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# Studies of the weathering of bricks and monuments

*English abstracts of three papers on a common theme, paraphrased with the author's permission and approval.*

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## THE TAFONI WEATHERING OF A RED BRICK WALL IN TOKYO DATING FROM THE LATE 19TH CENTURY. (2004). *MEMOIRS OF NARA UNIVERSITY,* 32: 75-87.

At the beginning of the Meiji Period in Japan (1868-1910), many Western-style buildings were constructed using red bricks imported from Europe. Few remain, but those that do now have considerable historical value. They need to be protected before they are lost forever.

The study reported here concerns part of one such structure, a red brick wall that originally surrounded the house of Mr Yataro Iwasaki, founder of the Mitsubishi Corporation. This wall was built around 1875, some 130 years ago. Its surface exhibits tafoni (honeycomb or cavernous) weathering [presumably as a result of 'acid' rain or rainfall polluted by industrial waste, and possibly also haloclasty?] of the type seen on natural stone surfaces in many parts of the world. In some instances adjacent small hollows have merged to form larger and deeper depressions. Many of the depressions have attained a depth of 10 cm, which bearing in mind the age of the wall implies a weathering rate of 0.8 mm/yr. This is similar to the 1 mm/yr recorded by the author on Buddhist sculptures of temples in southern India and on natural surfaces observed in South Korea.

The tafoni or cavernous erosion on the red brick wall has created a beautiful and eroded surface resembling an artform sculpted by Nature itself. The rustic character of this wall matches well the mood of the famous Yashima Shrine located next door.

However, the wall has been classified under the Fire Prevention Law as being susceptible to collapse in the event of a major earthquake. For this reason it is proposed to tear it down. The author sought the views of local people about the wall and its condition. Most stated that they had a close affinity to the wall and its history and wished that it could be retained.

Japan is an earthquake-prone country, and there are many old buildings that over time have become vulnerable to collapse if severely disturbed, so it is understandable that the authorities want to avoid the risks introduced by leaving the wall standing. However, as the desire to preserve historical and cultural assets in Japan grows, such assets should be studied and, where possible, strengthened and preserved so that they may survive seismic shock. They should be examined by experts from many fields and the data collected and analysed. This study can be viewed as an example, for in it a problem is identified. The author hopes it will be used to help protect not only this particular historical asset but also others like it in Japan and elsewhere.

**THE WEATHERING CHARACTERISTICS OF THE PALMYRA STONE RELICS. (2005)** *MEMOIRS OF NARA UNIVERSITY,* **33: 51-48.**

Palmyra was an oasis city in the Syrian desert. From the 1st Century B.C. until the 3rd Century A.D. it served as a staging post for caravans on the shortest route between Mesopotamia and the Mediterranean Sea. In 274 A.D. after defeat in a war with Rome, the route of the caravans changed and the city fell into ruin.

Palmyra was a very large city with many stone buildings and structures constructed mainly of limestone. Some idea of its size is indicated by the 1300 metre long Great Colonade, along its main road. Of this feature some 150 cylindrical limestone columns remain. In 1980 it was designated a World Cultural Heritage site.

With the passage of time, weathering has eaten into the limestone columns. The impact of weathering differs above and below ground level. The exposed areas are smooth and virtually pristine, but the buried areas display many shallow hollows. Palmyra stands on the gentle slope of an active alluvial fan and the lower parts of the columns were buried beneath [moist] sand and gravel. Today, some two metres of debris are being cleared in order to re-expose the old city centre and its cultural features, partly for study, partly for touristic purposes. These excavations have revealed the contrasted effects of weathering on the buried and exposed sectors of the columns.

Looking at the weathering on the excavated columns of the Great Colonade its upper limit forms an irregular but essentially horizontal line separating buried and exposed sectors. The depth of weathering was measured and fissures recorded. The horizontal zone marking the upper limit of burial was affected [presumably by dissolution and possibly haloclasty] by both surface and subsurface waters. Cavernous weathering was expected on the exposed areas, but no distinct examples were found, presumably because the climate (about 100 mm precipitation p.a.) is dry. On the other hand, soil moisture has caused much shallow dissolution.

