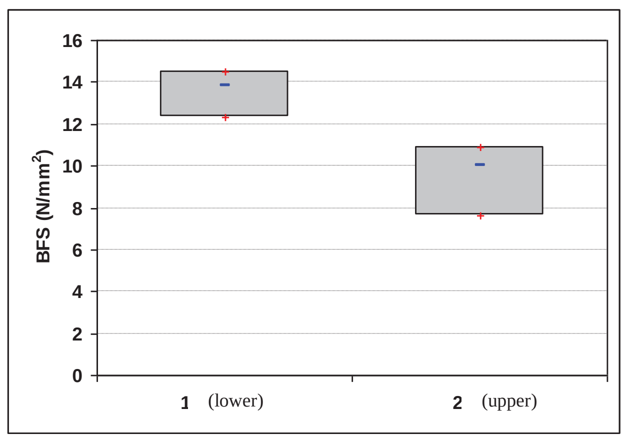


Figure 3. Water uptake coefficient measured on stone 1 and 2; Figure 4. Bi-axial Flexural Strength.

Capillary rise (B-value) as well as the water vapor resistance coefficient (μ) doesn't show any further distinction between the two samples (Table 1).

Moreover the two samples present different specific surface area (BET) (Figure 5). The tuff 2 (upper) shows a specific surface area twice as high as the tuff 1 (lower). High surface area indicates a greater percentage of very fine pores, higher in the tuff 2 (upper) than in the tuff 1 (lower), pores < 0.1 μm. The presence of very fine pores may involve an increase of the water absorption but may also lead to more damage. In fact, thermodynamic properties play a great role in the susceptibility of a stone to frost damage. Several authors (Everett, 1961; Fitzner and Snethlage, 1982) explain that small pores connected to larger pores could show a more damaging effect when a stone is exposed to frost. For thermodynamics reasons the pressure applied on the pores walls is proportional to their size, and mechanical failure may occur if this pressure exceed the strength of the porous material. The following equation shows that the pressure *p* is greater more the pore sizes of the material are different:

$$p = 2\sigma\ (1/r - 1/R)$$

where σ is surface tension; r is radius of the small pores; and R is radius of coarse pores. Therefore, water may stay liquid in the smaller pores (below 0.1 μm zone of capillary condensation) and serves as a substantial reservoir for the growth of the ice crystals in the coarse pores. If the coarse pores are filled up with crystals, these tend to grow into the small adjoining pores.
The higher amount of fine pores of the stone 2 (upper) demonstrated by BET measurement could be the main factor leading to faster damage (Figure 5).

Study on tuffs from Italy and Ecuador (Rossi-Manaresi, 1990) shows the influence of wet/dry cycles. Indeed, molecular layers of liquid water can be structured in very fine pores and exert as much pressure as crystalline water. In thin pores the entire volume of the pores is filled by water and can exert pressure on the pore walls. The authors calculated the different pressure related to each class of pores of two different tuff and prove that the total pressure generated in one of the tuff by its high percentage of fine pores, greatly exceed its compressive strength; mechanical failure can be very rapid.

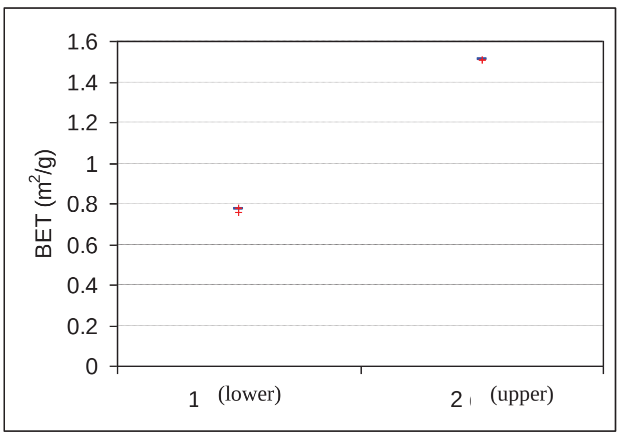


Figure 5. BET (Specific Surface area, m^2/g) measured on the two stones.

III.2. Properties of aged tuffs

By measuring the dynamic modulus of elasticity it is possible to monitor deterioration and determine the freeze/thaw resistance of the samples.
The dynamic modulus of elasticity of the tuff 2 (upper) decreases after 12 freeze-thaw cycles while tuff 1 (lower) remains stable (Figure 6). The internal decay is manifest even if it is not necessarily visible from the external face of the samples (Figure 7); then after 70 freeze-thaw cycles, the tuff 2 (upper) shows a decrease of 66 % of the dynamic modulus of elasticity, while a level 3 of observation of the stone decay is observed (one or several cracks are visible) (Figure 9). Level of observation 4 was also noticed (specimen broken in two or with major crack) for one of the sample of tuff 2 (upper) (Figure 9). No decay was observed on the tuff 1 (lower) after 70 freeze-thaw cycles (Figure 10), but a decrease of 10% of the dynamic modulus of elasticity reveals some changes in the internal stone structure.

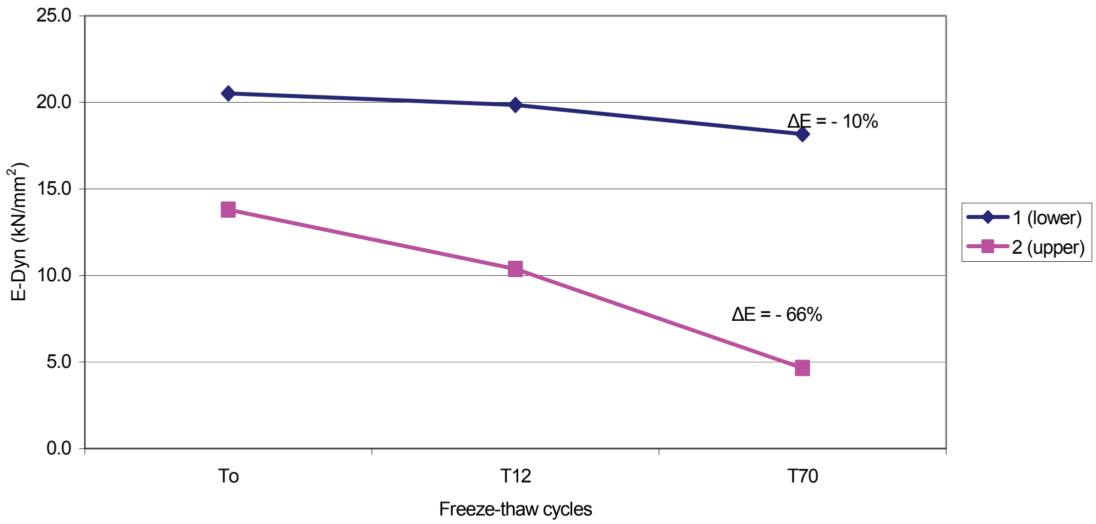


Figure 6. Dynamic modulus of elasticity measured at T_0 , 12 cycles and after 70 cycles.

Figure 7. The two stones after 12 freezing-thawing cycles (8cm height). On the left hand side the stone 1 (lower) and on the right hand side the stone 2 (upper) – samples don't show any external damage.

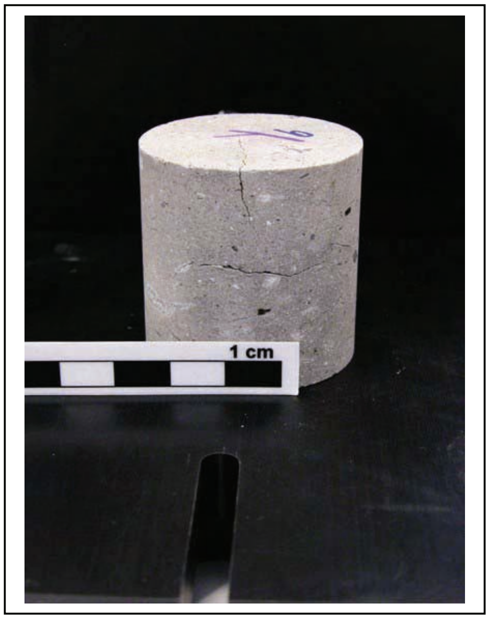
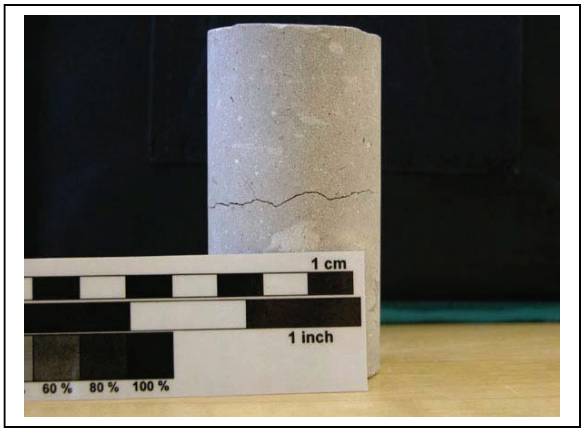


Figure 8. A smaller sample (4cm height) of stone 2 (upper) after 12 freezing-thawing cycles shows cracks parallel as well as perpendicular to the banding.



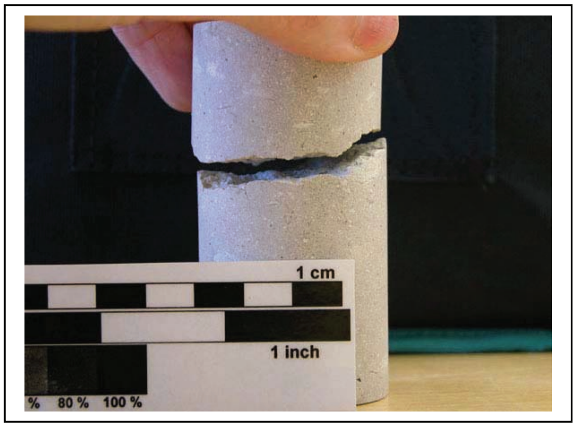


Figure 9. Stone 2 (upper) after 70 freezing-thawing cycles- Sample on the left hand side shows a level 3 of decay with open cracks, while sample on the right hand side shows a level 4 of decay, the sample is broken in two.

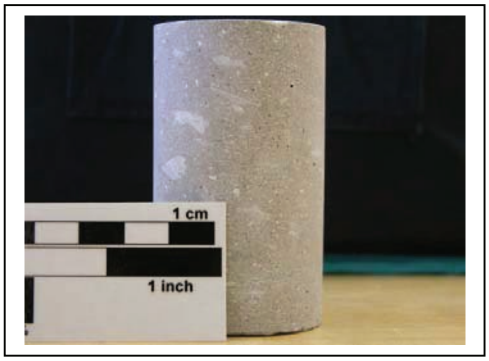
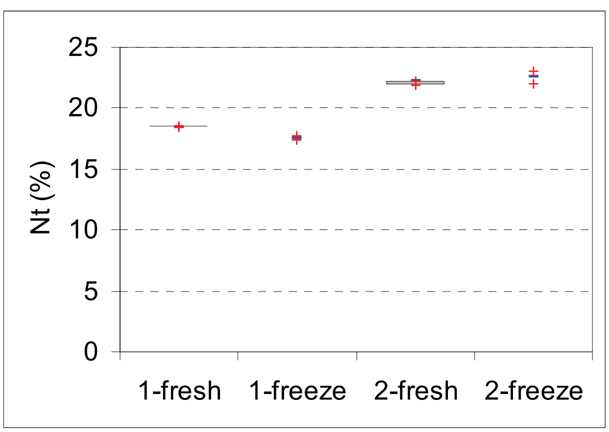


Figure 10. Stone 1 (lower) after 70 freezing-thawing cycles – no deterioration can be observed.

