

## **THE RUINS OF SAN IGNACIO MINI, MISIONES, ARGENTINA - CHARACTERIZATION OF THE STONE USED IN THEIR CONSTRUCTION**

**Les ruines de S. Ignacio Mini, Misiones, Argentina - Caractérisation des pierres utilisées dans la construction**

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### **SUMMARY**

The Jesuit mission of San Ignacio Mini was one of the larger missions founded in the early XVIIth century. Upon the expulsion of the Jesuit order from Spain and all its dominions, the missions declined. During the armed conflicts of 1814-1828, the settlement was burned down and abandoned. The restoration of the site was carried out in the forties. The remaining buildings are all in stone. The church and most of the buildings were constructed from a local red sandstone (Asperón Rojo). In some instances a marsh-ore (Ita Tacurú) was used. The stones do not present any serious deterioration problem except for the biological growth that tends to cover any available surface. From the point of view of the conservation of the site, the most urgent need is for a maintenance program.

### **RÉSUMÉ**

La mission jésuite de S. Ignacio Mini était une des plus importantes missions fondées dans les premières années du XVIIème siècle. Avec l'expulsion de l'ordre des Jésuites de l'Espagne et des tous ses domaines, la mission déclina. Pendant les guerres de 1824-1828, les édifices furent brûlés et abandonnés. La restauration du lieu termina dans les années quarante. Les bâtiments restants sont tous en pierre. L'église et la plupart des édifices furent bâtis avec du grès local (Asperón Rojo). Dans quelques cas un "marsh-ore" (Ita Tacurú) fut utilisé. Les pierres ne présentent aucun important problème de détérioration, si ce n'est pour les pousses biologiques qui tendent à couvrir toutes les surfaces disponibles. Au point de vue de la conservation de l'endroit, la nécessité la plus urgente est un programme d'entretien.

## 1. HISTORICAL INTRODUCTION

The mission of San Ignacio Miní was founded by the Compañía de Jesús in 1610. It was one of approximately fifty missions established by the Jesuit order for the Guaraní Indians in the region where Argentina, Brazil and Paraguay now come together.

The original San Ignacio Miní settlement was moved twice before reaching its present location in the province of Misiones, Argentina, near the Paraná and Yabirí rivers, in 1669. The ruins that remain of this mission cover some 12.5 square kilometers, and correspond to the buildings constructed in the nearly one hundred year span before the Jesuit order was expelled from Spanish domains in 1767. All of the remaining constructions are in stone. According to records, the settlement had more housing structures, but as these were built in adobe, no traces are left, except for the foundation stones in some cases.

The population of this settlement reached a maximum of about four thousand in 1733. More information regarding these Jesuitic missions can be found elsewhere (1,2).

During the armed conflicts between the three neighbouring countries, the settlement was burned down, and abandoned in 1817. At that point the jungle started to encroach upon it. It was restored between 1940 and 1948 (2,3). It has been on the World Heritage List since 1984.

## 2. DESCRIPTION OF THE SITE

The Jesuit missions were constructed following a "standard" urban design: a central "Plaza de Armas" in front of the church which faced north. To the left of the church, the cloister, and to the right, the cemetery. Around the other three sides of the Plaza were the town-hall, the administration buildings, and some living quarters for the indian families. There are two structures per side of the Plaza. Beyond these, following neatly the square lay-out, were more living quarters for the indians.

The church was built according to a common plan used for all these mission churches. It is 74 meters long, including the apse, by 24 meters wide, and had three naves, built of hardwood, which were burned down when the settlement was set on fire, leaving behind the outer stone walls. The portals of the church, the baptistry, and the cloister were carved by the Guaraní indians who were taught many crafts by the Jesuits. From the records it is estimated that it was finished around 1724.

The town-hall and the administration buildings have a rectangular plan divided into four to six rooms. Each room has a door on the side facing the Plaza, and in some cases a window in the opposing wall. The houses had a projecting roof forming an open gallery along both long sides of the house.

The living quarters, also of rectangular plan, were divided into smaller rooms. In most cases they had only one shaded portico on the side with the doors. The structures that face the church across the Plaza are slightly longer and the entrance to the mission was along the central corridor between these.

