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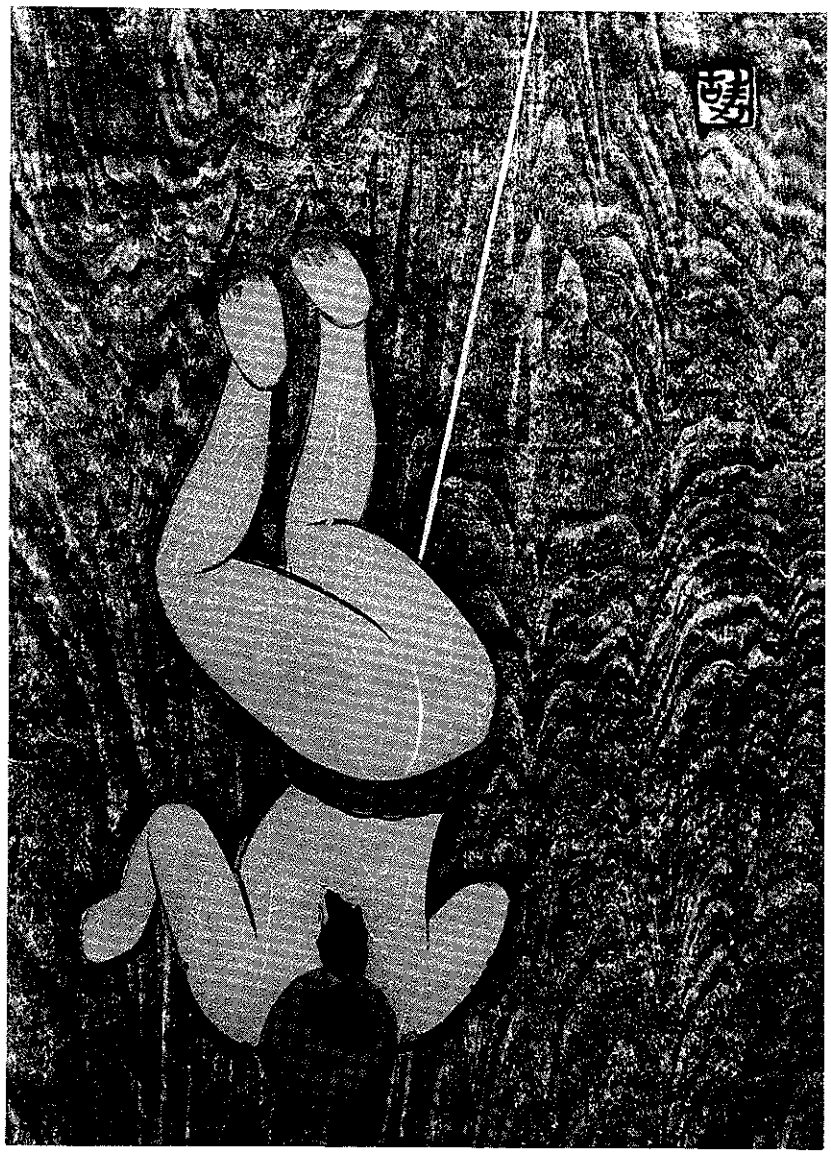


NAVSO P-3580

KOCHI, JAPAN, RADIOMETER INSTALLATION

Kevin G. Smith and Paul McGill

INTRODUCTION

Stanford University is establishing a global network of eight automatic radio noise measuring systems or radiometers. This survey is being conducted to study electromagnetic noise in the 10-32,000 Hz (ELF/VLF) frequency range. The Stanford University ELF/VLF Radiometer is a new computer controlled system recording several types of data. Narrowband (5% bandwidths) data, from 16 selected frequencies over the entire 10-32,000 Hz range, are recorded on digital tape. Wideband lower-ELF/VLF data (10-400 Hz) are also recorded digitally. Further, wideband ELF/VLF data are recorded on analog tape (flat response on the order of 200-25,000 Hz). All wideband data are recorded synoptically, typically in a one-thirtieth of a minute format, with other options available.

Present radiometer sites are:

- Arrival Heights, (near McMurdo Station), Antarctica,
- Sondre Stromfjord, Greenland,
- Thule, Greenland,
- L'Aquila, Italy,
- Kochi, Japan,
- Dunedin, New Zealand,
- New Hampshire, U.S.A., and
- Stanford, California, U.S.A.

Further technical information on the radiometer network is available in an article by Dr. A. C. Fraser-Smith and Dr. R. A. Helliwell entitled "The Stanford University ELF/VLF Radiometer Project: Measurement of the Global Distribution of ELF/VLF Electromagnetic Noise" (*Proceedings, 1985 International Symposium on Electromagnetic Compatibility*, Wakefield, Massachusetts, August, 1985).

- Kochi Earth Observatory

Kochi Earth Observatory is a new geophysical research facility established by Kochi University and dedicated to the study of seismic, electromagnetic, and cosmic ray phenomena. Kochi University is a small national Japanese university located in Kochi, Japan on the island of Shikoku. Shikoku is the smallest of the four principal islands and is relatively far away from the more densely settled sections of Japan. (See Figure 1 for an atlas insert showing the location of Kochi.) The observatory itself is located at the top of the hill, Sasayama, which is owned by Hidaka-Mura, the village of Hidaka. The rural nature of this area makes it a good site for investigators wishing to minimize man-made electromagnetic noise. (See Figure 2 for a sketch of the general layout of the observatory site.) Sasayama has been described as 309 m high and the top is partially cultivated. There

are few homes on the hill, but there is a nearby chicken farm and several religious shrines. The facility is approximately 15 km west of the campus (30 minutes by automobile). Photographs 7 and 8 illustrate the general remoteness of the site from the local communities.

All antennas are located at the top of Sasayama on a circular flat area about 25 m in diameter. The observation house is roughly 250 m down the hillside. Cables from the antenna farm to the observation house are direct buried in soft soil trenches. Cable lengths must be 285 m minimum.

At present, the observation house (Photograph 1) is a small air conditioned prefab building roughly 25 m^2. Kochi University may build a more permanent structure at some later date. There are no windows, but there are two air conditioning/heating units and a set of double doors at the front entrance.

The observation house is divided into two rooms, a front room presently used for storage and a back room containing shelf space, desks, and instrumentation. No living quarters are available. No plumbing or cooking facilities are provided and water must be brought to the site.

Shikoku Electric Power Company has brought power to the building by pole line from services available at the nearby chicken farm. In this area of Japan, the standard is 100 V and 60 Hz. A breaker panel located in the back room had some eight circuits at 15 A apiece. No voltage regulation or uninterruptible power supplies are at the site. Internal wiring is by surface-mounted, nonmetallic sheathed cabling and additional ground wiring. The facility at Kochi University stated that service could be expanded in the future for other experiments if need be. U.S. investigators should recall that Japanese and U.S. grounded plug/receptacles are mechanically incompatible. The Japanese standard receptacle accepts polarized plugs with a separate ground wire screw on the receptacle face plate.