Changes of physical properties can also be observed after freeze-thaw cyles (Figure 11). The total porosity Nt (measured under vacuum) is quite similar for both tuffs before and after aging, while the free porosity N48 (measured under atmospheric pressure) reveals a slight increase for the tuff 1 (lower) and a clear increase for the tuff 2 (upper). Such a measurement shows that freeze-thaw cycles change the porosity structure of the material. Crystallisation pressure developed within the pores may have modified and increased the pore connectivity. Therefore, the saturation coefficient or Hirschwald coefficient is also increased for both tuffs (Figure 12); the saturation coefficient of the tuff 1 (lower) passed from 0.6 to 0.7 and can be still considered as frost resistant (<0.8), while the tuff 2 (upper) almost reached a saturation coefficent of 1. Free water can penetrate pore network more easily after freeze-thaw cycles and fill the whole pore structure for the tuff 2 (upper).



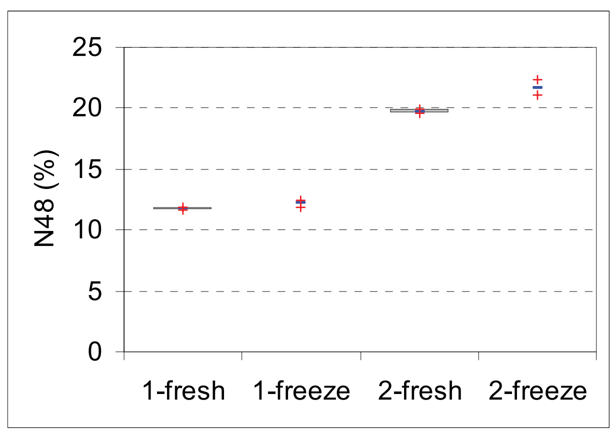


Figure 11. Total porosity and free porosity at 48 h. on the two tuffs before and after freeze-thaw cycles.

Changes in the pore network due to freeze-thaw cycles influence slightly the water uptake coefficient. Indeed, the tuff 1 (lower) shows a small decrease of the water uptake while the tuff 2 (upper) reveals a slight increase of the water uptake coefficient. Changes of pore structure of the tuff 1 may not have been important enough to have an impact on the water uptake coefficient, total porosity and free porosity were very slightly changed. The decrease observed can be due to a standard deviation; the measurement was done on different samples before and after freeze-thaw

cycles. On the other hand, pore size also has a great influence on the capillarity and may have been modified such that the pore size negative influence the water uptake coefficent.
As well, the high quantity of fine pores in the tuff 2 (upper) as it was proved through the BET measurement, may have influenced the pore network after freeze-thaw cycles, increasing the free porosity and the water uptake coefficient.

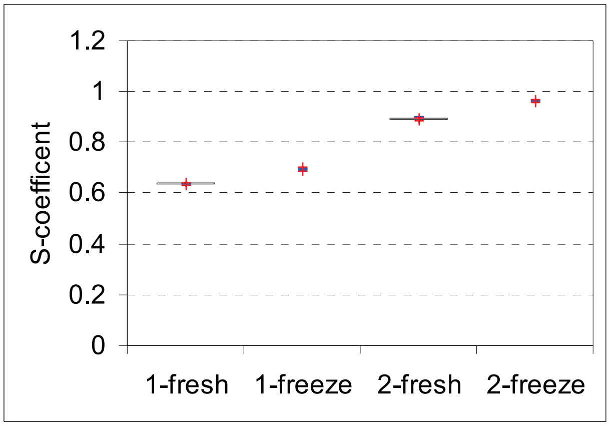


Figure 12. Saturation coefficient on the two tuffs before and after freeze-thaw cycles.

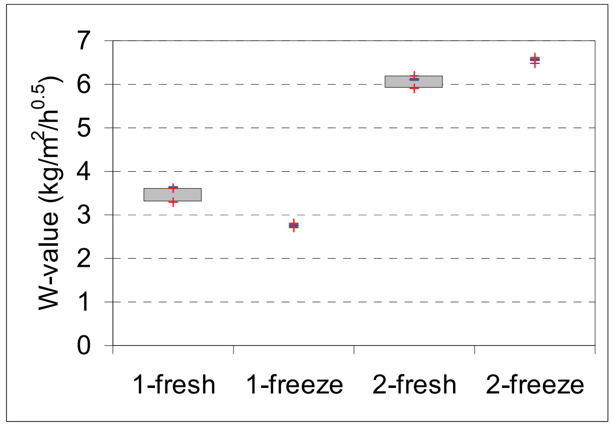


Figure 13. Water uptake coefficient meseasured on the two tuffs before and after freeze-thaw cycles.

IV. Conclusion

Pore properties influence directly the resistance of the two tuffs to frost damage. The high pressure that develops in fine pores may lead to greatest change in the pore network increasing pore connectivity and the capillarity of the stone. Crystallisation pressure on the pore walls can exceed the strength of the material and mechanical failure can occur very quickly; It has been proven through the measurement of the modulus of elasticity and visual observation: tuff 2 (upper) illustrates the characteristics of a highly decayed stone (66% decrease of the modulus, state 3 and 4 of visual decay), while tuff 1 (lower) stays intact after 70 cycles.
Therefore, both objectives above were positive. Differences in two types of tuff can be attributed to different porosity and pore size distribution.

V. Futher considerations

Is it possible to equate number of freeze-thaw cycles in laboratory testing with freeze-thaw weather data for the site?

VI. References

Everett D.H., 1961, *the thermodynamics of frost damage to porous solids*, The Faraday Society, Scotland, pp.1541-1551.

Fitzner B., Snethlage R., 1982, *Einfluβ der Porenadienverteilung auf das Vermitterungsverhalten ausgewählter Sansteine*, Bautenschutz und Bausenierung 3, pp. 97-103.

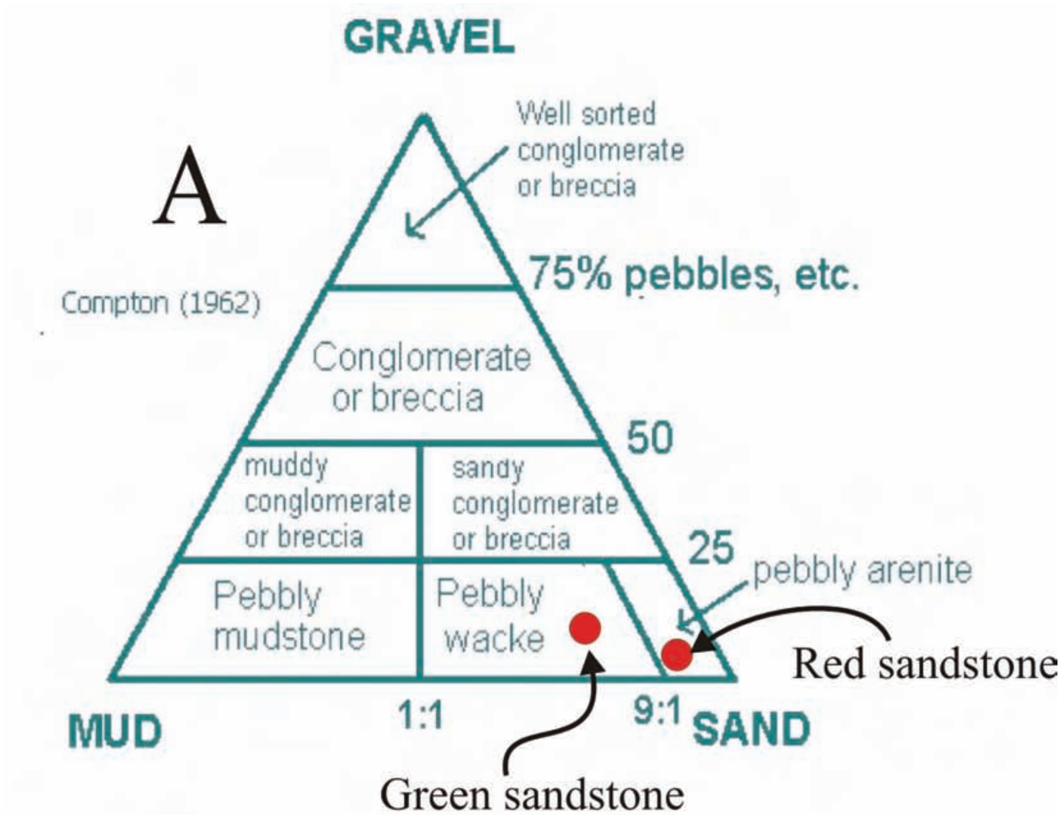
Hirschwald J., 1908, *Die Prüfung der natürlichen Bausteine auf ihre Wetterbeständigkeit*. Berlin: Verlag von Wilhelm Ernst and Sohn.

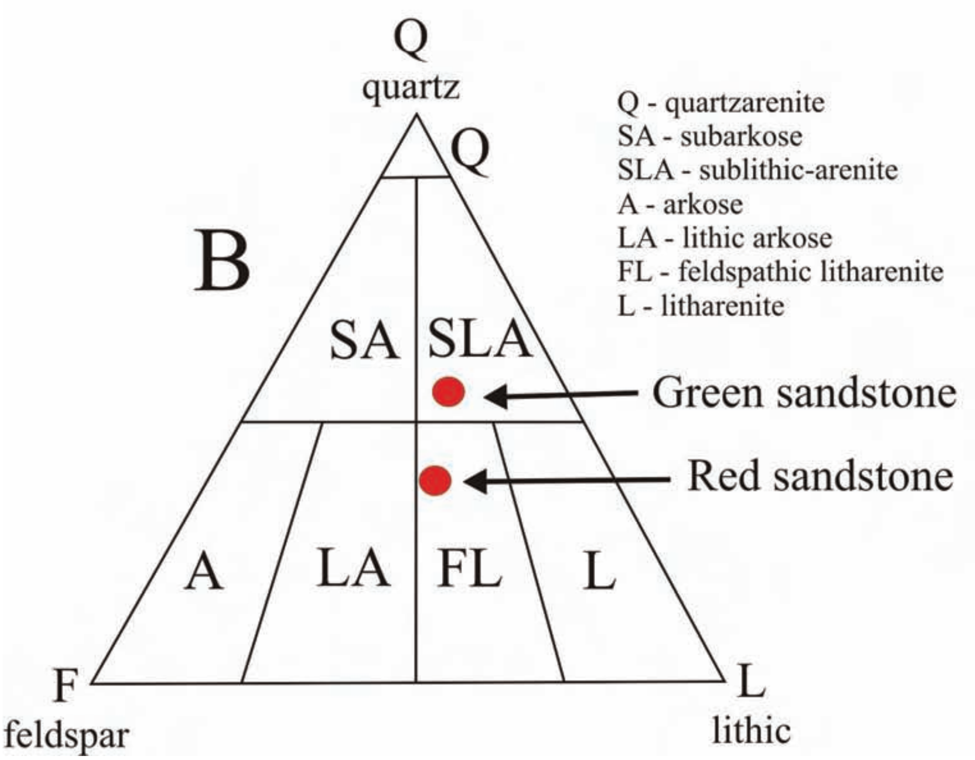
Rossi-Manaresi R., Tucci A., 1990, *Texture and mechanical disaggregation of tuffs from Italy and Ecuador*, Lavas y tobas volcanicas: trabajo presentados a la Reunion International, Isla de Pascua, Chile, pp.73-81.

