

From Earth to the Moon With Love

Japan translates its lunar fascination
into a scientific mission

By JONATHAN EBERHART

*A lunar halo –
Is it not plum-blossoms' scent
Rising to heaven?*

– a haiku by Buson

At the 1970 world's fair in Osaka, where promotional displays from 76 nations competed loudly for visitors' attention, many Japanese stood in line, uncomplaining, as long as 12 hours for even a brief glimpse of a single object in the U.S. pavilion. That object was a *tsuki no ishi*, or moonrock, plucked the year before by the Apollo 11 astronauts.

Some made their way through the stadium-sized exhibit without so much as a glance at the Indianapolis race cars, major league baseball uniforms, laser-beam artworks and other displays. One elderly woman, adorned with a halo of snow-white hair, trudged through the whole pavilion without raising her eyes even to the *tsuki no ishi* itself. As she emerged, however, she shyly told me she had traveled 1,600 kilometers from the northern island of Hokkaido not to see anything but merely to be in the presence of a piece of the moon. It was an encounter, she said, that she looked forward to describing to her children.

*The face of the moon –
Twelve years old –
About that, it may be.*

– a haiku by Issa

The moon has exerted a special pull on the Japanese since the country's early history. And now Japan has become the third nation on Earth to launch a mission to the moon.

On Jan. 24, Japan launched its moon-bound spacecraft, called Hiten, into an elliptical orbit around Earth from the Kagoshima Space Center on the southern

island of Kyushu. Hiten's only scientific instrument, developed by Munich Technical University in West Germany, will measure the velocities and masses of dust-sized meteoroids striking it in space.

"During our design study, we found that there was some extra available [payload weight]," Jun Nishimura, director general of Japan's Institute of Space and Aeronautical Sciences (ISAS), told SCIENCE NEWS. ISAS engineers considered several instruments as candidates for the mission, but Nishimura says they chose the micrometeoroid detector because it is the simplest in design and the lightest in weight.

The Sagami-hara City-based ISAS, one of two Japanese space agencies, built both Hiten and the Mu rocket that launched it. Hiten's primary objective is simply to try out the technique ISAS has chosen to put satellites into lunar orbit: having one spacecraft come close enough to the moon for the lunar gravity to capture a second craft into orbit. Project scientist Kuninori Uesugi says ISAS hopes Hiten will complete eight visits near the moon during the mission's planned one-year lifetime.

Hiten carries with it a second, smaller spacecraft. On March 19, if all goes well, this still-unnamed craft will separate from Hiten as the Earth-circling path swings the larger craft to within about 16,000 km of the moon. Then a rocket aboard the smaller satellite will fire, sending it into a nearly circular orbit at that altitude. Only then will the lunar orbiter receive a name. It carries no scientific instruments; its goal is purely engineering research.

If the maneuver proves successful, Japan will have presented Earth's moon with a moon of its own. Apart from the technological feat, the event will echo a familiar Japanese custom—the offering of a gift from visitor to host—that might well inspire haiku of its own.

地球より月に
愛をこめて

Calligraphy by Kyoko Okamoto

Hiten precedes a mission planned for 1992, in which a NASA Delta rocket will launch a Japanese spacecraft, called Geotail, into an Earth orbit that carries it beyond the moon and periodically through Earth's magnetic tail—the region pushed away from the sun by solar winds. Built by ISAS, Geotail will explore this zone as part of an effort called the International Solar-Terrestrial Physics program, which also includes participation by some European nations.

ISAS also is designing a larger rocket that Nishimura says should be capable of launching about three times Hiten's 200-kilogram mass. That launch vehicle, scheduled for completion in early 1995, may find its first use in a Very Long Baseline Interferometry experiment planned for later that year. For that experiment, ISAS plans to build an Earth-orbiting radiotelescope antenna and launch it to a distance of several times Earth's radius, electronically linking it with ground-based antennas in the United States, Europe, India and Australia. This will produce what amounts to a single antenna whose effective aperture is larger than Earth itself.

ISAS is studying three proposals for the mission after that, presently planned for 1996. The institute will probably make its choice in late March, submitting the winning proposal to the Japanese government's Space Activities Commission for approval, Nishimura says. Projects under consideration include:

• **A return to the moon.** At least three instrumented "penetrators" would be flown aboard a single orbiter and released like javelins to stick about 1 meter into the lunar surface. Equipped with seismometers to monitor the moon's

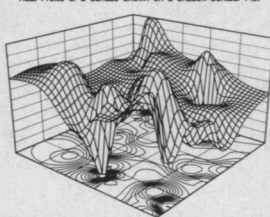
"creaking" — due to meteorite impacts and to temperature changes caused by the sun and whatever lunar interior heat remains — the instruments could help map the moon's interior structure. One of the seismic array's major objectives, says Nishimura, would be to determine the size and shape of the moon's core.