Instruments installed or planned for the observatory are as follows:

ELF/VLF radiometer	Stanford University
three-dimensional seismometers	Kochi Observatory
ELF ball antenna	Kochi Observatory
four "bucket" antennas - smaller variations of ball antenna placed underground N, S, E, W	Kochi Observatory
field mill	Kochi Observatory
cosmic ray detection system	Kochi Observatory (planned)

Station test equipment includes the radiometer instrument set, two Iwatsu digital storage oscilloscopes (model SS-5802), a Delica grid dip meter (model SP-7), a Sony PLL synthesized AM receiver (model CRF-1), a Takeda Riken Digital Spectrum Analyzer (model TR9404), and a Hitachi personal computer (model MB-S1/40). In support of all the above listed Kochi experiments, a variety of printers and plotters, amplifiers, and controllers have been installed. Electronic and mechanical hand tools are available including a butane-powered soldering iron for work at the antenna site.

Road access is via a well-maintained winding road up Sasayama. This location is subject to typhoons and lightning. U.S. investigators wishing to use this research facility may contact:

Dr. Toshio Ogawa
Department of Physics
Faculty of Science, Kochi University
Akebono-cho, Kochi 780
Japan
Telephone (0888) 44-011, Ext. 608

Slides of the observatory and radiometer installation are available at Stanford University.

PROJECT LOGISTICS AND SCHEDULING

The installation of the radiometer alone took approximately seven full working days but the entire trip lasted eleven days due to weather and training. A synopsis of the trip is as follows:

DATE	DAY	EVENTS
3 September	Tuesday	Arrive in Kochi
4 September	Wednesday	Introduced to Kochi University faculty, administration and students in the morning; visited observatory and finished unpacking equipment; performed site survey with portable VLF receiver; installed rack instrumentation.
5 September	Thursday	Planned antenna construction with Seiwa Denki construction company; soldered most of the field cable connectors.
6 September	Friday	Finished field cables; VLF preamplifier filter installed; preliminary cable and preamplifier system check.
7 September	Saturday	Inclement weather; Seiwa pulled cable but no antenna work today; preparation for next day
8 September	Sunday	Coordinated outside antenna work with Seiwa. ELF antenna and preamplifier installed and checked out.
9 September	Monday	VLF antenna installation begun; met local news media; gave joint seminar at Kochi University.
10 September	Tuesday	Finished VLF antenna installation; calibrated VLF receiver; checked out system noting interference; put up field expedient whip antenna for UTC (universal time coordinated) stations.
11 September	Wednesday	System training for Japanese personnel; spectrum analysis of sample data and project wrap-up.

We would not have been able to adhere to such a tight schedule were it not for the help of our Japanese collaborators at Kochi. Principals involved in the establishment of the Kochi Earth Observatory and the current experiments are listed as follows:

Umezawa, Dr. S. - Dean of the faculty at Kochi University,

Kusunose, Dr. Masahiko (Photograph 9) - Chairman of the Department of Physics at Kochi University and a specialist in cosmic ray studies; a sample of his papers is available at Stanford University,

Ogawa, Dr. Toshi (Photograph 9) - One of Japan's principal investigators in atmospheric electricity and manager of the Kochi Observatory; recently interested in the possible correlation of earthquakes and electromagnetic events; formerly at Kyoto University; a sample of his papers is available at Stanford University.

In particular, Dr. Ogawa and Dr. Kusunose took pains to support our work with whatever we needed and were very hospitable. Also Seiwa Denki was invaluable in erecting the VLF antenna and building the underground vault for the ELF antenna. Similar installations with two people only would have required another week. Two people are an absolute minimum for such installations.

ANTENNA CONSTRUCTION

- Site Survey

The site for the antennas had already been selected when we arrived, so all that remained was to determine the best orientation for the loops. The portable VLF receiver revealed strong alpha and omega navigation signals as well as two local sources of power line noise. One source seemed to be the chicken farm and the observatory just a few hundred meters down the hill, and the other source was probably the city of Kochi about 15 km to the east. We found that the direction of least interference was a line about 10° clockwise of magnetic north-south. Based on these observations, the contractor (Seiwa Electric Company) surveyed the site carefully to an accuracy probably within 1 cm.

- VLF Antenna

The Japanese provided an 11 m wooden pole for the VLF antenna mast. This pole was set in concrete to a depth of 1.5 m, leaving 9.5 m above the ground. Four steel guy wires were attached to deadman anchors, providing a very stable structure. Wooden corner posts were set in concrete to provide attachment points for the lower ends of the loops. Guy wires were not necessary for the corner posts.

After the pole was erected, the loops themselves went up very quickly. The linemen cut the top of the pole and attached our hardware according to our instructions. We had them bind the antenna wire to the top insulators to prevent the loops from sliding in the wind. The bottoms of the loops run about .5 m above the ground and are quite easy to trip over. This should not be a problem however, since a gate will be built at the only entrance to the site to prevent foot traffic around the antenna and other sensitive instruments.

We had wanted to place the VLF preamp on the side of the pole away from prevailing winds, but we were told that storms come from opposite directions in the winter and summer. We decided to place it on the shady side since the temperature was over 38°C

(100°F) much of the time we were there. Two corrosion inhibitor pads and a large bag of silica gel was placed inside the preamp to absorb moisture. As with the ELF preamplifier, an intercom jack is available for communication with the observatory instrument shelter. (See Photograph 6 for a view of the VLF antenna and preamplifier.)

We discussed putting a lightning rod at the top of the pole as lightning storms are common in the area. We were not sure how such a long current carrying conductor would affect the operation of the antenna so we decided to leave it off. Copper grounding rods were planted all over the site for other experiments, and are available if we decide to add a lightning rod in the future.

- ELF Antenna

The ELF loops were placed in an underground vault about 6 m from the base of the VLF pole, on the side of the site farthest from the observatory and the city of Kochi. The vault is a cube measuring 2 m on each side, and was constructed at the site with the metric counterparts of 4" x 4" cedar timbers (Photograph 4). The outside walls are covered with thick plywood, and all the joints are sealed to prevent water seepage. The lid is buried under about 10 cm of soil, but a small hatch provides access for maintenance. The Japanese carpenters were true craftsmen, using mortis and tenon joints to ensure a solid, tight fitting structure.

The ELF loops are held by a wooden frame shipped from Stanford University (Photograph 5), and isolated from the vault floor by thick foam padding. The ELF preamplifier was prepared similarly to the VLF preamplifier and mounted on an interior wall of the vault.

RADIOMETER LABORATORY SYSTEM

The system is mounted in a pair of six feet high 19" racks, brought to Kochi, and the terminal is placed on a nearby desk (Photographs 2 and 3). No significant shipping damage was sustained by the equipment and the installation itself was generally trouble-free. There is, however, much power line harmonic hum and radio communications interference. This information is discussed in more details in the Sample Data section below.