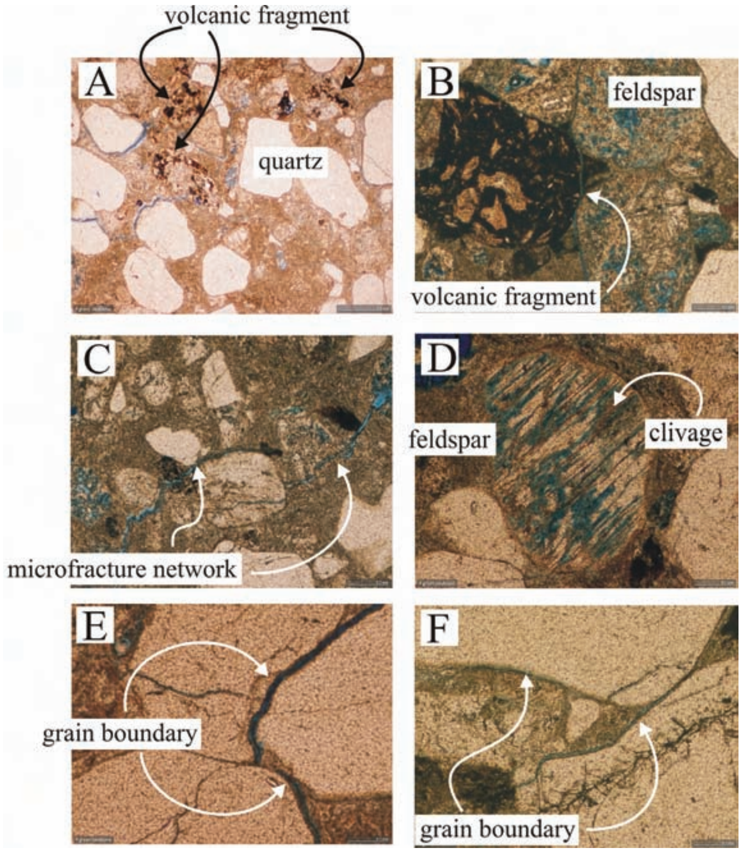
Wittmann F.H., Prim P., 1983, *Mesures de l'effet consolidant d'un produit de traitement*, Matériaux et Construction Vol.16 N.96 pp.235-242.

GREEN SANDSTONE	
Volcanic sandstone, matrix supported – Framework grains are floating in a finer grained material (the matrix); grain size: 1 - 0.3 mm (coarse-medium sand)	
Wacke – Sandstone with > 10-15 % mud (ternary diagram A)	
MATRIX	clay with silt-sized particles of quartz and other minerals
FRAMEWORK	Grain Size: between 1 and 0.05 mm; well rounded, moderately sorted
quartz	Quartz predominantly occurs in monocrystalline grains, rarely with undulatory extinction
feldspar	Orthoclase and microcline (Sanidine ?). They show the effects of alteration (growths of micro-crystalline clay minerals along cleavage planes)
lithic fragments	prevailing fine-grain volcanic rocks, greatly altered
POROSITY	secondary porosity is very abundant: along grain boundary; cleavage plain in feldspar, in mi-crofractue network
SUB LITHIC-ARENITE	

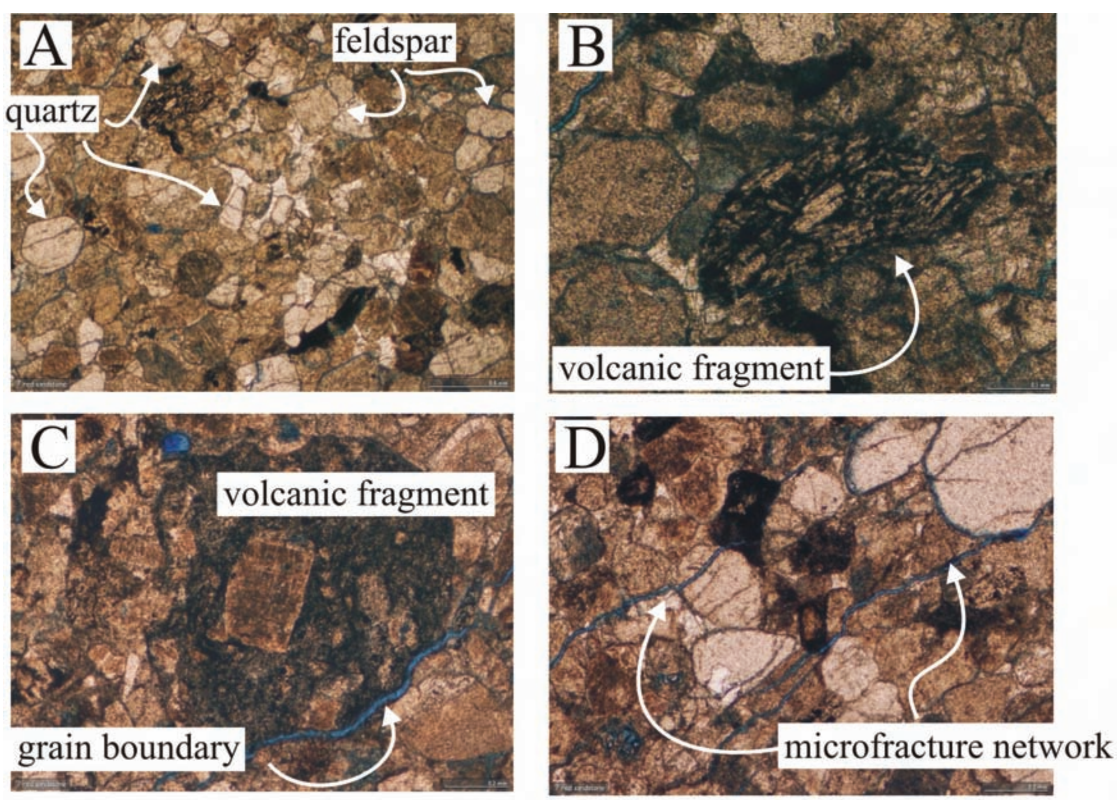
RED SANDSTONE	
Volcanic sandstone, clast supported – Framework grains are in contact with one another; grain size: 0.5 - 0.005 mm (medium- very fine sand)	
Arenite – Sandstone with < 10-15% mud (ternary diagram A)	
CEMENT	Calcite, common cement in sandstones does not tend to fill all pore spaces completely, but occurs as patchy cement.
FRAMEWORK	Grain Size: between 400 and 50 microns, well rounded, moderately sorted
quartz	Quartz predominantly occurs in monocrystalline grains
feldspar	Feldspars more abundant than quartz; less altered than Green sandstone.
lithic fragments	prevailing fine-grained volcanic rocks, greatly altered
POROSITY	secondary porosity is very abundant: along grain boundary and in microfracture network
FELDSPATHIC LITHARENITE	


GRAVEL
A
Well sorted conglomerate or breccia
75% pebbles, etc.
Compton (1962)
Conglomerate or breccia
50
muddy conglomerate or breccia
sandy conglomerate or breccia
25
pebbly arenite
Pebbly mudstone
Pebbly wacke
Red sandstone
MUD
1:1
9:1
SAND
Green sandstone


Q
quartz
Q
Q - quartzarenite
SA - subarkose
SLA - sublithic-arenite
A - arkose
LA - lithic arkose
FL - feldspathic litharenite
L - litharenite
B
SA
SLA
Green sandstone
Red sandstone
A
LA
FL
L
F
feldspar
L
lithic



PLM microphotographs of green sandstone



PLM microphotographs of red sandstone

Huicheng Hall, Shuxiang Temple, Chengde

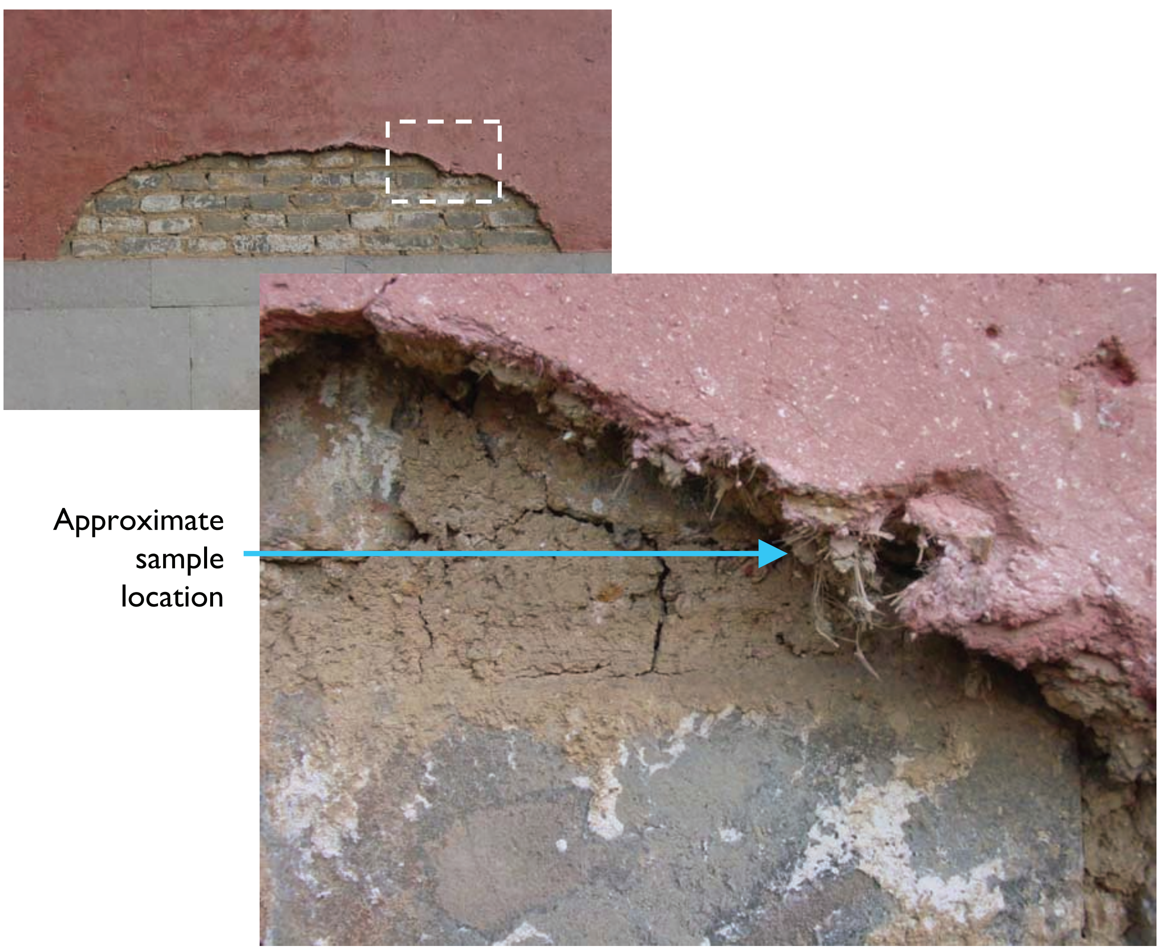
Sample #: **SX.HC.F02.S05 (SXE)**

Sample location: sample was collected from an area of loss of the exterior wall plaster from the west facade Sample was collected in September 2002.