The cloister had an inner square garden surrounded by paved stone walks that were formerly a covered gallery. The south walk, being slightly raised, has an elegantly carved balustrade, with a few steps going down into garden. To this side are the rooms that served as classrooms, kitchen, and refectory. To the west is the church, to the east a doorway opens to another court surrounded by workshops, and to the north the enclosing wall separating it from the Plaza. The missionaries living quarters were on the floor above the classrooms and were reached by a stone stairway which opens from the raised paved walk along the outer south side of the cloister and from where the vegetable garden and orchard could be reached.

### 3. CHARACTERIZATION OF THE STONES

The stones used in the construction of the buildings in this settlement were characterized by optical microscopy, scanning electron microscopy (SEM) and x-ray powder diffraction analysis (XRD).

The church and most of the buildings were constructed with a local sandstone, called Asperón Rojo (4). It was used in rectangular blocks of irregular sizes for wall construction, in more regular blocks for the square cross-sectioned columns that formed the porticoes along the houses, and for the carving of the facade of the church and the portals.

It is a red sandstone from the Triassic Misiones formation, also known as the Botú-catú formation, the colour results from iron oxides (5). The stone can vary from a somewhat layered structure to a very compact one. The first feature was put to practical use employing the slate-like stone for paving or for levelling larger blocks. The very compact stone was used only in smaller pieces to fill gaps in between the larger blocks.

The Asperón Rojo (Sample #1) is a quartz arenite composed almost wholly of monocrystalline quartz grains and a few feldspars grains (microcline) and cemented by haematite. The quartz grains are well-rounded and well-sorted. The haematite occurs as a very thin coating around the white quartz grains, or in pockets between them, giving this stone its characteristic red colour.

The slate-like variety (Sample #2) does not differ in microstructure from the previously described arenite. Figure 1 shows a thin section of this stone.

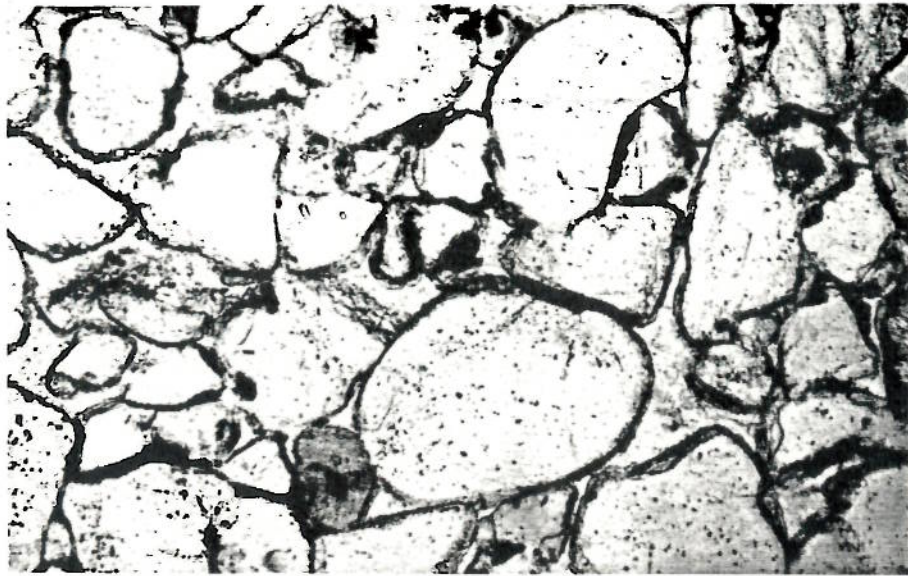


Figure 1. Photomicrograph of a thin section of the slate-like arenite (78 x, N //). Note the well-rounded and well-sorted quartz grains which are coated with haematite giving this stone its red colour.

The compact variety of this sandstone (Sample #3) gives a nearly conchoidal fracture. It is much harder and is cemented by quartz overgrowth or precipitated around the sand grains coated by the haematite. Figures 2 and 3 show scanning electron photomicrographs of the typical arenite and the compact variety.

