The conservation of the wall paintings in the Tomb of Nefertari was a six-year joint project between the Getty Conservation Institute and the Egyptian Antiquities Organization. Located near the modern city of Luxor in Upper Egypt, the tomb was re-opened to the public in November 1995. Vaisala temperature and relative humidity sensors were used to monitor the micro-climate in the tomb.

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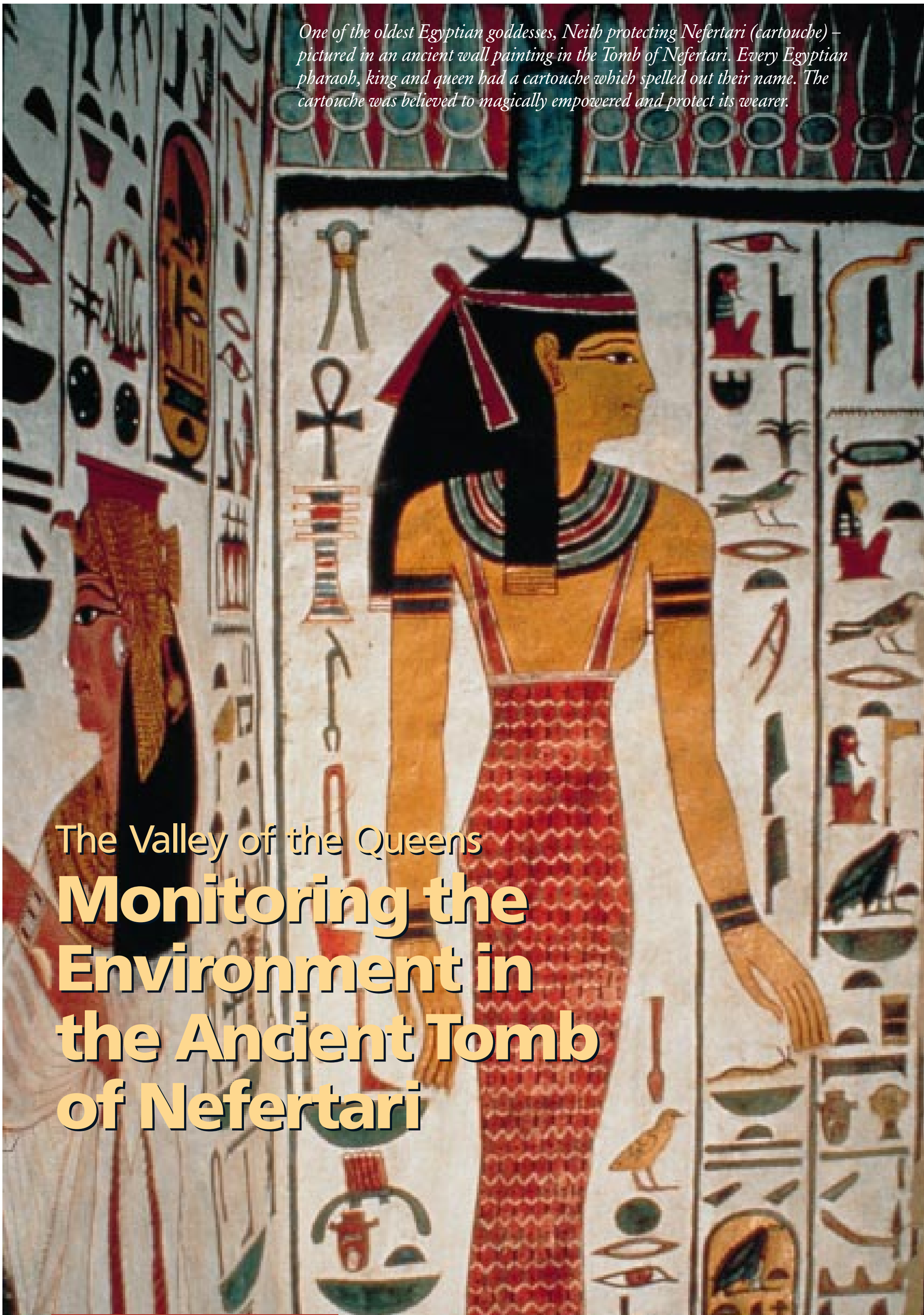
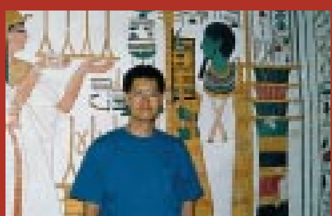


One of the oldest Egyptian goddesses, Neith protecting Nefertari (cartouche) – pictured in an ancient wall painting in the Tomb of Nefertari. Every Egyptian pharaoh, king and queen had a cartouche which spelled out their name. The cartouche was believed to magically empowered and protect its wearer.