Sample description: sample contains a pink-colored upper layer of plaster on a lower clay plaster base.

Sampling rationale: to characterize the plaster used on the building exterior.

Analysis: optical microscopy, thin-section, ESEM/EDS



SX.HC.F02.S05

Summary of Analytical Investigation Results

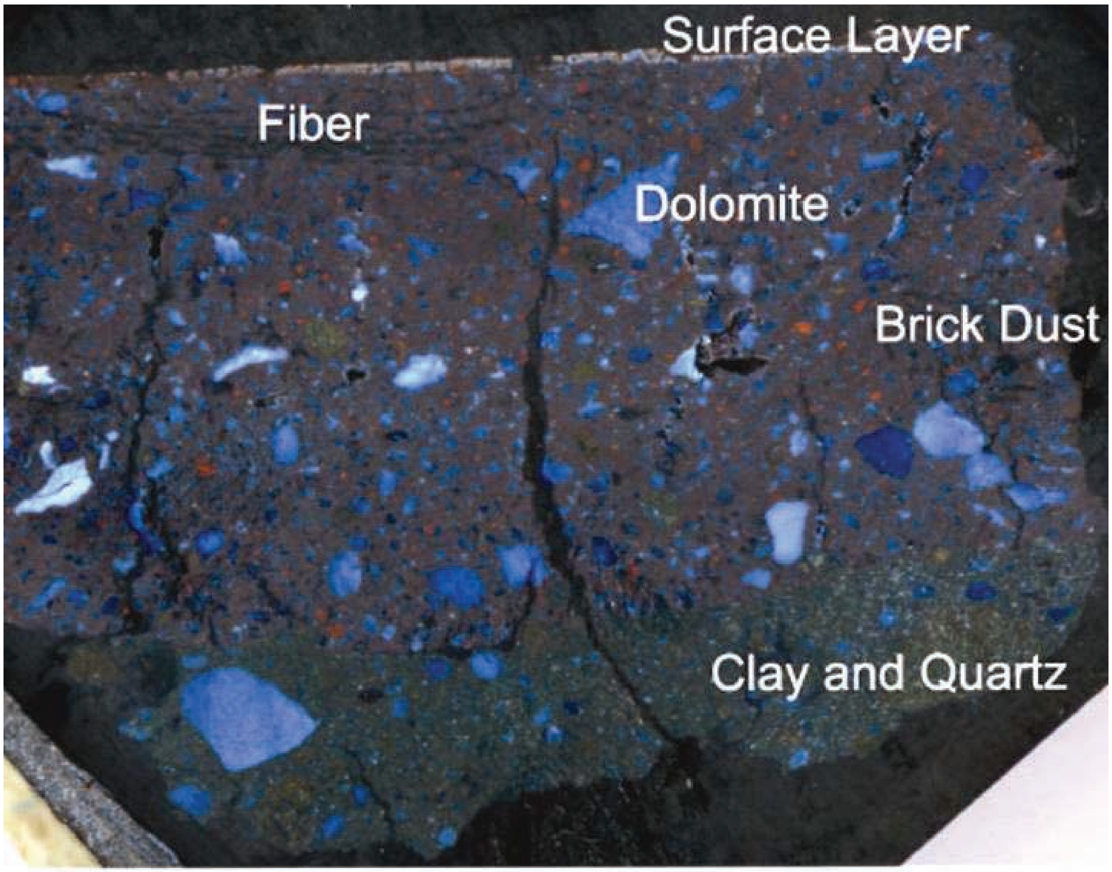
Plaster:

Sample has two easily distinguishable layers, the first is an earth-based plaster found to contain clay and quartz. The upper plaster is lime plaster with a dolomitic limestone aggregate and crushed red brick dust. The brick dust gives the plaster its pink color. Fibers are visible.

Layer 1 Clay plaster

Layer 2 Pink-colored plaster

SX.HC.F02.S05



Polished thin-section of SX.HC.F02.S05

Sample measures 2cm across. The thin-section shows the texture of the sample. The major features are fibers, complex iron rich aluminosilicate particles (most likely brick dust), dolomite aggregate in the upper plaster layer and clay and quartz in the lower plaster layer.

The sample is characterized by several parallel layers. From top to bottom, these include a surface layer that includes aluminosilicate dust, the main lime plaster layer containing brick dust, dolomitic limestone aggregate and fibers (straw?), and a lower base layer containing quartz aggregate in a clay matrix.

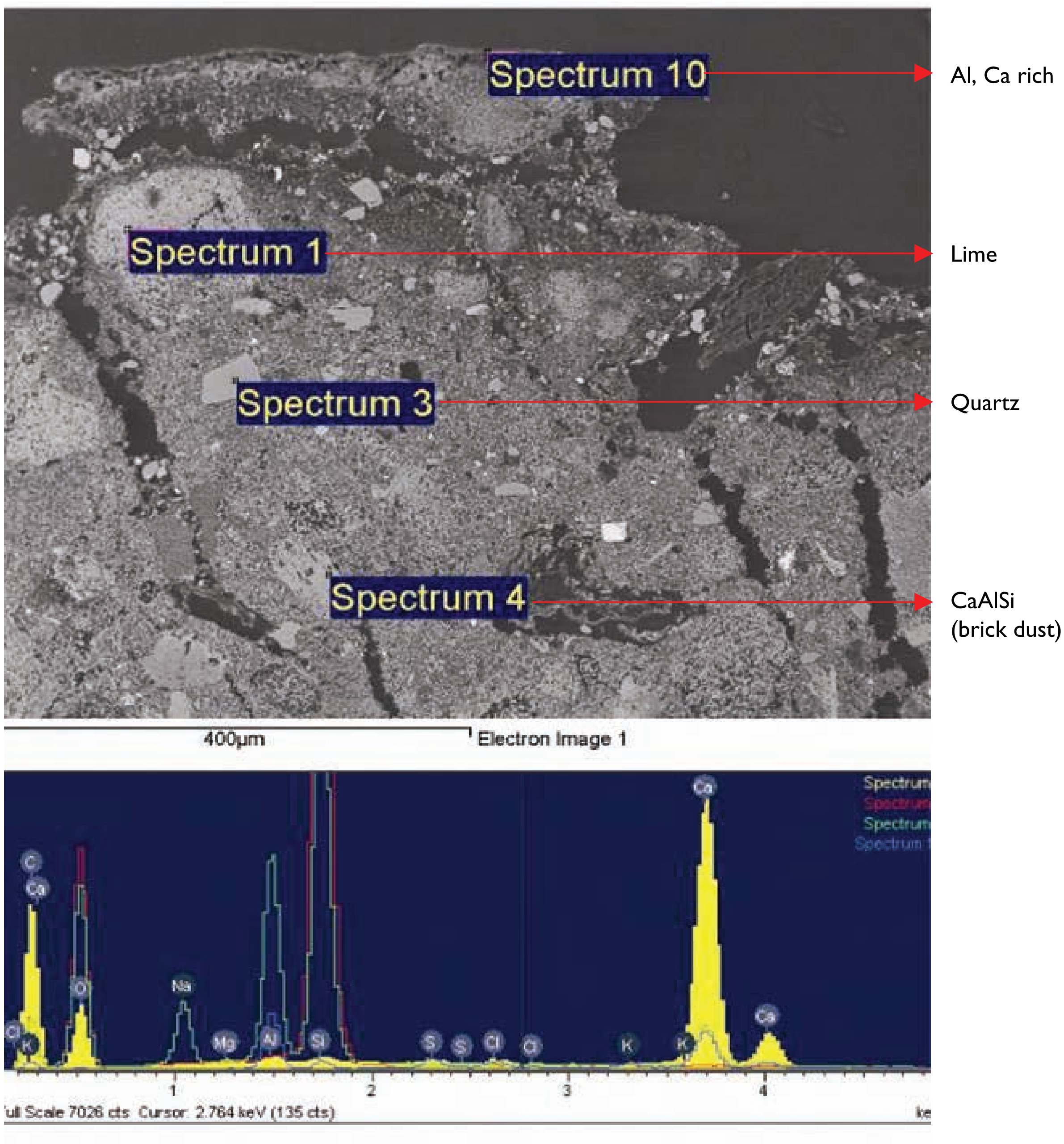
Orientation: Particles and pores are randomly oriented; some areas of the section are occupied by single large aggregate grains.

Structure: grains angular to subangular; some large aggregate grains but bulk amount of the sand-silt sized grains well sorted; moderate amount of clay and fine silt in lower layer; some air voids and interstitial pores

SX.HC.F02.S05

SEM Dot map and Spectra

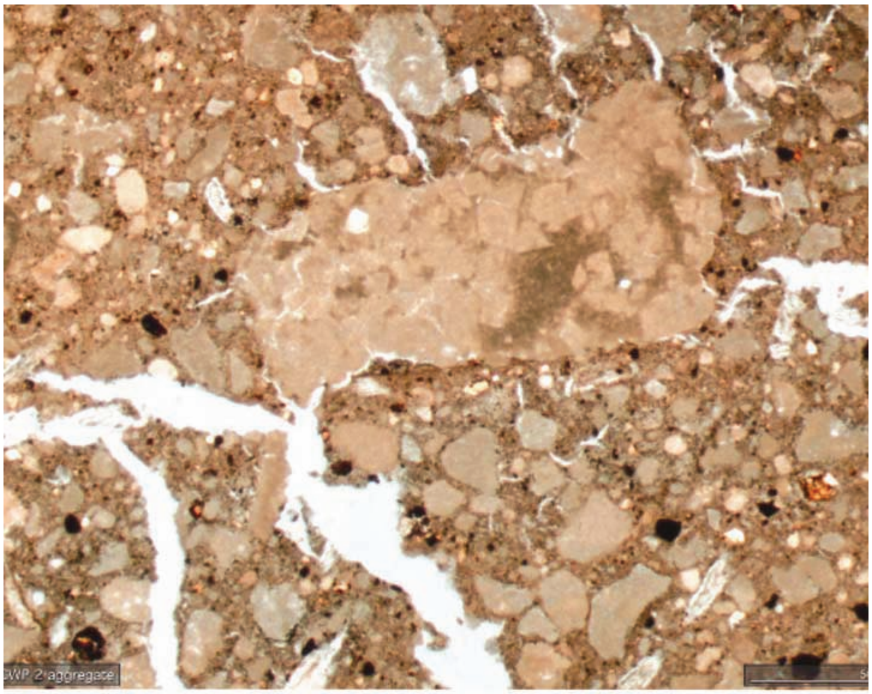
The results document the elemental composition of the plaster sample including grain size and distribution of phases in the plaster sample. Complex iron-rich aluminosilicate particles are present, which appear to be crushed brick dust.