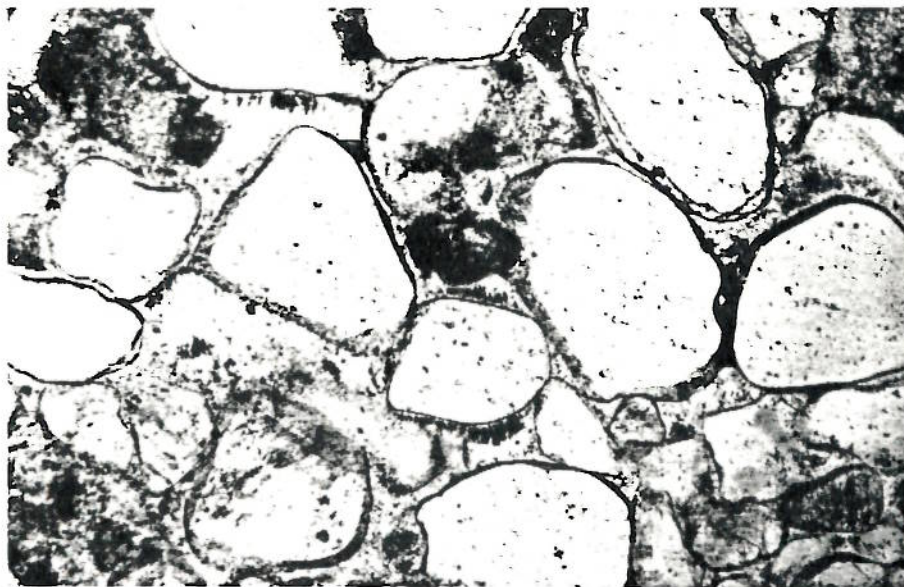


Figure 2. Photomicrograph of a thin section of the compact variety of the Asperón Rojo (78 x, N //). The quartz crystals are partially coated by hematite and cemented by quartz overgrowth.

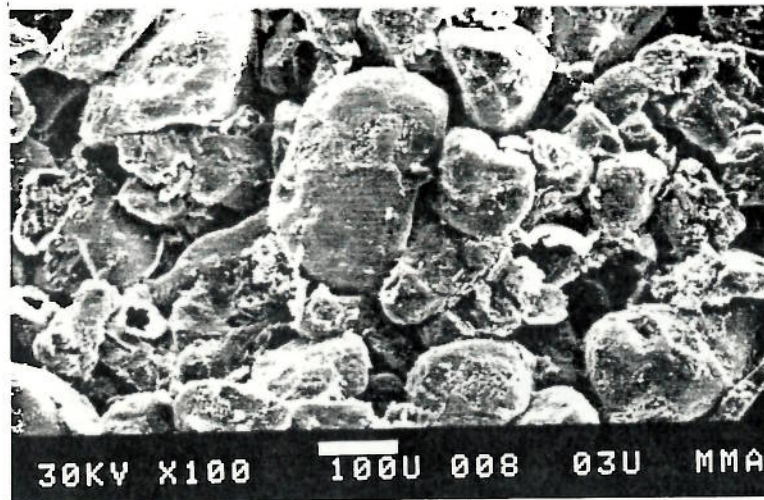


Figure 3. Scanning electron micrograph of a fracture surface of the Asperón Rojo sandstone. Note the coating of haematite on the quartz grains and the open pocket of amorphous haematite in the lower left side of the picture.