The Valley of the Queens

Monitoring the Environment in the Ancient Tomb of Nefertari



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Queen Nefertari, the favorite wife of Ramses II, was buried about 3,200 years ago in the most exquisitely decorated tomb in Egypt's Valley of the Queens. The tomb was discovered by Ernesto Schiaparelli, an Italian archeologist, in 1904. After the discovery, its wall paintings deteriorated at a very fast rate. In fact, comparisons of historical photographs from 1904 to the present reveal that the tomb deteriorated to an alarming extent before emergency conservation began in 1987.

Deterioration of the tomb paintings

In 1986, the Getty Conservation Institute (GCI) and the Egyptian Antiquities Organization (EAO, an Egyptian government organization) initiated a six-year project to conserve the wall paintings in the tomb. An international conservation team, consisting of a wall painting conservator, a geologist, a chemist, a microbiologist, and an environmental scientist, was founded.

The Tomb portrait of Queen Nefertari during the final treatment.

The entrance to the Tomb of Nefertari, located in the Valley of the Queens, is among the most spectacular works of art ever created.

The team first took steps to evaluate the condition of the wall paintings and develop a conservation strategy. The consequent analyses confirmed that the main cause of the paintings' long-term deterioration was the presence of sodium chloride in the limestone and plaster.

Salt in the limestone dissolves in water and migrates to the near surfaces on which the wall paintings are located, whereupon the moisture evaporates and the salt crystallizes. In some parts of the tomb, salt crystals had eroded the paint on the surface, turning it to colored dust. In other areas large and hard crystals had formed between the limestone and plaster, pushing the plaster surface away from the rock and destroying its cohesion. Several water sources were identified by scientists in the tomb: (1) water introduced through the original plastering of the walls; (2) flooding via the tomb's entrance; (3) rain seepage throughout the rock and through fissures in it; and (4) water vapor from the atmosphere, introduced mainly by visitors.

Conservation treatment started in 1987

While the project's scientists proceeded with their work, the conservators surveyed all of the wall paintings in the tomb. Every deterioration-related problem was recorded and mapped. When the survey was completed, emergency conservation work was started in 1987. The treatment was aimed at protecting the paintings from further losses, while the most appropriate methods for conservation treatment were being investigated in the laboratory.

The final conservation treatment followed in February 1988, being completed in April 1992. No compromises were made in keeping the authenticity of the wall paintings throughout the conservation treatment process.

Documentation of the tomb's micro-environment

Between August 1991 and April 1992, numerous experiments were conducted in the tomb to understand the dynamics of the micro-environment for long-term preservation of the wall paintings. The environmental conditions inside and outside the tomb were documented and analyzed during the tests, and the following operational recommendation was made.

It was suggested that for the safety and comfort of visitors, as well as for the preservation of the paintings, visits to the tomb should be strictly limited during the summer months, when the base-line relative humidity is high and natural ventilation is at the minimum.

The EAO agreed to restrict visits to the tomb for at least three years. In the following three years (from May 1992 to November 1995), the environment of the Valley of the Queens, the micro-environment in the tomb, and the occasional entry of visitors were recorded while the above recommendations were followed.

However, in early 1995, the EAO decided to open the tomb to the public and set the maximum daily intake of visitors at 150. A mechanical ventilation system and illumination were installed in the tomb to handle the effects of the increased number of visitors. Monitoring of the micro-environment and the condition of the wall paintings was continued for an additional 16 months after the tomb was finally opened to visitors in November 1995. The monitoring documents showed that the tomb's micro-environment was maintained at a safe and stable value.

Vaisala's sensors for micro-climate studies

Six Vaisala HMP35A temperature and relative humidity sensors were used throughout the monitoring work in the tomb. One HMP35A was placed in a vented radiation shield and mounted on an outside tripod to measure the climatic conditions of the Valley. Five other HMP35A probes were installed in various locations in the tomb to monitor the micro-climate there.

The measurement routine was performed every minute, and the measured values were stored in a high-capacity, self-powered, solid-state device. The stored data was downloaded monthly from the datalogger to a PC diskette for analysis at the GCI. The monitoring task was concluded in May 1997.

The decision to select the Vaisala temperature and relative humidity sensor for these tasks was based on the following criteria:

- The relative humidity sensor had to have high accuracy in the range of 10 to 90 %
- As visitors have a very fast effect on the tomb's micro-environment, at least 90 % of responses had to be documented within 60 seconds as visitors moved from one part of the tomb to another
- The sensors needed to operate with 12 Vdc, as a rechargeable battery was the only power source
- The sensors needed to maintain calibration for an extended period of time, as field calibration could be performed only once a year.

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*) Shin Maekawa is a senior environmental scientist who is responsible for environmental monitoring and control projects at the Getty Conservation Institute. In this capacity he has conducted environmental monitoring projects for a number of unique historical places around the globe, such as the Great Sphinx of Giza, the Mogao Grottoes along the ancient Silkroad in China, and Tiwanaku in the Andes Mountains.

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