An autotransformer, brought from Stanford, was used to boost the 100 V local power up to 120 V for the American equipment. The transformer is rated at 1.8 kW, but the radiometer requires only about 0.8 kW. This leaves plenty of power for additional test equipment and keeps the transformer running cool.

No problems were noted in calibrating the line receivers. However, it was observed that oscillations could be provoked when loading the output stages of the noise filter. No craft recorders were connected to the noise filter outputs during the original installation, but their use is anticipated after the oscillation problem is solved.

For calibrating the clock, a "field expedient" high impedance whip about 11 m long was strung from the shelter to a nearby utility pole for use with our WWV receiver. A variety of UTC (universal time coordinated) stations were received, but the optimum signal was received from BPM in Xian, People's Republic of China, which uses 1 kHz tones as does WWV in the U.S. The Japanese may erect a more permanent antenna and elect to use JJY near Tokyo.

The system was left operating with the default recording schedule of one-sixtieth of a minute synoptic for VLF broadband recording, one-thirtieth of a minute synoptic for ELF broadband recording, and 1 sample/second continuous noise filter sampling. The Japanese faculty and students were trained on the system on September 11th. The Japanese are interested in the data and are making arrangements to perform simultaneous recording. As of this writing, they expect to be on-line within two to four weeks.

- Sample Data

Appended to this report are two minutes of annotated analog spectrogram data recorded from the VLF north-south channel on 18 September and illustrating local interference. The data is displayed on two separate scales. (The ELF channels were relatively interference-free except for some power line hum.) A quick look at the VLF data shows that a number of VLF transmitters, both American and Soviet, all present between 10 and 20 kHz and that power line hum is present also. In particular, there is an anomalously high harmonic at 1380 Hz. Finally, a strong RF signal is apparently causing the preamplifier to cut out on occasion. The data will undergo further analysis, and filters will be fabricated and shipped to Kochi as required. Despite these interfering signals, the Kochi site remains a relatively quiet one.

EPILOGUE

As of March 1986, Kochi University had shipped 19 analog tapes and 36 digital tapes to Stanford University for study. Another experimental facility, a meteorological satellite imaging system, has been added at Kochi Observatory for the study of conjugate location thunderstorm clouds. More construction has been reported on Mt. Sasayama and the impact of related powerline hum on the data is under investigation. The authors would like to thank the faculty and students at Kochi University for their continuing support.