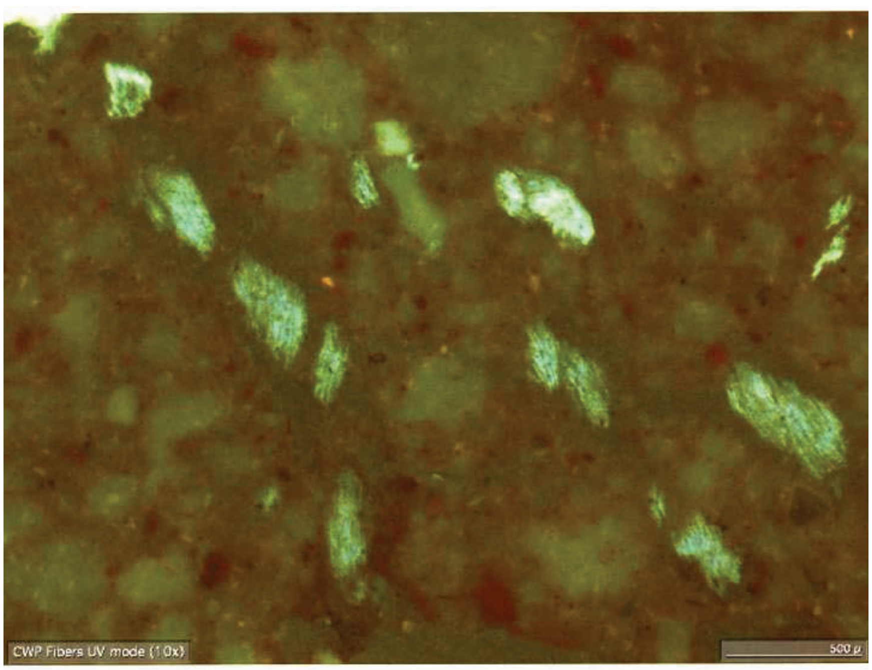
SX.HC.F02.S05

Optical Microscopy

Optical microscopy of the thin-section in PLM and UV micrographs. The iron-rich areas in the ESEM correspond to the red particles in the optical microscope.



Polished thin-section, in transmitted light



Polished thin-section, in UV reflection mode showing fluorescence of fibers.

附件3: 调查记录表
Appendix 3: Survey Tables

	立面	左尽间	左稍间	左次间	明间	右次间	右稍间	右尽间
台基	南	顶端压面石完好，其它局部片层剥落，微小裂隙发育，外表有颜料污迹；陡板石保存较好，外表轻微风化。	压面石边缘微小裂隙发育，陡板石保存较好，底部风化个别边缘剥落。	压面石边缘裂隙发育，局部表皮分层剥离；台阶边缘剥蚀，边部植物生长，西侧垂带片状剥落。	当中压面石完好，其它表皮剥蚀不平，局部较重2厘米深，并有较长裂隙；台阶边缘剥蚀，有生物生长。垂带局部片状剥落，颜料污迹。	压面石普遍表皮剥蚀，局部剥蚀达3－4层；台阶石边缘、表皮普遍剥蚀，边部生物生长，有颜料污迹。	压面石保存较好，轻微风化，个别缺失1角并破裂；陡板石完好。	顶端压面石少许龟裂风化，另一局部深度风化并失2　角；陡板石中度风化风化，深2厘米
	西		压面石表面水蚀凹痕，；陡板石1块风化严重；2块表皮稍风化。	压面石完好，有砂岩和鹦鹉岩两种；陡板石风化，分层（表皮剥离）起甲脱落，最深处达4厘米；边缘局部崩落。边部生物生长。	压面石接缝处少许风化；个别陡板石风化，严重者深达2厘米；陡板石外闪2厘米；	压面石边缘少许风化、起甲，表皮空鼓；陡板石外闪2厘米；	压面石空鼓，表皮脱落，避雷针铁锈污染；陡板石风化，1角脱落；	
	北	压面石外表局部轻微风化剥落，有水泥浆痕迹，水泥勾缝；陡板石轻微外闪。	压面石较大面积片状剥落，1块稍外闪。内侧石条风化并与墙体产生缝隙。	压面石外表轻微风化，有雨水滴形成麻点，边角脱落。	压面石保存较好，有雨水滴形成麻点(外表水侵蚀)；	压面石外表轻度风化并剥落，外表有水侵蚀形成的凹痕，边角脱落。有生物生长，潮湿痕迹	压面石局部表皮剥落，底部外表析盐；	压面石接缝处风化，外表水侵蚀；陡板石表皮脱落3层。生物生长，局部析盐。
	东		压面石1块外表轻度风化、水蚀凹痕，下边缘脱落；陡板石接缝处轻微风化。	压面石1块边部轻度风化，缺失1小角；一块鹦鹉岩色泽明显不同。2块陡板石中度风化，陡板石外闪2厘米。	压面石完好；陡板石外闪5厘米，轻度风化，边角剥落，个别开裂。	压面石完好；陡板石外闪3－4厘米，轻微风化，其中1块大面积剥落和水蚀凹痕。台面有灰浆残留物。	压面石完好；2　块陡板石风化较重，其它边部轻度风化。	

	立面	左尽间	左稍间	左次间	明间	右次间	右稍间	右尽间
台基	南	（角柱）柱顶石完好； 槛下石完好；	柱顶石完好； 槛下石表皮风化不平；柱础室外部分普遍有沉积物。	柱顶石风化，外表有粉末，盆唇边缘脱落； 槛下石完好。	左柱顶石完好；右柱顶石边缘轻度风化； 槛下石完好。	柱顶石完好，局部有麻点。 槛下石完好，局部有麻点。	柱顶石完好； 槛下石完好。	柱顶石较好，边缘轻微风化，鸟粪污染； 槛下石完好。
	北			柱顶石多道裂纹，盆唇中度风化； 槛下石普遍麻面（水滴），个别断裂。	左柱顶石多道裂纹，表面剥蚀，盆唇边缘已失；右侧柱顶石四道裂纹，外表剥蚀，堆积鸟粪。槛下石为1整块，2道通裂缝，有麻点。	柱顶石局部破碎、空鼓，鸟粪； 槛下石浅表皮风化，有潮湿痕迹。		
	室内柱顶石	室内柱顶石完全完好者3块，其它不同程度风化，4枚盆唇风化片甲剥落；其它础底四边风化，3 块有3－4道断纹。						

	立面	左尽间	左稍间	左次间	明间	右次间	右稍间	右尽间
上 层 斗拱	南		斗拱6朵； 正心枋有漏雨痕迹。（斗拱略向西歪斜），彩画地仗崩裂。	8朵斗拱，檩条后换，平身斗拱昂嘴开裂3。	8朵斗拱， 檩条端部开裂，环状劈裂。 左柱头昂开裂。 挂匾铁钩造成檩条开裂。	8朵斗拱， 大斗、柱头昂开裂。檩条有彩绘，但左半部糟朽、断裂。	6朵斗拱， 正心枋有水啧，檩条右端糟朽，昂嘴劈裂2。	
	西			后补檩条。	檩条地仗局部脱落；	个别斗拱构件掉落；斗拱略向西倾斜。		
	北			基本完好。	；仅见柱头斗拱昂劈裂。	可见个别斗拱构件被修补过。		
	东			5朵斗拱， 斗拱完好，上层小斗松动、少许错位。	8朵斗拱， 上层小斗松动，柱头斗拱外倾，檩条外移，缺小斗3，残耳5个。	5朵斗拱， 上层小斗松动，后补小斗5，昂嘴劈裂3。檐檩后换。		

<table>
<tr><td></td><td>立面</td><td>左尽间</td><td>左稍间</td><td>左次间</td><td>明间</td><td>右次间</td><td>右稍间</td><td>右尽间</td></tr>
<tr><td rowspan="4">上 层
檐椽</td><td>南</td><td colspan="2">翼角13根，平身8根，</td><td>16根</td><td>16根</td><td>16根</td><td colspan="2">平身8根，翼角13根</td></tr>
<tr><td>西</td><td colspan="3">翼角13根，平身5根</td><td>14根</td><td colspan="3">翼角13根，平身5根</td></tr>
<tr><td>北</td><td colspan="2">翼角13根，平身8根，</td><td>16根</td><td>16根</td><td>16根</td><td colspan="2">平身8根，翼角13根</td></tr>
<tr><td>东</td><td colspan="3">翼角13根，平身5根</td><td>14根</td><td colspan="3">翼角13根，平身5根</td></tr>
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	立面	左稍间	左次间	明间	右次间	右稍间
上层平板枋、额枋	南	小额枋下沉，与大额枋分离7厘米，有大量鸟粪。大额枋有彩绘，但地仗空鼓。	大额枋4道箍，保存较好，小额枋中部崩裂3厘米，并下部向外扭闪。平板枋在柱头处断开。	大额枋有彩画地仗空鼓，小额枋局部外露，细水平裂缝。平板枋在柱头处断开。	大额枋有彩绘，小额枋局部外露，外边角劈裂。平板枋在柱头处断开。	均有彩绘，地仗空鼓，大额枋下沉3厘米。
	西	大额枋保存较好，4道箍，有修补木条，小额枋当中有裂纹。平板枋与大额枋分离10厘米，大额枋下沉。		大额枋有彩绘，小额枋局部外露，显裂纹。额枋下沉。	大额枋完好，当中有修补木条，小额枋有较宽裂缝，左端东移。额枋下沉10厘米。	
	北	大额枋有彩画，大小额枋分离7厘米，小额枋有斜向开裂。平板枋在柱头处断开。	局部有彩画，大额枋端部开裂，小额枋较好，平板枋在柱头处断开。	均有彩画，平板枋在柱头处断开。	局部有彩画，额枋上部或边角有通长开裂。平板枋在柱头处断开。	小额枋、平板枋彩画，大额枋上见修补木条。平板枋在柱头处断开。
	东	均有彩画，大额枋下沉5厘米，木材保存较好。有蝙蝠粪便。		均有彩画，大额枋右端下沉12厘米，拔榫3厘米，左侧下沉8厘米。平板枋在柱端翘起。有蝙蝠粪便。	大额枋左下沉10厘米，右下沉4厘米，端部平板枋折断，小额枋有裂缝（斜）。	