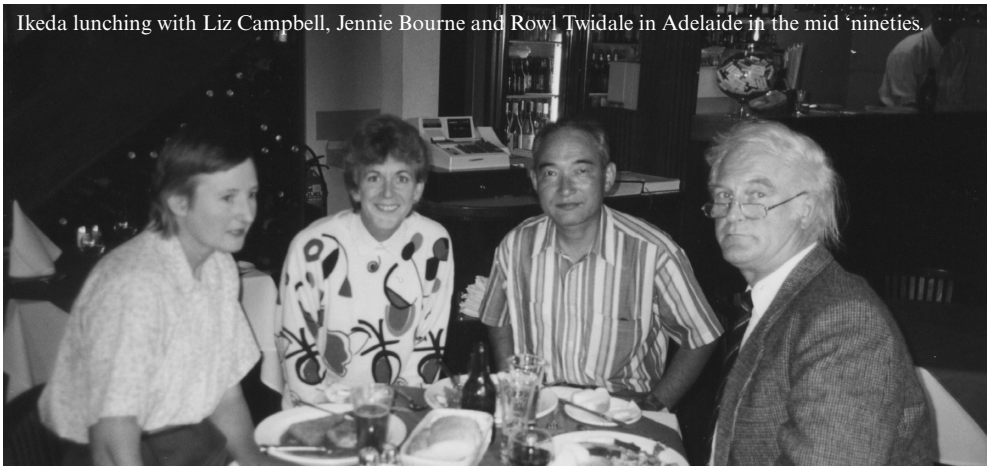
**ON THE TOPOGRAPHY AND WEATHERING OF STONE CASTLE RUINS IN BYBLOS AND SIDON, LEBANON. (2007).** *BULLETIN OF RESEARCH INSTITUTE, NARA UNIVERSITY,* **15: 35-48.**

Lebanon is a small country, some 10,000 km2 in area, located on the eastern shore of the Mediterranean Sea. Its topography reflects Alpine (Tertiary) orogenesis, with a chain of mountains running parallel with the coast and attaining heights of more than 3000 m. Climate varies with topography, but summers are warm on the coastal plain with its rich agricultural land. The upland areas receive high snowfalls in winter as do the western slopes facing the seas. However, desert conditions obtain to the east, on the Syrian side of the mountain chain. The beaches and snowfields attract tourists.

The castle ruins in the coastal cities of Byblos and Sidon, erected during Phoenician rule (1st millennium B.C.) were built of local limestone, with stones or blocks laid down in layers, one upon the other. However though the walls are all of the same limestone and were erected at about the same time, weathering [presumably dissolution plus haloclasty] has proceeded at different rates on different parts of the walls. In particular, a central horizontal zone has been weathered more rapidly than the zones above and below, with the blocks of the middle zone pitted by tafoni or cavernous weathering

The central section of one of the walls of Byblos castle consists of 198 blocks in 15 layers. Of the blocks 18 were weathered through, leaving gaps, and another 13 were seriously damaged, i.e. 31 of 198 blocks (16%) were severely weathered. At Sidon the castle was erected on a rocky offshore island. The central section of one wall consisted of 339 blocks in 24 layers. Of these 81 were deeply weathered, and another 40 markedly hollowed, i.e. 121 blocks out of 339 (36%) were severely damaged.

The greater degree of weathering at Sidon can be attributed to its insular position bordered on three sides by sea water, whereas the Byblos structure stands some 200 m inland on a terrace overlooking the sea.



Ikeda lunching with Liz Campbell, Jennie Bourne and Rowl Twidale in Adelaide in the mid 'nineties.

[*Editors' note*: Professor Ikeda's contributions are atypical in that, like Liz Campbell and the editors of this volume, his first love is granite (e.g. IKEDA, 1999) and they had several enjoyable and fruitful excursions in granite terrains together. Yet the papers cited here also reflect another Ikeda characteristic, namely his predilection for measurement. The three papers are concerned with weathering and demonstrate the varied rates and types of change in different environments. They also confirm the contrasts between rates of weathering on exposed and covered surfaces, on 'dry' sites and sites in contact with soil moisture. As LOGAN (1851, pp. 329 and 326) pointed out: "The soil is always kept moist…" and as a result, whereas on exposed bare rock surfaces decomposition is arrested or retarded, "Under-ground decomposition tends to spread unchecked on all sides."

IKEDA, H. (1999). *The World of Granite Landforms*. Kokon-Shoin, Tokyo.

LOGAN, J. R. (1851). Notices of the geology of the Straits of Singapore. *Proceedings of the Geological Society of London,* **7**: 310-344.]