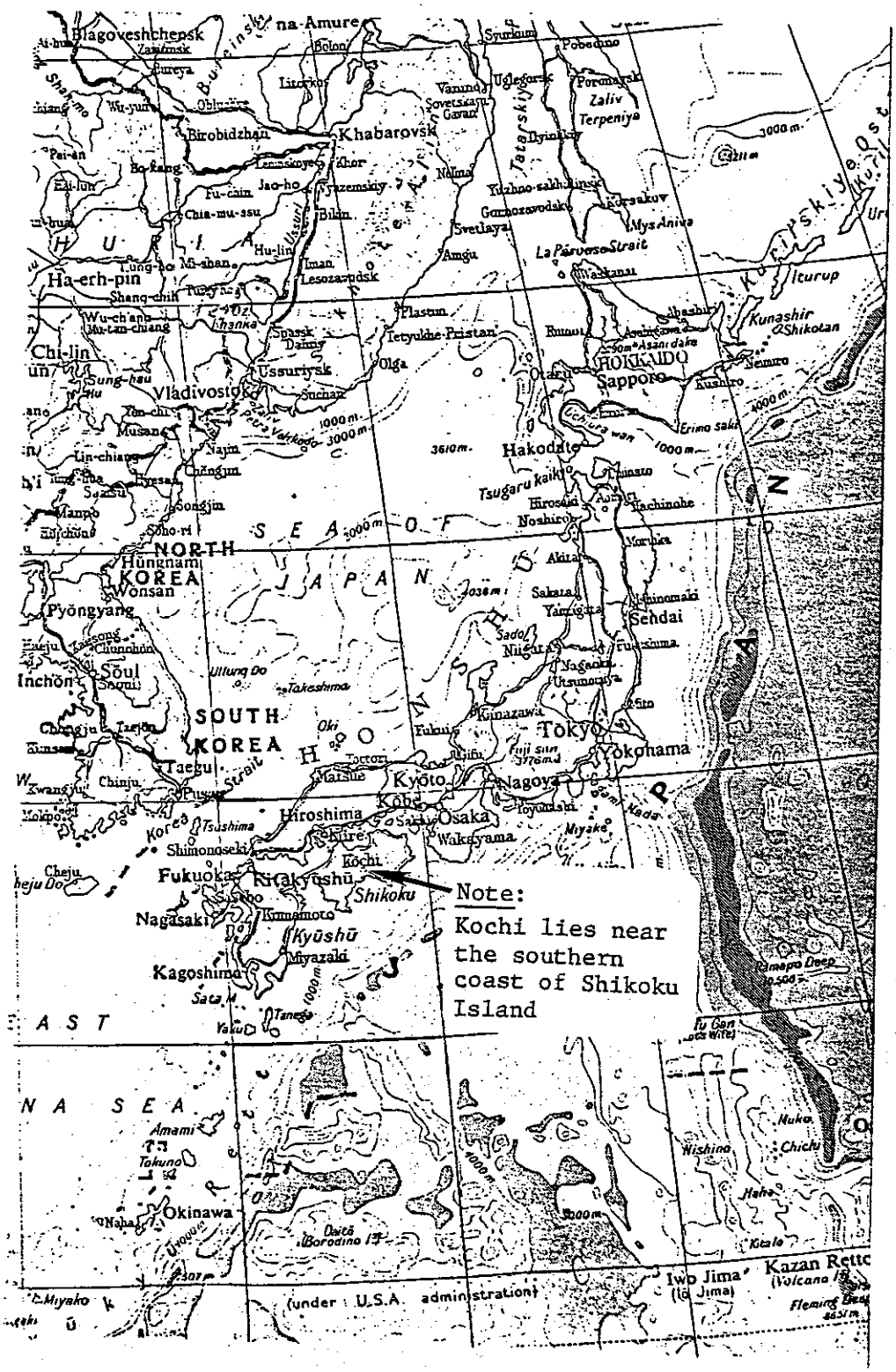


Figure 1. Location of Kochi, Japan

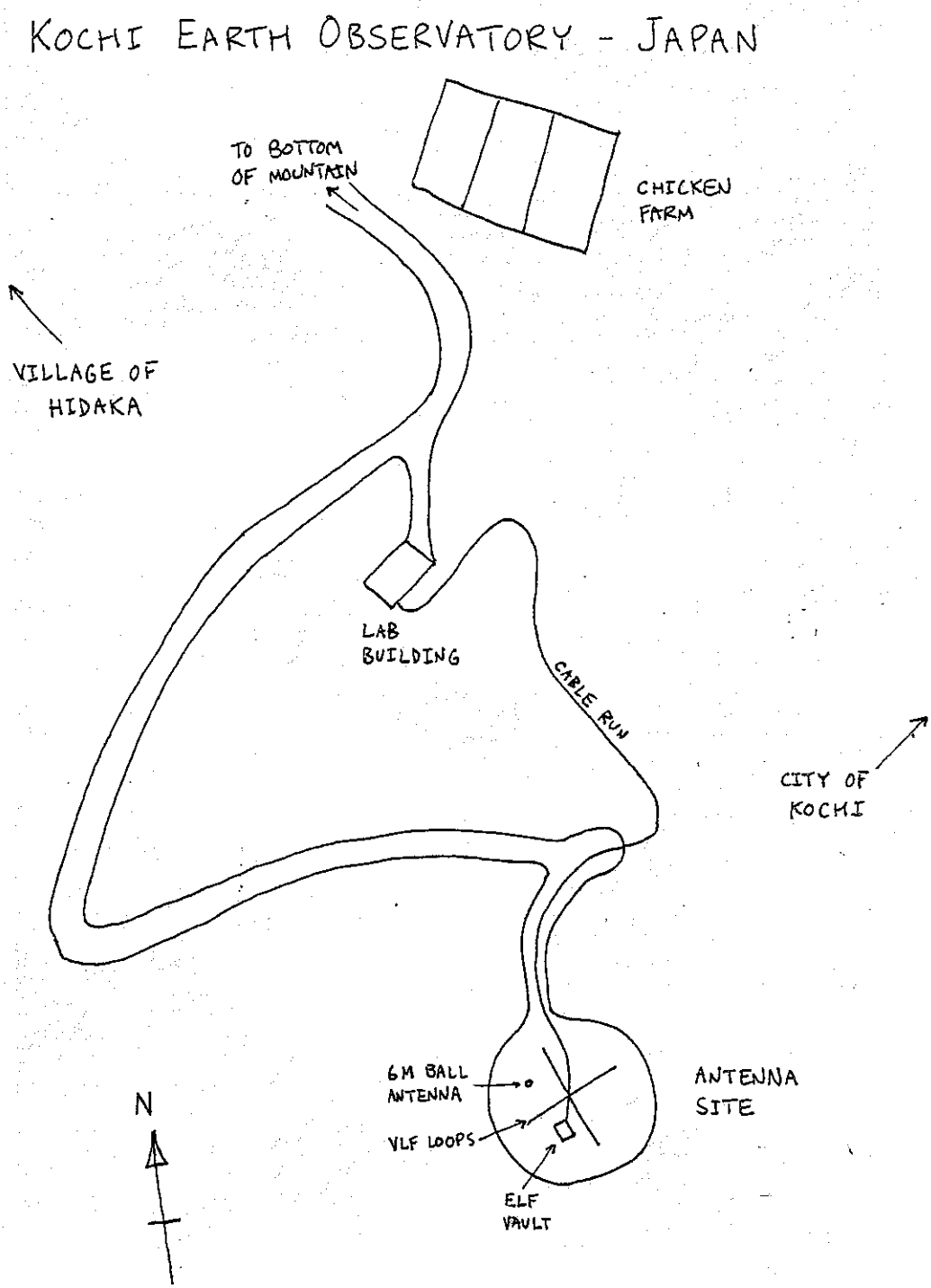
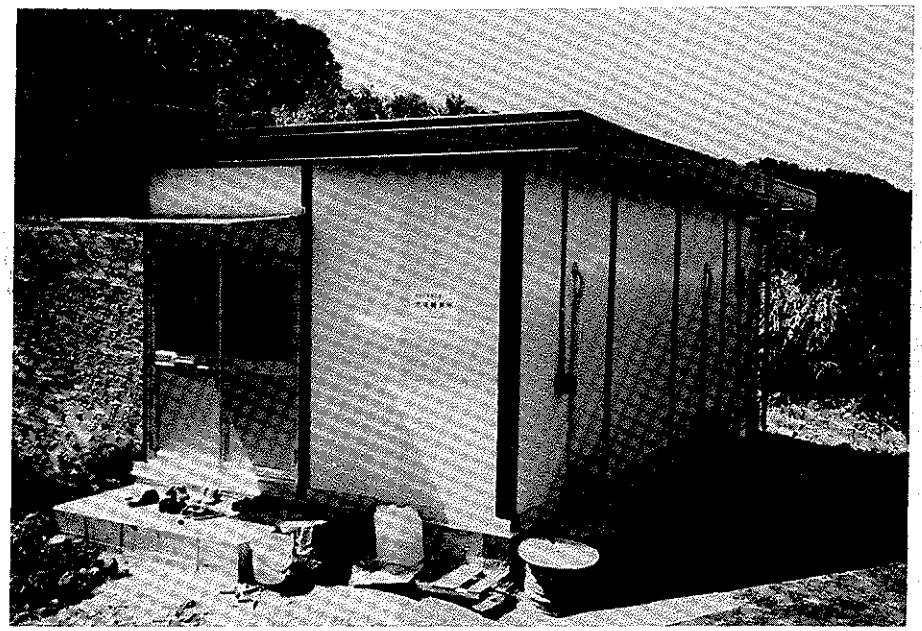