	立面	左稍间	左次间	明间	右次间	右稍间
上层屋面	南	戗脊上瓦陇8，围脊下14陇。2勾头残。	围脊下17陇，2勾头残。	围脊下17陇。	围脊下17陇。	围脊下14陇，戗脊下8陇，勾头残1。
	西	戗脊下8陇，围脊下11陇，勾头残4。		围脊下18陇。	戗脊下8陇，围脊下11陇	
	北	戗脊上瓦陇8，围脊下14陇。	围脊下17陇。	围脊下17陇。 共计勾头残10个	围脊下17陇。	围脊下14陇，戗脊下8陇。
	东	戗脊下8陇，围脊下11陇，勾头残1。		围脊下18陇。	戗脊下8陇，围脊下11陇，勾头残1。	

	立面	左尽间	左稍间	左次间	明间	右次间	右稍间	右尽间
下 层 椽飞	南	翼角13根	14根。	16根。	16根。	16根。	14 根。	翼角13根
	西		翼角13根	10根。	16根；	10根；	翼角13根；	
	北	翼角13根	14根。	16根。	16根。	16根。	14 根。	翼角13根
	东	翼角13根	10根。	16根；	10根；	翼角13根；		

	立面	左尽间	左稍间	左次间	明间	右次间	右稍间	右尽间
下 层 瓦面	南	戗脊下14陇，	围脊下16陇	围脊下17陇	围脊下17陇	围脊下17陇	围脊下16陇	戗脊下14陇，残2勾头
	西		戗脊14陇，围脊下2陇	围脊下11陇	围脊下18陇； 共有4勾头残，6 滴水残	围脊下11陇；	；戗脊14陇，围脊下2陇	
	北	戗脊下14陇，	围脊下16陇	围脊下17陇	围脊下17陇	围脊下17陇	围脊下16陇	戗脊下14陇，共有2勾头残，滴水4残
	东		戗脊14陇，围脊下2陇	围脊下11陇	围脊下18陇； 共有2滴水残	围脊下11陇；	；戗脊14陇，围脊下2陇	

	立面	左尽间	左稍间	左次间	明间	右次间	右稍间	右尽间
下檐斗拱	南	平身3朵，基本完好，正心枋有裂缝。檩条地仗脱落。	平身6朵，斗拱完整。檩条局部地仗脱落。	平身8朵，柱头昂开裂，梁头有裂缝。	平身8朵，柱头昂开裂，3朵平身科斗拱下昂开裂。	斗拱完好，柱头昂开裂。	檩条上有漏雨痕迹，柱头昂开裂。其它完好	3朵，两平身科斗拱昂开裂。
	西		平身3朵，防鸟网内斗拱个别小斗缺失。	平身5朵，完好	平身8朵，柱头昂开裂，其它完好	完好；	防鸟网内斗拱个别小斗缺失。	
	北	（斗拱轻微外闪）	柱头昂开裂，其它完好。	8朵，均修补过，补拱件10，翘2，昂5，小斗40。檩条后部并当中劈裂。	8朵。左柱头斗拱后补，平身科补配昂2，拱3。檩条及外拽枋后补。右梁头开裂。檩条被补配。	8朵，柱头昂、梁头开裂，拱顶板缺，檩条通长开裂。	柱头昂开裂，局部缺拱顶板。其它完好。	完好
	东		3朵，完好	5朵，个别小斗松动错位。	8朵，2柱头昂开裂，2平身科昂开裂（水平缝）。	5朵，柱头昂开裂。	完好。	

	立面	左尽间	左稍间	左次间	明间	右次间	右稍间	右尽间
下檐大小额枋，平板枋	南	平板枋、大额枋有彩绘，小额枋外露，当中水平裂缝2厘米。	平板枋、大额枋有彩绘，小额枋外露，看面有细缝，上下边缘修补加木条。	大小额枋地仗均无，大额枋上部水平通缝2厘米宽，当中修补木条1，小额枋完好。	局部有彩绘。大额枋有通缝3道，端部与平板枋2－3厘米分离；小额枋较好，当中修补木条。	大额枋、平板枋有彩绘，小额枋中部有修补木条。	平板枋、大额枋有彩绘，小额枋通身斜细裂缝，上下边角修补。	平板枋、大额枋有彩绘，小额枋上下边缘劈裂，右端略有拔榫。
	西		构件均完好；	平板枋、大额枋有彩绘，50％外露，大小额枋完好，	地仗70％无，大额枋端部有小裂缝。	局部有地仗（40％），大额枋当中有修补木条，小额枋西水平裂纹。	保存较好，大额枋有崩裂。	
	北	均有彩绘；	均有彩绘	顶部存地仗；基本完好，大额枋有修补木条。表面鸟粪。	顶部存地仗，小额枋完好，大额枋顶部通长开裂。表面鸟粪。	平板枋、大额枋有彩绘，小额枋外露，完好。外表鸟粪。	平板枋、小额枋有彩绘，大额枋外露，通长细裂纹。	均有彩绘
	东		均有彩绘	均有彩绘	均有彩绘	有彩绘，大额枋局部外露，有细长水平裂缝。	均有彩绘，大额枋当中开裂1厘米宽。	

	立面	左尽间	左稍间	左次间	明间	右次间	右稍间	右尽间
石质槛墙或下碱	南	完好，榻板与柱缝隙5－6厘米。	榻板石完好，与柱间缝隙4厘米；立石角破损，底部有15厘米高风化、析盐。				榻板石完好，右侧与柱缝隙4厘米；立石左下角风化、析盐。	完好，仅灰缝不存。
	西		基本完好；边角少许破损，少量起甲，角部底缘有20厘米高（水）污迹。 。	基本完好；边角少许破损，少量起甲，上缘略风化。	表皮轻微风化，过斧痕迹不显。上缘略风化。	表皮轻微风化，过斧痕迹不显。下缘略风化，并有水迹。	表皮轻微风化，过斧痕迹不显。边角轻微破损。毛细裂缝发育。	
	北	卧石毛细发育，立石表面轻微风化，下缘勾水泥；	卧石完好，立石风化析盐，底部外表呈粉磨状。				卧石毛细裂缝发育；立石外表轻度风化，底部风化较重。	卧石完好；立石底部风化，左侧较重。
	东		完好，卧石构造裂缝。	基本完好，外表略水蚀风化，有污迹。	较好，立石局部毛细裂缝发育，边缘轻微破损。	较好，外表轻微风化；一块石上有细微开裂。	较好，外表轻微风化。	

	立面	左尽间	左稍间	左次间柱	明间	右次间	右稍间	右尽间
檐柱	南	大额枋以下地仗无，铁箍表面生锈，木材无明显糟朽，但外表灰黯，表层材质损失，部分木钉不存。	同左，铁箍松，拼缝张开；底部微腐。	西侧深色灰黯，局部裂缝，局部虫洞。	柱颜色较深。底部微腐。	（同左）。垂直开裂，拼缝张开，外表材质损失。	拼缝张开，外表材质损失。外表变灰黯。	同左尽间。
	北	柱头地仗完整。	柱头地仗完整。	底层铁箍上下木块糟朽，上部少量木块轻度糟朽，虫洞，表面木纤维破损。	根部局部糟朽，右柱内部木心糟朽；左柱表面有少量虫蛀。表面有鸟粪。表面被晒灰黯。	1．5米以下木块糟朽，根部深度（6厘米）糟朽，内部虫蛀洞。表面被晒灰黯。	柱头地仗完整。	柱头地仗完整。
槛框	南	中槛中部通裂；下槛不连续通裂，左框环向劈裂，右框外闪，崩裂；	中槛中部通裂；下槛局部开裂，左右框小裂缝。	中槛通斜裂缝；下槛外表磨损，左、右框上下通裂1厘米宽。	中槛两端开裂；下槛较好，左框5道细裂缝，与柱间有缝隙，右框当中通裂。	中槛两端开裂；下槛局部轻度糟朽，左右框均有崩裂。	中槛中部通裂；下槛当中通裂，左框、右框外边角劈落。	中槛中部通裂；下槛较好。左框不连续劈裂缝，右框上下通缝1厘米。
	北			中槛小裂缝；下槛完好，下部木条朽，左框短缝劈裂，右框较好，与柱有缝隙。	中槛中部通裂；下槛较好，左框不规则劈裂，右框有小缝劈裂。	中槛中部通裂；下槛完好，左框较好，右框中部劈裂，与柱间有空隙。		

	立面	左尽间	左稍间	左次间	明间	右次间	右稍间	右尽间
格扇	南	2扇；完整，外观风化，大边较重。	2 扇；完整，外观风化，大边较重；	6扇；完整，外观风化，大边较重；边扇仔边与大边分离。	6扇；完整，外观风化，大边较重。	6扇；2扇格芯后补饰红，其中1／6为原有菱花条，1格芯两侧加木条。	2扇；1扇格芯后补饰红；另1 有4个菱花条后补。	2 扇；1扇仔边后补，端部劈裂。格扇上有后加钉子。
	北			格芯仅1扇完整，2扇缺1／4，2扇缺1／8；大边外表风化；铜饰件仅1 块	格芯3扇完整，其它各缺1／5，或局部缺菱花条，无铜饰件，1 大边通裂。	4扇完整，1扇格芯缺1／3，另一缺1／5，存铜饰件1角；1扇的1大边糟朽。		
横披窗	南	格芯局部破损，缺5个菱花条，上槛立框完好；	格芯完好，上槛完好，局部存地仗，2立框上下通裂。	格芯完好，上槛完好，3立框上下通裂。	格芯完好，仅少1菱花条，上槛上部有劈裂，2边立框有裂缝。	格芯完好，缺菱花条4根；上槛完好，2立框崩裂，右边框竖通裂。	3扇格芯有破损，缺22根菱花条，上槛有细裂缝，1立框上下通裂。	格芯缺菱花条3根，上槛完好；1立框上下通裂。
	北			3扇格芯完好，上槛通长细裂缝，2立框通裂。	2扇格芯完好，1扇全无，上槛完好，局部存地仗，2立框上下通裂。	3扇格芯完好，上槛贯通裂缝，立框完好。		

断面位置	现状描述	备注
横西1排柱（西山墙）	柱枋均有彩画，斗拱完好，各柱有柱门；米黄墙面，绿框；挑尖梁、穿插枋完好，有彩画；稍间存2块天花彩画，其它仅存平綦板，均有水痕；当心间平綦板后换成条状板，另有4块平綦板开裂。	
横西2排柱	当中2柱上部内闪，跨空枋、大小额枋、承椽枋完好，当心间承椽枋略低于两侧，跨空枋及承椽枋间木格糊纸，约2平方米破损，与西3排柱间天花板全部有水痕，彩绘2块完整，2块脱落下垂，1块板崩裂。	
横西3排柱	上下用11道铁箍，每柱16块板拼成，柱完好；挑尖梁、穿插枋完好；西3－4柱间天花彩绘存1块，其它水痕。前金柱油饰崩裂。	
横西4排柱	柱、梁、枋完好；檐部存2块有彩画天花，1块下垂，其它均有水痕；前金柱油饰崩裂。前金柱油饰崩裂	
横东4排柱	当中7架梁随梁底面有通缝，天花彩画2块下垂，其它水痕，1块平綦板缺失，北侧檐部挑尖梁及外拽斗拱后换。	
横东3排柱	大木构件完好，天花存6块均下垂，其它水痕，1块平綦板缺失。	
横东2排柱	当中2柱上部略内闪；南侧中柱南北两侧加方型扶柱支撑跨空枋，北次间上层大小额枋在上层角柱处下垂。两块平綦板缺失，仅存1块天花彩画。	
横东1排柱东山墙）	木构件完好，跨空枋及承椽枋木格糊纸，2平方米破损。	