• **Sampling the tail of a comet.** In 1986, two Japanese craft worked in distant orbits to study ultraviolet sunlight reflected from Comet Halley when it passed close to Earth. But the new plan would send a spacecraft through a comet's tail, capturing traces of dust and gas that could be analyzed aboard the craft to determine their composition.

• **Japan's first mission to Venus.** This craft would neither land on Venus nor sample its atmosphere, but instead would study the structure of the planet's ionosphere from orbit.

While many Japanese talk of expanding their space program to include studies of other planets, the moon still retains that nation's special affection. In one of those ambiguities so common in the Japanese language, Hiten — which translates roughly as "sky flight" or "flying in heaven" — is also the name of a Buddhist deity of music. The double meaning, Uesugi observes, evokes "something like playing music in heaven." □

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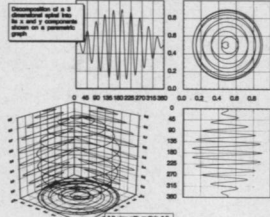
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what types of social classes characterized Sumerian civilization and why they emerged at that time.

Knowledge about Sumerian settlements built before 3400 B.C. is similarly scant, observes Wright of the University of Michigan. “The Uruk expansion must have started earlier and been more complex than Algaze assumes,” he argues.

While Algaze proposes that long-distance trade resulted in the explosive growth of Sumerian city-states, Wright argues just the opposite. As he sees it, competitive city-states attempted to control ever-larger territories, and trade was an outgrowth of their political jousting.

In a fundamental challenge to this already-diverse collection of views, Gregory A. Johnson of the City University of New York, Hunter College, questions the whole notion of a strong, expanding Sumerian civilization in Uruk times. Instead, he contends, the period was one of political collapse and fragmentation.

Johnson says the Sumerian colonists described by Algaze were most likely a group of refugees, initially consisting of administrative elites who had been defeated in the political power struggles that flared up in budding city-states.

“Why were Uruk outposts established in distant areas fully equipped with household utensils, administrative paraphernalia, husbands, wives, children, sundry relatives, animals, architects, artisans — all the comforts of home? Perhaps things at home were not that comfortable,” he suggests.

If, as Algaze argues, traders founded communities such as Habuba Kabira, they could easily have adapted to local ways of life without taking with them everything but the kitchen hearth, Johnson points out. Refugees, however, are more likely to recreate the lives they were forced to leave behind.

And masses of Mesopotamians indeed left their lives behind. Populations declined sharply in many southern Mesopotamian cities and their surrounding villages at the end of the 4th millennium B.C. Surveys conducted by Johnson and others indicate the abandonment of nearly 450 acres of occupied areas representing as many as 60,000 people.

The populations of inhabited areas of seven major Sumerian cities dropped by an average of 51 percent in the last few centuries of the Uruk period, Johnson notes. Only at the city of Uruk have archaeologists documented significant expansion during that time.

Moreover, widespread abandonment of settlements on Iran's Susiana plain created an uninhabited, 9-mile-wide

“buffer zone” between two large Late Uruk communities known as Susa and Chogha Mish. What once had been a single state in its formative stages was thus sliced in half, Johnson says. The buffer zone probably became the site of intense warfare between administrative elites from the two sides, who wrestled for control of rural labor and agriculture on the plain. Some Sumerian cylinder seals portray political conflicts of this type rather than economic rivalries, he asserts. Susa gained the upper hand and remained an urban center into the 3rd millennium B.C., while Chogha Mish became a ghost town.

Johnson says competing political factions undoubtedly plagued other nascent states, creating a reservoir of disgruntled Sumerians with plenty of incentive to haul their belongings to distant greener pastures.

Further archaeological work, particularly in areas remote from the intensively surveyed river sites, may clarify some of the controversy surrounding the rise and rapid fall of the world's first civilization. But a consensus will be difficult to dig out of the ground.

“Quite frankly, no one has come up with a good explanation for the Uruk expansion,” concedes Weiss. “It remains a great mystery.” □