Figure 2. Layout sketch of Kochi Earth Observatory atop Mr. Sasayama

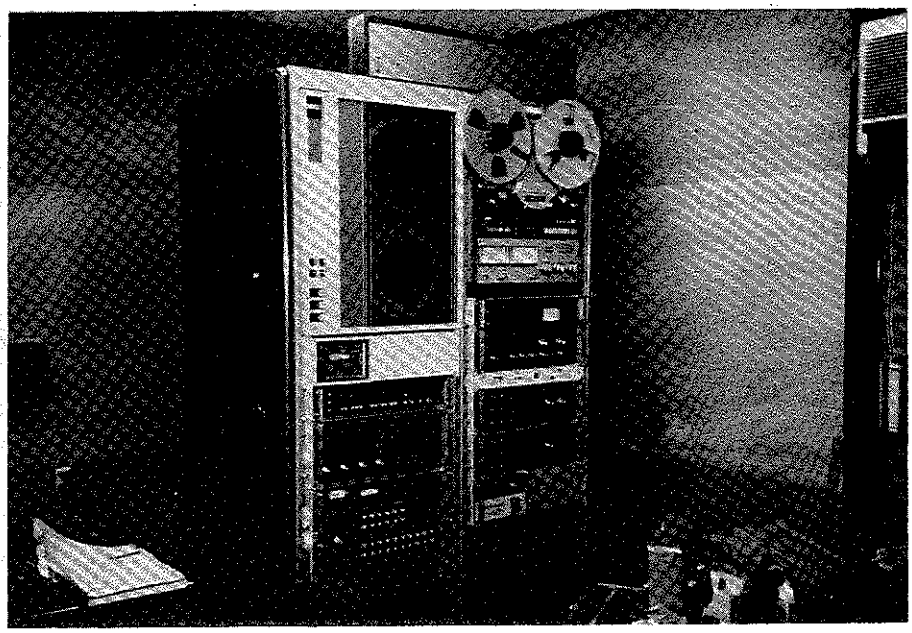


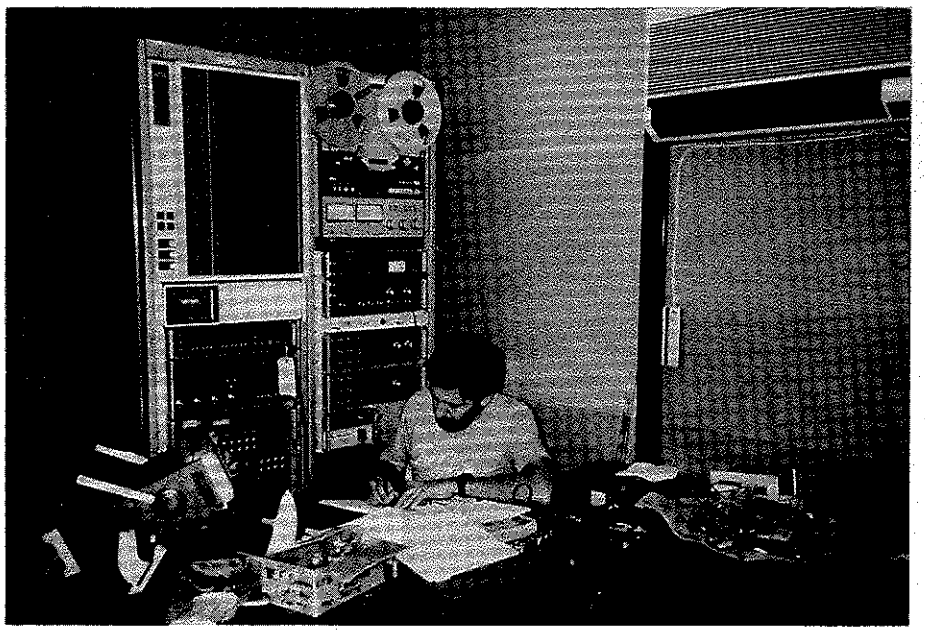
Photograph No. 1

Kochi Earth Observatory instrument shelter on Mt. Sasayama.

Photograph No. 2

Stanford ELF/VLF radiometer as installed in instrument shelter.



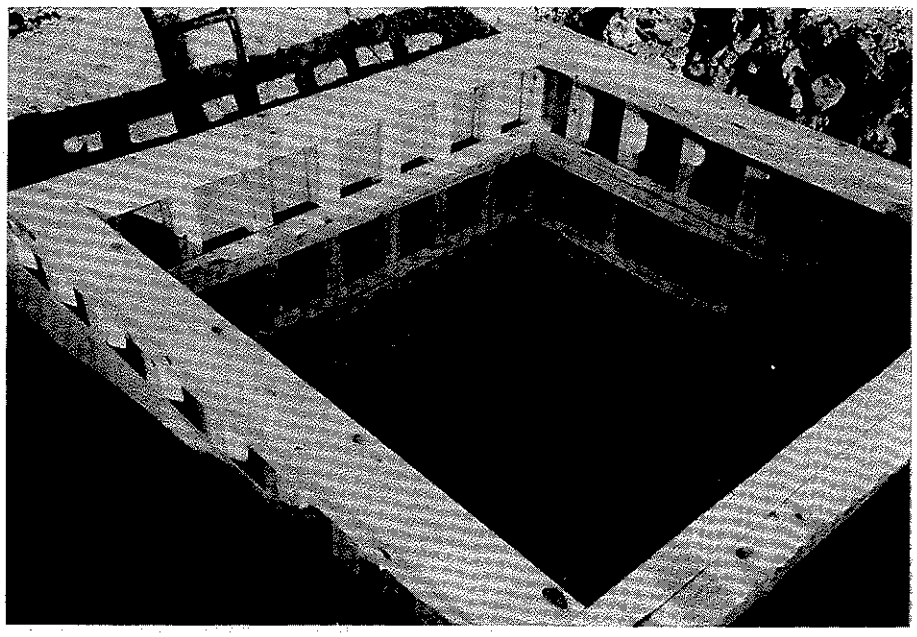


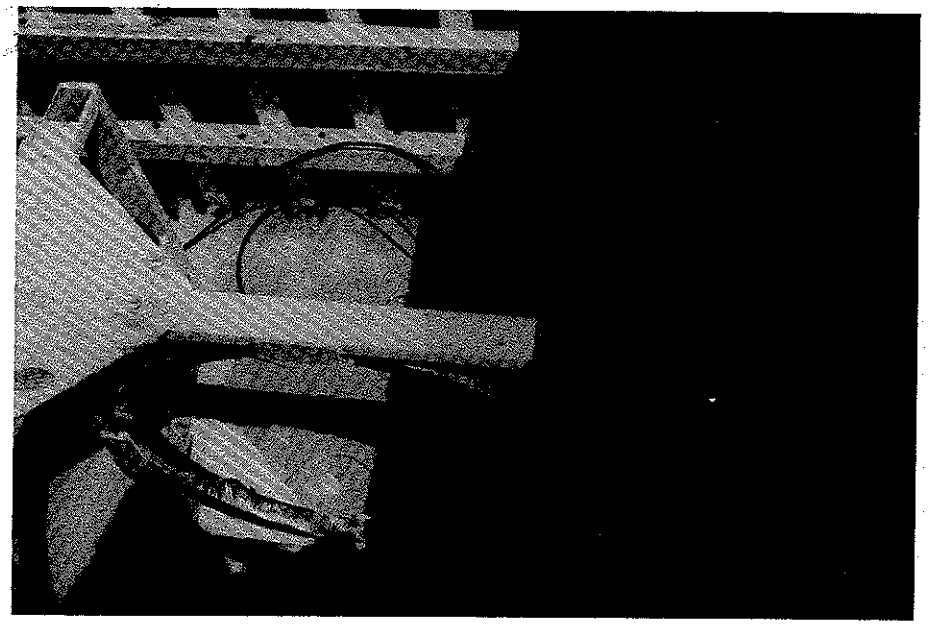
Photograph No. 3

Mr. Paul McGill seated at work-bench during system checkout.

Photograph No. 4

ELF antenna vault during construction (lid and hatch not in place).