断面位置	现状描述	备注
纵南1排柱 下层南檐柱	所有门龙木、荷叶墩保存较好；门拴缺失7根；明间小额枋上托横匾；斗拱完好；稍间槛墙20厘米高有轻微风化，在柱础处加重。	
纵南2排柱 金柱	大木构件完好；跨空枋及承椽枋间木格糊纸，纸有破损，少量；西次间缺失木幡杆，木托存。	
纵北2排柱 金柱	东西稍间木格糊纸，纸缺1／3；明次3间跨空枋、承椽枋间为栈板。承椽枋以下佛像背后为栈板墙，有边框，腰槛2道，木板并拼，铁局、木银锭榫固定；栈板两侧原有地仗油饰，栈板保存较好。	
纵北1排柱 下层内檐柱	西尽间、稍间下碱石起碱风化，稍间下部风化严重，有粉末剥落，东稍间下碱30厘米高轻度风化；明间、次间横披窗内加衬板，格扇少门拴2根，1根被截断；西次间内檐斗拱全部补配过，新补构件无油饰，明间6攒斗拱后尾修补过。	

墙体部位 （下碱以上）	现状描述	备注
西山墙	西南角脱落灰皮0。5平方米，西北侧约10平方米，脱落部分四周空鼓，局部空鼓部分有继续坠落危险；灰皮表面局部有小洞（0.5－1厘米）和裂缝；	
东山墙	整体较好，2米以下高度有刻画，2米以下高度颜色不同于上部，应是雨水淋的结果；北金柱处有开裂上下贯通，表明柱子变形，上部有鸟粪。	
北檐墙	东侧局部空鼓，整体较好，2米以下高度有刻画，上部有鸟粪。小空洞处见虫卵。	西侧局部脱落，灰皮沿角柱开裂长1.5米，2米以下高度有刻画。高处有鸟粪。

会乘殿室内陈设物状况描述；（04／05／04）

楠木千佛塔：
东塔：保存完好；一层塔座勾栏不存，塔座8角存有卯口，个别木质滴水缺失；佛龛后衬板松动；
西塔：保存完好；一层塔座勾栏不存，塔座8角存有卯口，须弥座束腰有7个宝珠残；二层勾栏1面缺1栏杆。

石佛台：
佛台侧面及垂带踏步原有木勾栏缺失，存卯口痕迹，式样应同南侧现存部分；西侧踏步南侧垂带外闪错位；其它石件完好；南侧木勾栏两块云板残。
佛台为草白玉石。

东侧佛经格：
1、 两层顶部装饰（毗卢帽）保存完好，顶层橱板完好；
2、 整体经格框架完好。
3、 上三层橱格面板共33块，现存11块为原物，22块后仿制，材质做法改变；底层应有可开启门板22块，现无原物，均为仿制，铜合页、门钹全失。
（内隔板均罩朱漆，立面框架地仗：灰泥麻刀1道，披布灰泥2道，细灰泥上漆；经格面板：4边绿色，当中红地，浮雕部分绿红等色）
西侧佛经格：
4、 两层顶部装饰（毗卢帽）保存完好，顶层橱板完好；
5、 整体经格框架完好。
6、 上三层橱格面板共33块，现存10块为原物，其中9块在原位，23块后仿制；底层应有可开启门板22块，现存原物9块，其中6件在原位；存铜合页8件，门钹5个。（原合页数44块，门钹数33个）

钟架、鼓架
木构框架完好，无缺损；钟架新做油饰，表面有小麻点，铜钟放于钟架旁，铜钟下缘残缺1／2；鼓架地仗龟裂，局部漆皮脱落，鼓无存。

供桌：
大曲腿供桌3，分别在三大士前；三木条桌，分别在三大士前；小曲腿供桌2，放在殿西北角。可移动木踏步1。
上述物品木构架均完好，板面无损。但漆皮地仗脱落，仅有雕刻花饰部分彩绘保存较好。
（供桌地仗灰泥＋麻布2层＋灰泥＋红漆；台面地仗加厚）

评估综述：
1、 木构件干裂（崩裂）较多，额枋、槛框、斗拱均普遍存在，表明建造时木材没有充分风干；
2、 上层建筑质量较差，主要表现在：
    A、 平板枋与额枋结合不紧密，或折断，或在柱头部位故意锯断。应是额枋收缩引起；
    B、 东西两山斗拱均有倾斜，金柱内闪，原因待查。东侧挑檐檩外移带动斗拱变形。
3、 根据调查结果可以确定50年代维修范围和内容：
    A、 檐部瓦面、灰背；围脊、戗脊全部维修过；
    B、 全部上下檐椽飞椽，上檐老角梁，下檐仔角梁更换；
    C、 下层后檐明间斗拱、挑尖梁，东侧少量拱件、小斗，进行了维修，更换檩条？根。
    D、 部分格扇装修。

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Platform 台基	S	paint staining (50s), horizontal cracking towards steps, some vertical cracking, horizontal scaling, W corner in good condition		steps: edge erosion, corner loss, biological growth (plants), scaling W side splay: extensive scaling	steps: edge erosion, corner loss, biological growth (plants and dark algae?), extensive scaling, west end more severe side splay: scaling, paint staining	steps: worst bay, edge erosion, widespread biological growth (dark algae?), extensive corner loss, extensive scaling, paint staining (50s) side splay: localized scaling	basal scaling, corner loss, some erosion, 2nd stone from E corner shows basal and side flaking/scaling		base course of stone is red sandstone, top course is yingwuyan (local volcanic gray stone) – perhaps added later?
	W		sandstone: flaking/scaling and pitting, some basal loss	sandstone: scaling, corner loss, limited basal biological growth (dark algae?) yingwuyan: horizontal surface scaling (5x10cm) and adjacent scaling	sandstone: deep scaling on 1 stone; outward movement	yingwuyan: generally good condition with localized scaling and adjacent scaling; outward movement of sandstone	localized scaling, adjacent scaling, staining (from metal lightning rod), corner loss		base course of stone is red sandstone, top course is red sandstone and whitish-green sandstone– perhaps added later?
	N	selective surface erosion and flaking/scaling; cement intervention in interstices and surface spill; basal erosion and efflorescence	large area of scaling; basal erosion; center stone displacement 2cm out from E stone, continued to W; inner edge has erosion and resulting 3cm gap to wall	severe edge erosion, selective surface erosion and flaking; inner stone scaling W column base: bird droppings, cracking E column base: bird droppings, cracking, edge loss and erosion	extensive scaling on one stone, large crack, pitting, selective surface erosion, basal erosion E column base: bird droppings, edge erosion	selective erosion, scaling, basal biological growth (black algae?) and staining, edge loss, moisture on sill E column base: bird droppings	scaling with adjacent scaling, esp. large area on one stone; basal salt efflorescence	surface erosion and pitting; interstitial edge erosion and loss; severe scaling, biological growth (black algae?), and some efflorescence along side splay of steps	base course of stone is red sandstone, top course is yingwuyan (local volcanic gray stone); only yingwuyan is visible; N walkway and bridge added later (LiL)

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Stone wall base (sill wall) 槛墙 (?)	S	loss of fill between ston and column; basal fill (orig.?)	E column base erosion; basal salt–fretting and loss; scattered staining from repair above		surface erosion; E column base flaking and surface loss	gap between paving stones; flaking of E column base;	lower infill of joint with paving; lower infill and efflorescence	E column base bird droppings; edge erosion; uneven erosion of vertical stones @ edge against columns; gap between paving stones; lower west corner repair	varied stone orientation (bedding planes) and source; horizontal surface tooling (keying of mortar?); use of iron spacers in mortar, allowed to rust to fill mortar joints (WH); copestones darker and w/ different patterns along bedding lines than vertical stones below
	W		corner loss; open vertical joints; upper edge staining and erosion; basal staining up to 20cm @ corner	limited corner loss; open vertical joints; upper edge erosion	limited corner loss; basal staining (rust?); upper edge staining/erosion	basal staining to 5cm high; minor basal erosion	basal staining to 25cm; basal fill (orig. lime–based?); minor surface erosion		
	N	basal erosion; cement fill @ E base; W end has open joint at base; staining	graffiti on W end; severe salt–fretting and loss on entire block height				localized basal salt–fretting and loss; basal staining; E basal erosion and scaling to 25cm	corner fracture; open vertical joints; limited joint erosion; basal staining; localized surface staining	

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Columns 檐柱	S	similar to Further Left Bay	open joints; inner core sound; basal erosion/ rounding	more color (lignin) on W side; upper cracking in one section; localized insect flight holes	basal rounding (erosion)	vertical cracking; open joints; raised grain and bleaching	opening joints; graying; raised grain	graying; raised grain; missing interstitial (joints) wooden pegs; basal rounding and loss of outer layers; splintering	columns are composite pieces: inner solid core surrounded by paneling; cladding is nailed into core, wooden pegs in joints for tension, and iron hoops around circumference; plastering and painting done before stucco on brick walls (column plaster remains behind painted stucco)
	N	intact plaster (at top)	intact plaster (at top)	basal erosion continuing above first hoop; localized flight holes; reamining plaster and paint at top; raised grain	bird droppings; basal erosion; E column gray and bleached; W column shows more color	graying and bleached; basal erosion and loss; surface penetration to 2–3 mm; remnant plaster at top	intact plaster (at top)	intact plaster (at top)	

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Wooden Door Panels and frames 格扇	S			wood color and surface material intact; some plaster and paint remnants; W door – 2 bronze fittings missing; erosion of horizontal surface of threshold	bleached horizontal surfaces; cracking of baffleboard; horizontal cracking of frame; E part of frame has 1cm vertical check; more color and surface material than E with some plaster remnants; visible cutmarks for keying	some door displacement; baffleboard cracking; horizontal surface bleaching; vertical checking of frame up to 1cm wide; graying of threshold and lower frame			All latticework replaced at least once; inner edges of door show multiple cutmarks for keying of plaster; plaster repairs (orig.) often in door frame checks (drying cracks); often extant plaster and paint on baffleboards; extant bronze fittings
	N			similar wood condition; missing lattice pieces	similar wood condition; missing lattice pieces	similar wood condition; missing lattice pieces			
Sill windows and frames 槛窗	S	similar wood condition; E part of of frame cracking to 2cm; W severe cracking and splintering	horizontal surfaces eroded; horizontal frame cracks 2–3cm				horizontal surfaces eroded; E part of frame, vertical base splintered and delaminating;	2 upper bronze fittings extant; surface soft to 2mm; lower part of sill eroded from weathering	some extant bronze fittings; some extant plaster and paint; horizontal surfaces eroded; vertical surfaces generally good with some raised grain
Horizontal windows and frames 横披窗	S	missing lattice pieces	E– extant plaster and paint on frame; vertical crack on W frame 1–2cm	some vertical cracking on frame	missing lattice pieces; upper horizontal cracking	missing lattice pieces; minor vertical cracking in frame	missing lattice pieces	missing lattice pieces	wood condition similar to rest of building

