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First Considerations on the Stability of the Buddha Niches and their Stone Material, 2002*

The rock niches as well as the two Buddha statues were carved out of the rock faces (figs. 1 and 2). These rock faces are mainly composed of two types of rock that are present in alternating series of strata. The principal part (ca. 70 % of the statue) is a typical loosely deposited conglomerate. That conglomerate is interspersed with sandstone that, however, only makes up ca. 20 % of the volume of the statue; the remaining 10 % are surface material.

The compressive and tensile strength of the materials is very low, even the influence of small forces leads to destruction.

The conglomerate is highly susceptible to water. Under water, a specimen of the material disintegrated into a pile of sandy pebble stone after only a few seconds (see fig. 3). Examinations have shown that the binding agent between sand and pebble granules mainly consists of sodium chloride salt, which also explains the cause of the high susceptibility to water. The crystals of the salt are clearly visible under the microscope.

The surfaces of the statues as well as of the other formations appear to be more resistant to water and mechanical influences. It remains to be examined whether this was caused by an artificial treatment of the surfaces in the past or by the many years of climatic strain on the areas near the surface and the chemical reaction connected with it.

The cracks in the niches can be subdivided into three groups - cracks that existed prior to the blasting, cracks widened by the blasting and new cracks caused by the

Fig. 1. The Western Buddha, 2002

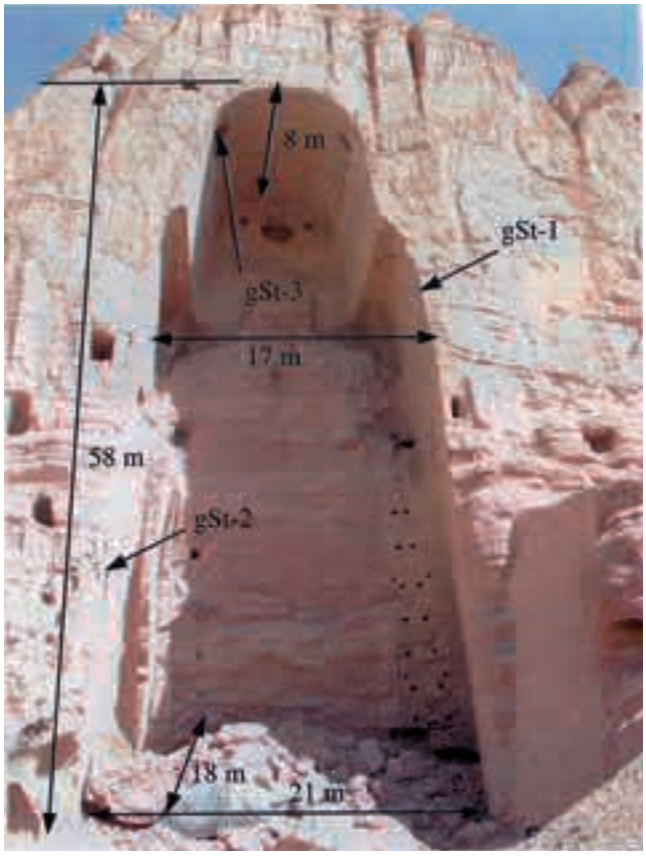

Fig. 2. The Eastern Buddha, 2002

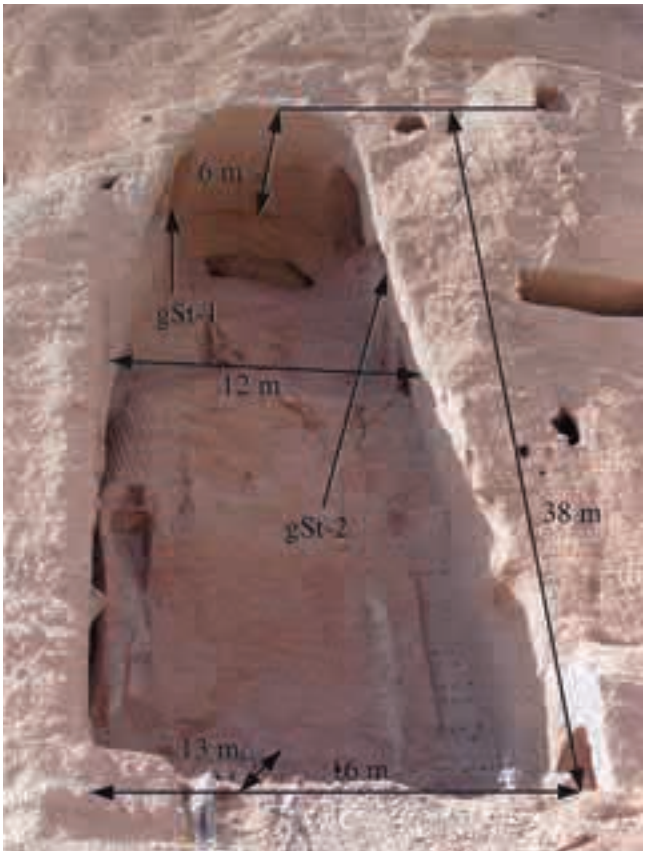

Fig. 3. Testing the conglomerate: dry specimen (left), after a few seconds under water (centre), after sedimentation (right)

blasting. The cracks that already existed prior to the blasting are mainly located in the vault area above the head and on the side walls of the niches and run downward in straight lines. The blasts caused new cracks especially in the area of the back wall of the niche (viewing area). Figures 4 and 5 (view from the bottom) show the location and extension of the various forms of cracks.