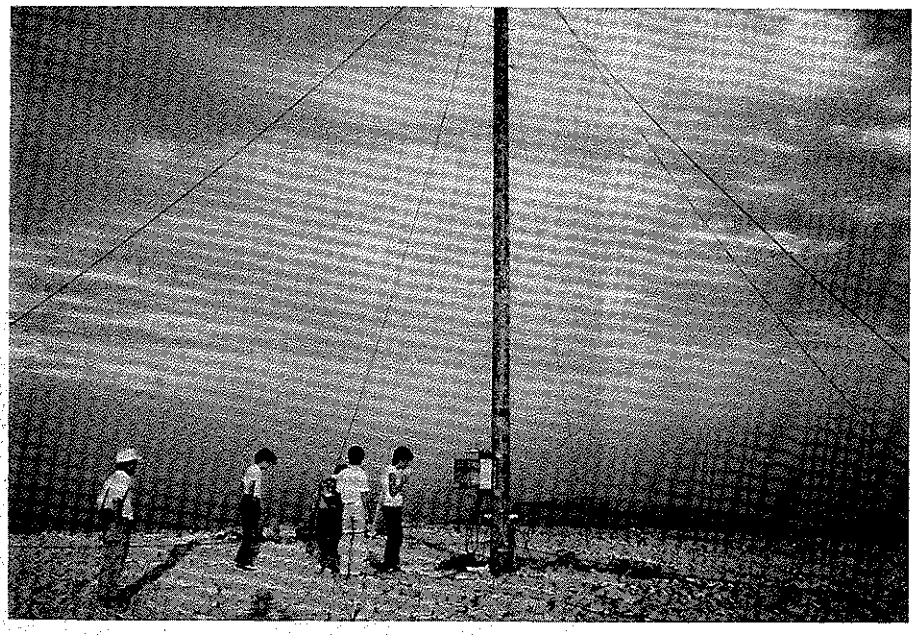


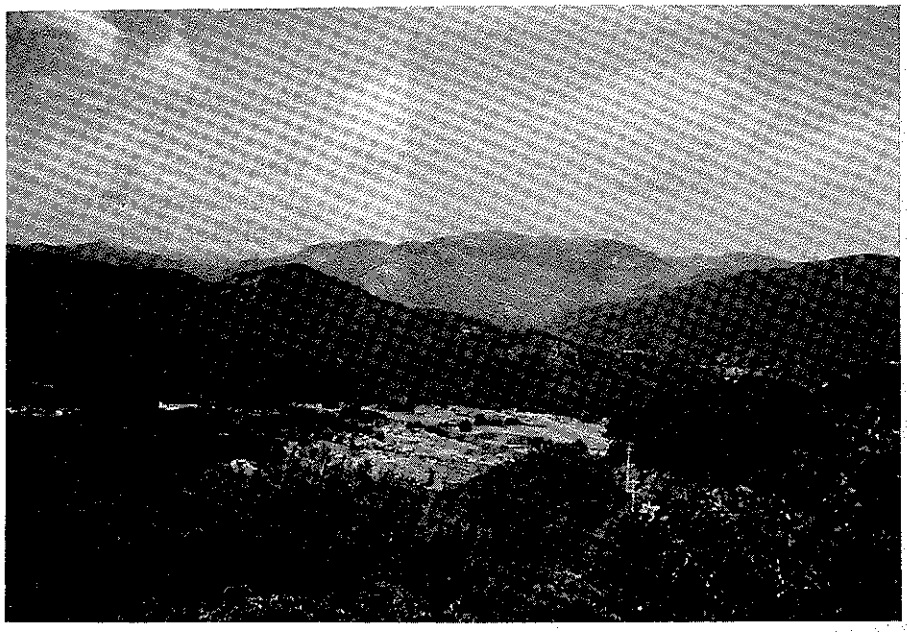
Photograph No. 5

View of the ELF antennas and pre-amplifier in the vault during system checkout.

Photograph No. 6

Dr. Kusunose and students next to the VLF antenna. A student is using the intercom to contact the instrument shelter.



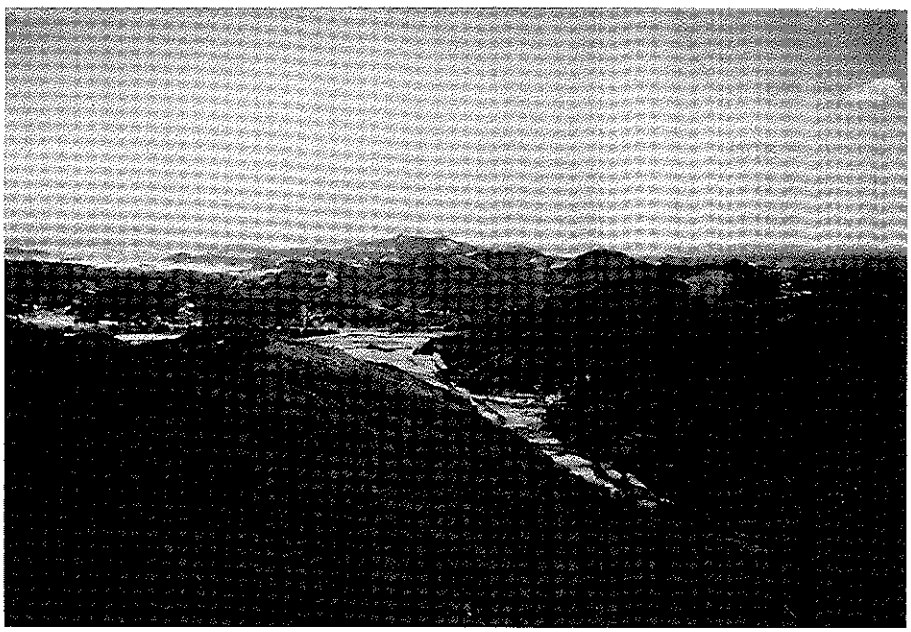


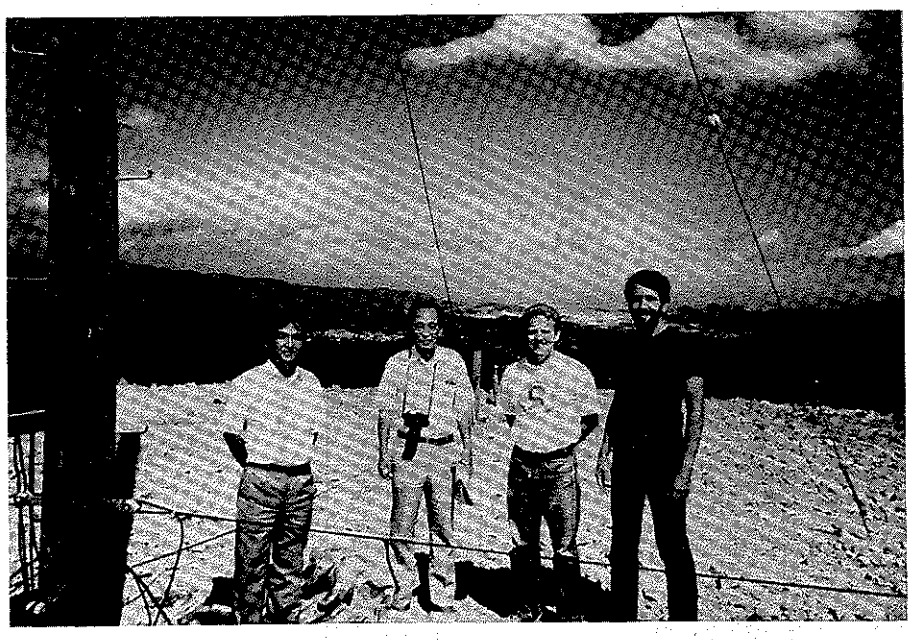
Photograph No. 7

Hidaka-Mura viewed from the observatory.