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Plaster/ Stucco	W		band of loss 1m in height with surrounding detachment; large detached piece (0.5m2) suggesting imminent loss	band of loss 1m in height	holes (0.5–1cm diam.); widespread detachment; band of loss begins and continues to N end; surface cracking	large area of loss 1.5m wide; surface cracking; distributed holes 0.5–1cm diam.	widespread cracking; S corner loss	SW corner graffiti; edge loss in upper area	masonry revealed by loss in good shape; minor mortar leaching; hemp string hbeam cap ending from mortar joints used as method for keying plaster; lower register of plaster often brighter in color: dust and dirt occluding upper areas
	N	same as further left bay	W edge erosion (against wood); small area of loss; graffiti to 1m; distributed gouging; small holes (3–5mm diam.); bird droppings				3 areas of localized loss; graffiti to 1m high; distributed gouging; bird droppings staining	lower loss 1.5m long x 0.5m high; vertical cracking; scarring	
	E		large holes (3); graffiti; gouging; color loss; bird droppings	holes; graffiti; gouging	distributed holes; cracking on lower register; graffiti	graffiti; gouging; cracking at column (vertical); small holes	similar to N facade; graffiti higher up; gouging; bird droppings		small holes caused by small pellets (shot by children?); some found in holes; insects have often moved in

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Lower Eave Lesser Architrave	S	exposed; bird droppings; horizontal check	exposed	exposed; minor surface cracking; splintering	exposed; minor diagonal cracking; bird droppings	exposed; bird droppings	exposed; minor climbing horizontal cracking	exposed; lower horizontal crack	wood condition similar to rest of building, where visible; 4 metal rings on beams with remnant rope, about 0.75m apart; water staining on underside
	W		exposed	50% exposed; extant detached and paint largely lost	75% exposed; extant plaster detached; localized wood staining	40% exposed; extant plaster detached	exposed; some detached plaster on column		wood condition similar to rest of building, where visible
	N	plaster and paint intact; pattern discernible	plaster and paint intact; pattern discernible	upper edge has extant plaster and paint; some bird droppings; composite beam, unlike others on this facade	upper edge has extant plaster and paint; bird droppings; wood gray	W has small localized area of extant plaster and paint; bird droppings	intact plaster with paint; pattern discernible; bird droppings	intact plaster layer with paint; pattern discernible	
	E		intact plaster layer with remnant paint	intact plaster layer with remnant paint	intact plaster layer with remnant paint	intact plaster layer with remnant paint and cracking	intact plaster layer; detached with crack resulting in partial exposure		
Lower Eave Greater Architrave	S	intact plaster with remnant paint	intact plaster layer with remnant paint	exposed; upper horizontal checking	partially exposed; horizontal checking	intact plaster layer with remnant paint and visible detachment	intact plaster layer with remnant paint and visible detachment	intact plaster layer with paint	wood in condition similar to rest of building, where visible; beams of principle crossbeam strapped with 4 metal hoops
	W		95% exposed	90% exposed	exposed	largely exposed, minor horizontal cracking	largely exposed, horizontal cracking		
	N	plaster intact; 95 % paint loss and some detachment	extant plaster; 15% area of paint loss; detachment	1 portion of extant plaster and paint (35%); severe detachment suggesting imminent loss; graying wood with minor cracks	exposed; gray; minor horizontal cracking	plaster and paint intact, but severe detachment (imminent loss); full pigment rbeam cap ende visible	exposed; W hoop lost; minor horizontal cracks	intact plaster and remnant paint, detached at bottom; pattern discernible	

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Lower Eave Dougong/ Brackets and Purlin	S	purlin exposed	purlin partially exposed; minor horizontal cracking	purlin partially exposed; diagonal cracking on E	purlin has plaster layer; partial detachment and exposure	purlin has detached plaster with paint	purlin partially exposed; detached plaster layer	largely intact	
	W		some loss of dougong components in bird netting; 50% purlin exposure		30% purlin exposure; plaster detached	partial purlin exposure	some loss of dougong components in bird netting		
	N	slight movement of dougong towards E and down; 20% exposure of purlin	purlin has intact plaster with remnant paint	replaced purlin (50s?) and some dougong components	replaced purlin and some dougong components;	minor dougong component loss; purlin exposed	50% purlin exposure; remnant paint;	purlin plaster intact; pattern discernible	
	E		purlin largely exposed	intact plaster layer with remnant paint on purlin	purlin plaster detachment	partial purlin exposure and checking	partial purlin exposure		
Lower Eave beam cap ends and rafters	S	beam cap end checked			W beam cap end exposed		E beam cap end exposed		Rafters all replaced in 50s intervention; in good condition with some checking, surface cracking and loss of paint at ends
	W			Slight movement of beam cap end towards N (orig?)		Slight movement of beam cap end towards S (orig.?)	beam cap end cracking		
	N			beam cap end has new end cistered on	E beam cap end replaced; W beam cap end has huge check	beam cap end exposed and slightly towards W	beam cap end movement slightly towards W		
	E				S beam cap end exposed and checked; N beam cap end upper exposed and cracked		beam cap end checking		

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Lower Eave roof tile and ornaments	S	Glaze loss, plant growth, some broken end tiles							
	W		Glaze loss, plant growth, some broken end tiles						
	N	2 glazed animal ornaments lost; partial loss of 3 others; cracking at ridge	Glaze loss, plant growth, some broken end tiles			severe glaze loss; plant growth		severe glaze loss; 3 animal ornaments lost, plant growth	
	E		Glaze loss, plant growth, some broken wa dbeam cap end, cracking along ridge						

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Upper Eave Lesser Architrave	S		partially exposed; bat guano/rat droppings and urine	exposed; horizontal cracking 3-4cm wide (checking?)	partially exposed	partially exposed	plaster layer detachment		
	W			exposed; sagging of architraves	plaster layer detached with areas of loss	90% exposed; large checks			
	N		90% exposed; falling extant plaster and paint; diagonal cracking; outward movement at E end	30% exposed; plaster detached and lifting off; some remnant paint, but seems to be powdering	10% exposed; areas of extant paint; but seemingly powdering; plaster detachment	20% exposed; paint powdering; plaster severely detached suggesting imminent loss	70% exposed; extant plaster detached		
	E			partially exposed; bat guano/rat droppings	plaster layer intact and detached; bat guano/rat droppings	partially exposed; plaster completely detached (held by nail); horizontal cracking of beam			
Upper Eave Greater Architrave	S		intact plaster layer detached	extant plaster; minor checking of beam	intact plaster layer with remnant paint detached	intact plaster layer with extant paint detached	intact plaster layer with extant paint detached		
	W			Exposed	intact plaster layer with extant paint; flat tie beam warping as in Next Left Bay	80% exposed; outward corner movement; cracking of tie beam			
	N		exposed; top graying, but lower portion has good color	40% exposed; plaster detachment; paint loss and friability	10% exposed; some plaster detachment; paint loss and friability	25% exposed; extant plaster detached and lost in select areas; paint largely lost	60% exposed; extant plaster and paint with mid-level horizontal crack; discernible pattern		
	E			intact plaster with remnant paint; detaachment	intact plaster with remnant paint	partial exposure; minor horizontal cracking			

Bay / Item	Facade	Leftmost Bay 左尽 间	Further Left Bay 左稍 间	Next Left Bay 左次 间	Center Bay 明 间	Next Right Bay 右次 间	Further Right Bay 右稍 间	Rightmost Bay 右尽 间	Comments
Upper Eave dougong/ brackets and purlin	S		loss of dougong component; minor twisting/movement toward W; purlin largely exposed	loss of dougong component; replaced purlin; some warping of purlin due to beam cap end weight	purlin exposed; large cracks from metal hooks for central plaque	partial purlin exposure; detachment of extant plaster; cracking	exposed purlin; minor cracking/ checking		
	W			replaced purlin; beam above purlin warping from lower settlement of crossbeams and higher column position	partial purlin exposure; fallen plaster;	fallen dougong components; purlin exposed; column pushing out slightly towards W			
	N		Difficult to assess from ground through bird netting; but largely intact; some apparent loss on E, resting in bird netting; general plaster and paint loss; westernmost bay has crushed crossbeam and displaced dougong.						
	E			warping top beam (as above)	warping top beam	warping top beam; replaced purlin			
Upper Eave beam cap end/ cantilevers and rafters	S		checking and cracking of paint layer, generally good condition		W beam cap end exposed; slight movement towards S	checking and cracking of paint layer, generally good condition			
	W			checking, end paint loss, cracking, generally good condition					
	N		localized paint loss, checking of members, generally good condition						
	E				replaced beam cap end, pushed eastward; S beam cap end partially exposed	replaced beam cap end			

<table>
<tr><th>Bay
Item</th><th>Facade</th><th>Leftmost Bay
左尽 间</th><th>Further Left Bay
左稍 间</th><th>Next Left Bay
左次 间</th><th>Center Bay
明 间</th><th>Next Right Bay
右次 间</th><th>Further Right Bay
右稍 间</th><th>Rightmost Bay
右尽 间</th><th>Comments</th></tr>
<tr><td rowspan="4">Upper Eave Roof tile and ornaments</td><td>S</td><td></td><td colspan="5">glaze loss, limited end roof tile breakage</td><td></td><td></td></tr>
<tr><td>W</td><td></td><td></td><td colspan="3">glaze loss, cracking, limited end roof tile breakage</td><td></td><td></td><td></td></tr>
<tr><td>N</td><td></td><td colspan="5">extensive glaze loss, plant growth (less pronounced than lower eaves)</td><td></td><td></td></tr>
<tr><td>E</td><td></td><td></td><td colspan="3">glaze loss, limited end roof tile breakage</td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">Gable</td><td>W</td><td></td><td></td><td colspan="3">large verticle tiles show cracking (5 full width cracks); glaze loss at ridge</td><td></td><td></td><td></td></tr>
<tr><td>E</td><td></td><td></td><td colspan="3">limited end roof tile breakage, glaze loss at ridge; crack in one large verticle tile</td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">Roof Ridge</td><td>S</td><td></td><td colspan="5">glaze loss; staining from lightning rod clamps; limited staining (surface biological growth?)</td><td></td><td></td></tr>
<tr><td>N</td><td></td><td colspan="5">glaze loss, localized tile cracking</td><td></td><td></td></tr>
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