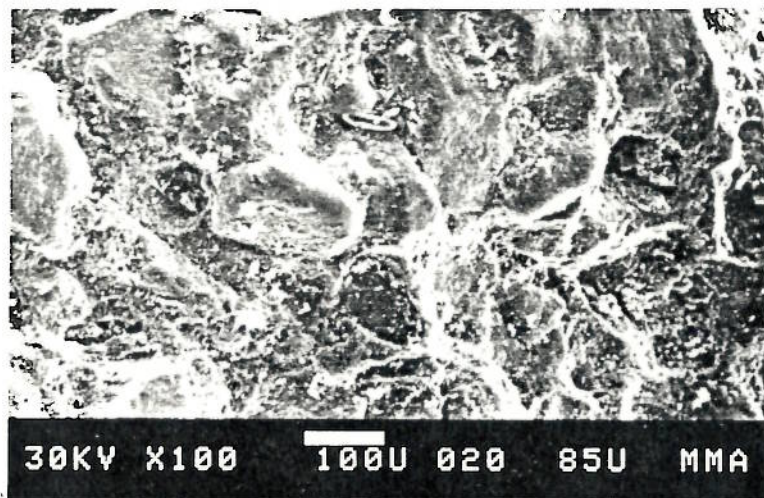


Figure 4. Scanning electron micrograph of a fracture surface of the compact arenite variety. Note the silica cementation between the quartz grains.

Another stone, locally called Ita-Tacurú (which is Guaraní for "hard stone"), was also used mainly in the construction of the north wall around of the cloister and in parts of the sacristy. It is a bog-iron-ore, or marsh-ore (5). This is a sedimentary iron deposit formed in swamps and marshes. It is composed chiefly of haematite-goethite oolites and monocrystalline quartz grains scattered in the mass.

The goethite and limonite, which cover a range of mixtures of iron oxides and iron hydroxides, appear to be the weathering product formed by hydration of haematite. In thin section the goethite-limonite is yellow to brown and generally appears isotropic and is present as thin beds and laminae around the massive red haematite. Figure 5 shows a thin section of this stone.

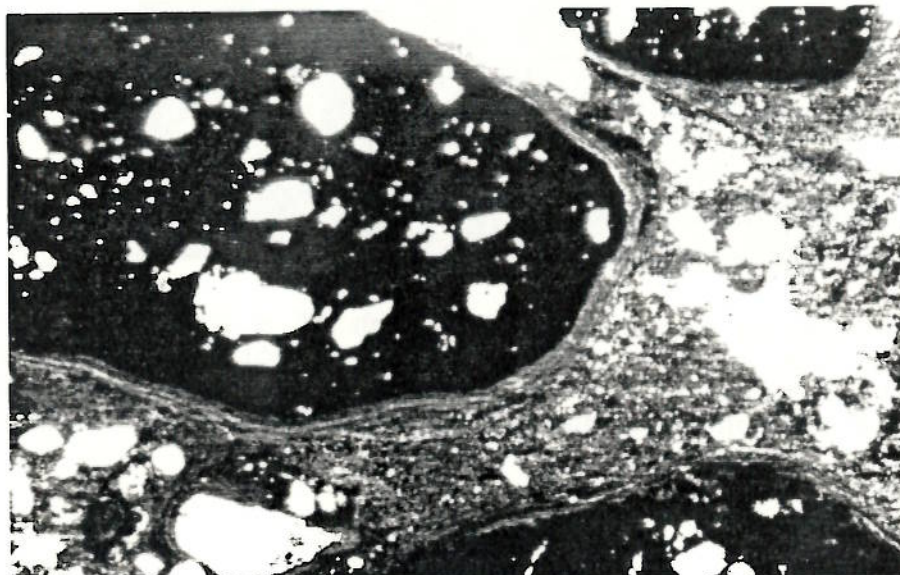


Figure 5. Thin section of the Ita-Tacurú stone showing its pisolitic structure (31 x, N //). Note the masses of goethite-limonite around the haematite oolites.

Table I gives the XRD data for the quartz arenite and the bog-iron ore. The amount of hematite in the samples of Asperón Rojo is lower than the sensitivity of the equipment.

Table I. X-Ray Powder diffraction data obtained for the Asperón Rojo and the Ita-Tacurú stones.

Stone	Asperón Rojo			Ita-Tacurú
	#1	#2	#3	#4
Quartz	++	++	++	+
Feldspar	+	+	+	
Haematite				+
Goethite				+

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 ++ = predominant; + = present

#### 4. EFFLORESCENCES

Efflorescences were only found in the damp basement under the kitchen pantry and as very light surface deposits on some of the stones. The sample analyzed corresponded to the deposit found on Sample #3.