Photograph No. 8

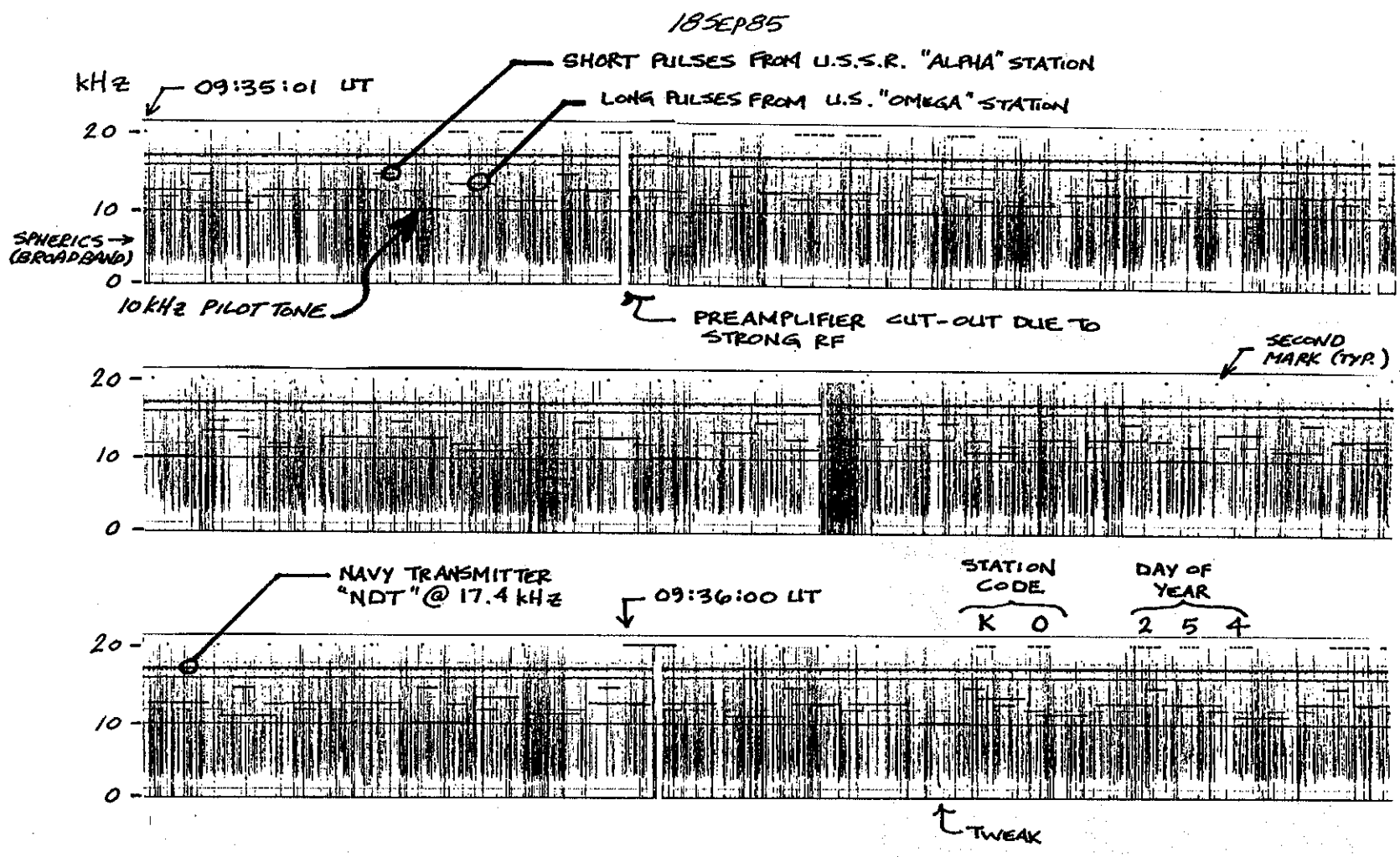
The city of Kochi on the left and the ocean on the right as viewed from the observatory.