The areas at risk can be classified into three risk groups:

Risk Group gF-1: *Highly endangered areas*

Areas often cut through by new cracks, a falling-down of major fragments is to be immediately expected, i.e. these areas are just in a state of limit equilibrium. These highly endangered areas are mostly located in the upper part of the back wall of the niche. The average weight of fragments that are at the risk of falling down is ca. 1 metric ton.

Risk Group gF-2: *Area with a locally endangered stability*

These are areas that are not yet in a state of limit equilibrium with regard to their static stability. But concussions/vibrations or further weathering may lead to a falling-off of fragments, which, however, currently does not affect adjacent areas or the overall formation (static stability of the niche as a whole). In these areas already existing old cracks intersect with new cracks caused by the blasting. If, however, these cracks should further widen due to concussions/vibrations or weathering, the entire cave will lose its stability.

Risk Group gF-3: *Areas that, in case of failure, directly endanger the entire formation*

With regard to their static stability, these areas (just like gF-2) are not yet in a state of limit equilibrium. That, however, may occur as a consequence of concussions/vibrations or further weathering. Here, the particular risk is caused by the cracks widened by the blasts.

At the Western Buddha, the stability of the niche is endangered on three spots (gSt-1 to 3, see Fig. 1). On the spots gSt-1 and gSt-2, the local stability is at risk. If the local stability is lost on several spots, the overall stability will be endangered by further weathering. On the spot gSt-3, the rock is cut through by cracks widened by the blasts. Inside the staircase, the widened cracks are clearly visible at that place behind the wall. The stability on this spot influences the entire stability of the cave.

At the Eastern Buddha, the overall stability of the niche is highly endangered on the two spots gSt-1 and gSt-2 (see Fig. 2). The cracks newly caused as well as the cracks widened as a consequence of the blasts are clearly visible here. The stability on both spots has a direct influence on the overall stability of the niche.

Proposals for the protection and identification of the fallen-off pieces of rock

The rocks are highly susceptible to water so that rain or melt water might cause the fallen-off pieces of rock to disintegrate into a pile of sandy pebble stone within a very short time. Therefore, the pieces of rock must urgently be protected against water and further weathering. A coating might provide a long-term protection if this is not in conflict with aspects of the preservation of historical monuments and other solutions are not possible. A suitable material would have to be found by specific examinations. Before that, the fallen-off pieces of rock should be identified for the reconstruction. The identification could be carried out together with measures for the protection of the fragments. For that purpose, the fragments must be transported. In order to avoid damage caused by transport and storage as well as in view of the assessment of possible reconstruction measures, it is necessary to determine the mechanical properties of the different rocks and adapt the transport measures to the strength properties.

Proposals for the stabilization

The endangered areas in the viewing walls of both niches (back walls of the niches) are so much at risk with regard to their stability that, prior to the performance of any possible reconstruction measures, it will be necessary to take measures for their stabilization (including the removal of areas that were damaged to a particularly large extent).

Areas that cause a danger to the overall stability must be secured, since otherwise even slight concussions/vibrations in connection with weathering processes might cause the niches to collapse.

In order to guarantee the stability of the rock niches as well

as safety on site in the long term, it is necessary to secure also those areas that only constitute a danger to the local stability.

The rock and the conglomerate are so loose that it must be expected that they will disintegrate as a consequence of drilling work that may be necessary. This fact is to be taken into consideration in particular with regard to the cave systems (staircase) located behind the endangered areas where the classical system of stabilization by means of anchors cannot be used. The local stability of the endangered rocks and thus the overall stability of both niches with the caves located behind them (staircase) should be thoroughly examined prior to stabilization. A promising stabilization method can only be determined by means of tests.

[*] Abridged version of the report *Situation of the Buddha Statues in the Valley of Bamiyan, Afghanistan* by Dr.-Ing. Y. Zou and Dipl.-Ing. F. Unold, 5 November 2002. – See also Yazhou Zou and Florian Unold, *Die großen Buddha-Statuen von Bamiyan/Zustand, Stabilität und Möglichkeiten der Rekonstruktion*, in: Bautechnik 80 (2003), Heft 7, pp. 417–422.

Fig. 4. Upper part of the Western Buddha

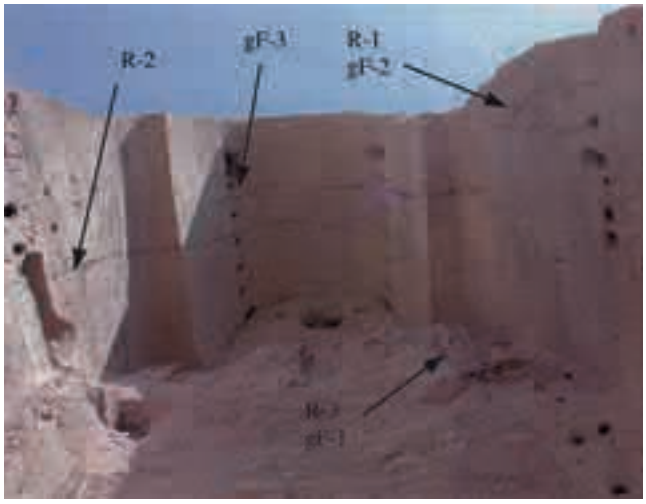

Fig. 5. Upper part of the Eastern Buddha

At the end of 2002 ICOMOS Germany organised the first meeting of a UNESCO/ICOMOS Working Group on the Preservation of the Bamiyan Site:

[*] Abridged version without recommendations on wall paintings and archaeological projects. For the full text see Heritage at Risk 2002/2003, pp. 19f.