The efflorescence found in the basement were analyzed by traditional chemical analysis (6). On the basis of the differences in concentrations found for the various ions, it can be stated that the main component is calcium sulphate. The concentration for the other ions, in decreasing, are:  $\text{NO}_3^- \gg \text{K}^+ \gg \text{Mg}^{++} \text{ \& \ } \text{Cl}^- \gg \text{Na}^+$ .

The thin deposit on the surface of sample #3, analyzed by XRD, proved to be gypsum, and some calcite.

The gypsum found in these efflorescences can be attributed to two sources: for the basement, filtration from the surrounding ground; for the surface deposit on the stones, leaching from the mud-based mortar, locally called "ñauí", used for the laying of the stones.

Some instances of powdering of the stone were found at the base of the balustrade columns of the outer raised south walk. As this had been heavily restored with Portland cement there is no doubt that the powdering is due to the migration of the soluble salts leached out from the cement pavement.

#### 5. CONSERVATION PROBLEMS

Given the nature and structure of the stones used in the construction of this settlement, the deterioration problems are mainly those of the structures or the site, but not in the stones per se. It was shown in the previous section that very few instances of salt deterioration were encountered.

One of the main problems is the extensive growth of micro- and macro-flora on moist stone. Walls exposed to sunlight for several hours are dry and no growth develops on them. On the other hand, the top of the walls, now unprotected from the tropical rains by roofs, and in most cases shaded by the many trees growing on the site, have a luxuriant growth of ferns, mosses, algae, lichens, etc.. The prolonged growth of such plants will eventually break down the stone, hence a maintenance program should be developed to control this biological attack.

Higher vegetation, such as shrubs and ficus trees, are also prone to develop by, on, and around the structures. Their growth induces mechanical stresses that open cracks in the stones. One example, left during the restoration as illustration of the power of the jungle, is a ficus tree that grows

around one of the columns in front of the houses. At present, only part of one side of the column is visible within the split trunk. It is locally known as "el árbol de corazón de piedra", the tree with the heart of stone.

Another problem is presented by structural failures, such as the rotting of the wood lintels put in during the restoration which can induce mechanical failure in the stones. One such example occurred in the decorated portal of the baptistry. Several stone panels, some decorated, a capital and drums of the one of the flanking columns cracked or split. The damage has now been repaired, but it demonstrates the need for a regular survey of the structures.

Finally, as in any site open to the public, an adequate management strategy is needed so as to diminish the impact of the public on the structures. At present, the entrance to the site is on the west side and serves also as the exit, thus concentrating the visitors in this area. Opening the original entrance to the settlement to the north and leaving the present gate as the exit would improve visitors circulation.

## 6. CONCLUSIONS

The ruins of San Ignacio Miní are endangered through the tropical climate which induces heavy biological growth which in time will deteriorate the stone chemically and mechanically. A regular maintenance program to control this problem is urgently needed as the present maintenance is not adequate. This on-going program should also consider periodic surveys of the structural stability and the design of adequate circulation patterns for the visitors.

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## REFERENCES

- (1) GUTIERREZ, R. - Las misiones jesuíticas de los guaraníes, UNESCO, Secretaría do Patrimônio Histórico e Artístico Nacional/Fundação Nacional Pro-Memória, Rio de Janeiro, Brasil, 1987
- (2) CHAROLA, A.E. - The Ruins of San Ignacio Miní, Misiones, Argentina: Conservation Problems. Wiener Berichte über Naturwissenschaft in der Kunst, Vol. 6/7/8, 1989/1990/1991, pp. 372-380
- (3) ONETTO, C.L. - Las Ruinas de San Ignacio Miní. Revista de Arquitectura, No.283, July 1944, pp. 314-327
- (4) RUHSTALLER, R.E. - Report to the Comisión Nacional de Museos y de Monumentos y Lugares Históricos, Buenos Aires, September 1983
- (5) PUTZER, H. - Geologie von Paraguay. Beiträge zur Regionalen Geologie der Erde, Band 2. - Gebrüder Borntraeger, Berlin-Hikolassee, 1962, pp. 69-75
- (6) DUPAS, M. - personal communication