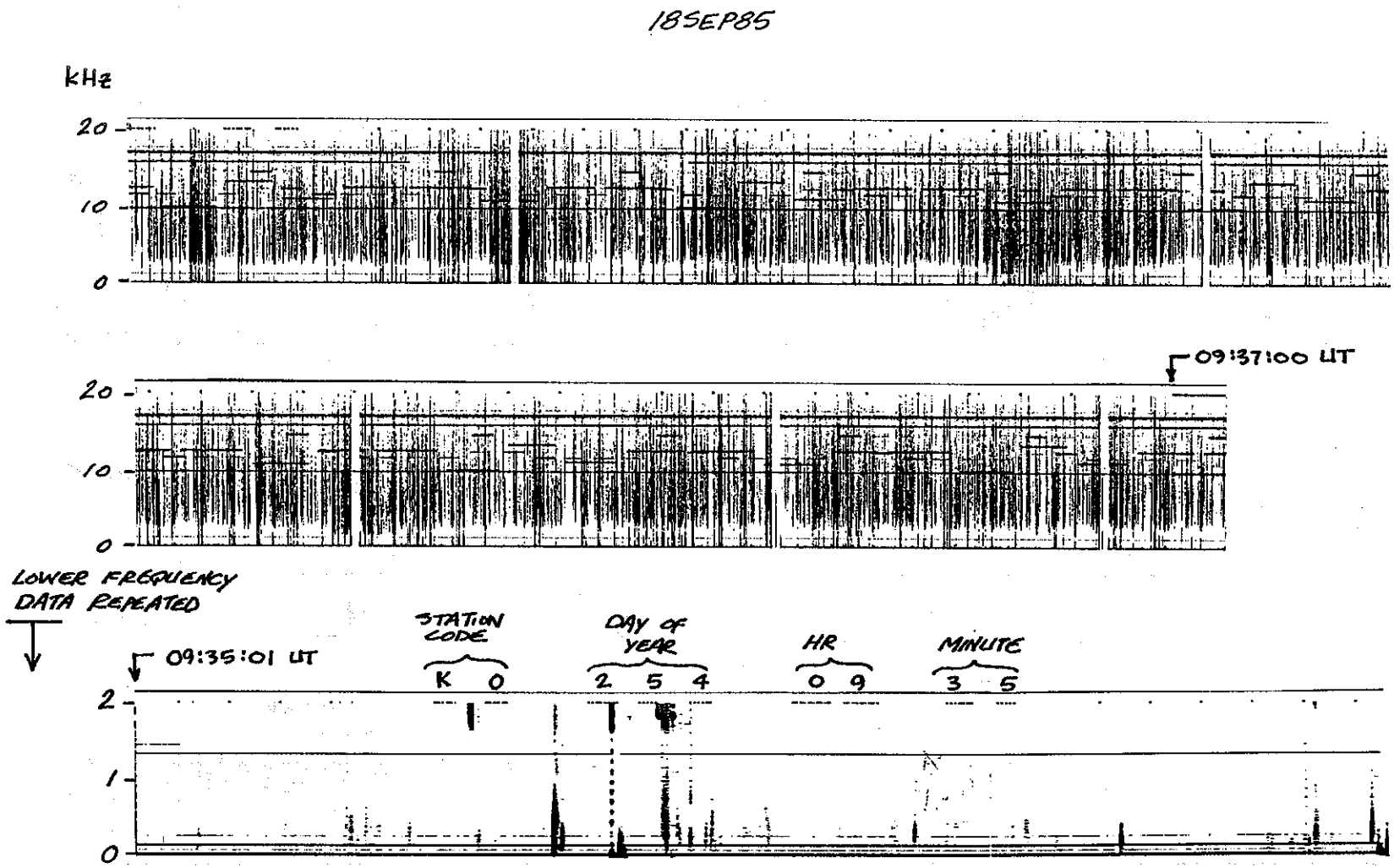


Photograph No. 9

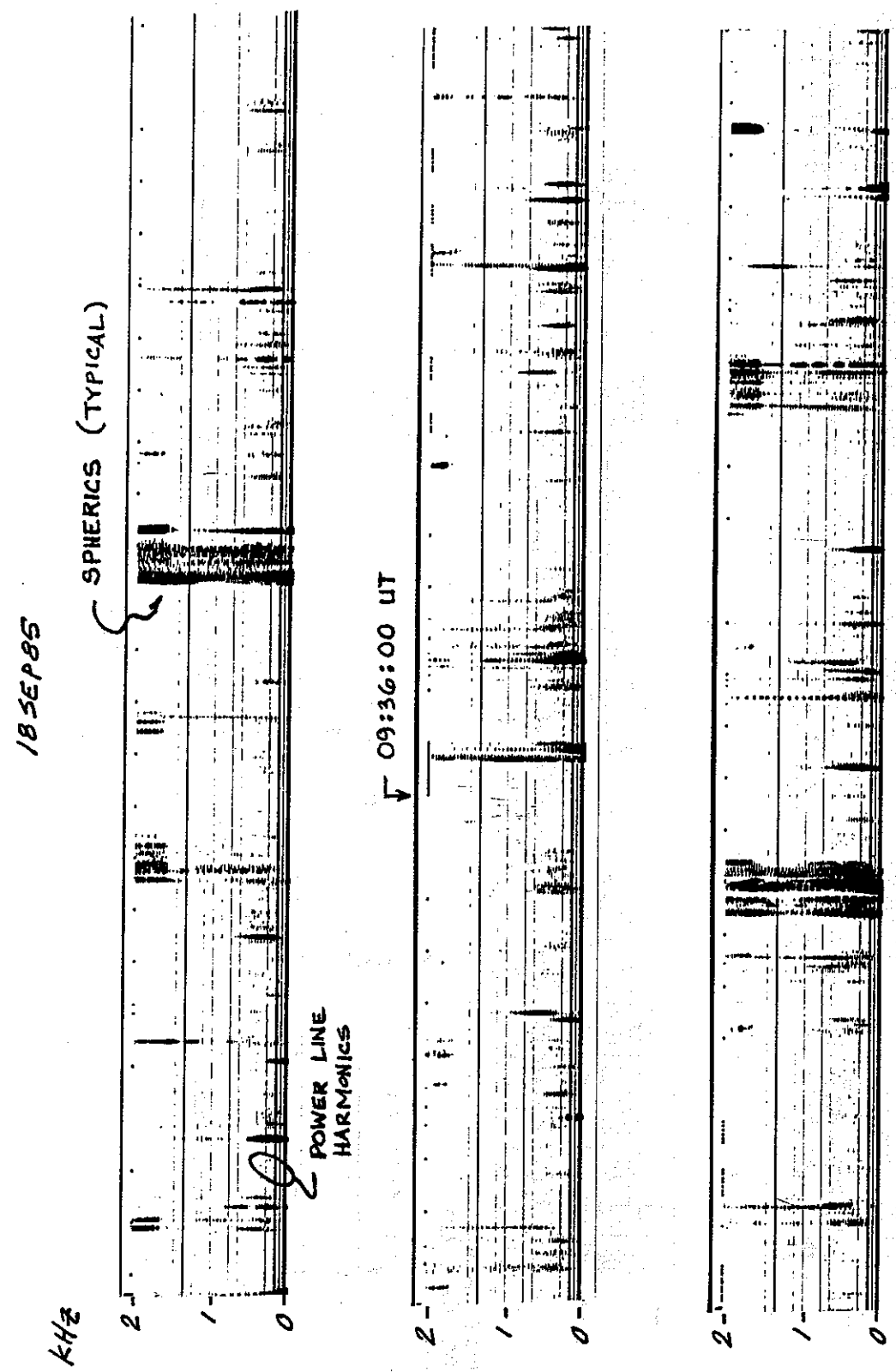
Left to right:
Dr. Masahiko Kusunose,
Dr. Toshio Ogawa,
Mr. Kevin Smith,
Mr. Paul McGill.



Kochi VLF N-S Sample data
Sheet 1 of 4



Kochi VLF N-S Sample data
Sheet 2 of 4



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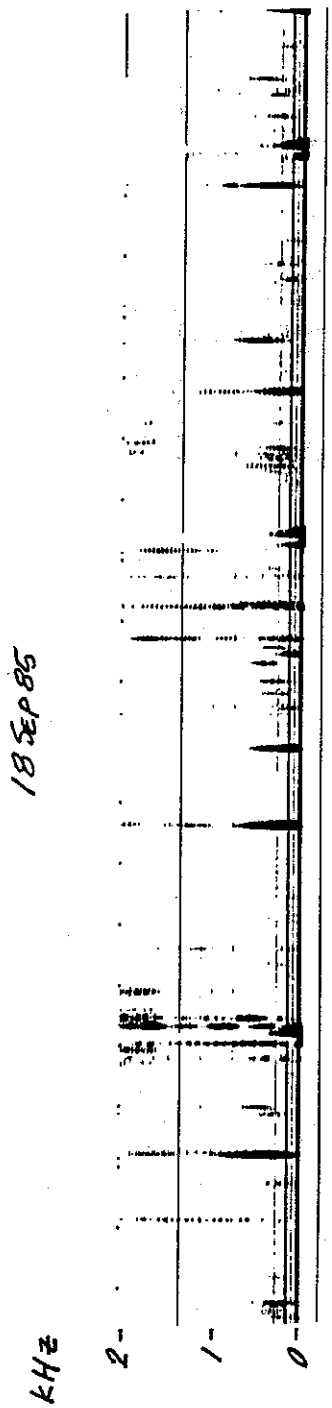
Sheet 3 of 4



Kochi VLF N-S Sample data
Sheet 4 of 4

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