VI. Tentative calculation of natural gas reserves in the "200 m reservoir" of the Kathmandu area

As already explained, the natural gas deposits of Kathmandu valley are based on the reservoirs of dissolved-in-water type the following tentative calculation of gas reserves is worked out for rough evaluation of the "200 m reservoir".

area of the reservoir ------------ 2 km x 2 km (=4,000,000 m^2)
thickness of the reservoir ------- 60 m
porosity of the reservoir -------- 35 % (0.35)
average value of gas-water ratio- 1 : 2 (0.5)
reserves of natural gas (m^3)

$$4,000,000 \times 60 \times 0.35 \times 0.5$$
$$= 42,000,000 \ (m^3)$$

The calculated value of reserves, 4.2×10^7 m^3, is almost the same as to that of the Kamisuwa natural gas field in Central Japan, which has been developed economically since about 100 years ago.

Further estimation of gas reserves in the reservoirs, both shallower and deeper than 200 m, will be necessary in the future.

VII. Future Works

Judging from the data of field survey and laboratory operations given in the foregoing pages, it is considered necessary to undertake the following works for early and successful exploitation of the natural gas resources in Kathmandu valley.

1. Areal Geochemical Exploration

The hydrogeochemical exploration conducted during the present survey covered an area of only about 60 km^2 out of the total distribution area of the Quaternary sediments, about 250 km^2, and only 18 wells were selected for observation in this small survey area. Hence, the remainder of the distribution area needs to be covered by the next hydrogeochemical prospecting. According to the data of WHO and other organizations, it is likely that the existing water wells in the remaining distribution area will be kept in use until the next prospecting taken place. It will be possible to obtain groundwater samples from some of these wells for geochemical exploration.

During the survey, the southern part of Patan city engaged the team's special attention because of the WHO's data on the content of hydrogen carbonate ion in groundwater which suggested a probability of locating a gas field of dissolved-in-water type.

2. Exploration of Reservoirs Deeper than the "200 m Reservoir"

Considered from the viewpoint of prospecting techniques, it can generally be said that "three-dimensional survey" is the most expedient and important means of successful exploration of natural gas resources. Hence, the knowledge about the geoscientific condition of the deeper part of the basin to be surveyed is of vital importance.

In the present survey, however, it was not possible to obtain information on the geochemistry of hydrocarbons from the gas and water reservoirs (aquifers) lying below a depth of about 330 m because the deepest of the 18 wells selected for the observation has that depth.

The production rate of natural gas is expressed by the following formula.

$$Vg\ (m^3/d) = Vw\ (kl/d) \times GWR$$

where,

Vg	:	gas production rate
Vw	:	water production rate
GWR	:	gas-water ratio

As can be seen from the above formula, the value of GWR must be high in order to obtain a high production rate. Since GWR is determined by the reservoir depth, exploration of deep gas reservoirs is of vital importance in promoting economic development of natural gas deposits. Drilling of exploratory wells to deeper reservoirs is therefore one of the most important tasks to be undertaken in the future.

3. Drilling of Exploratory Wells

All wells used for hydrogeochemical exploration were originally drilled for the purpose of water supply, so that they were functionally not suited to the intended exploration of natural gas resources.

It is therefore necessary to drill two types of exploratory wells having the specifications and functions described below.

i) Shallow exploratory wells

The shallow exploratory wells must have a depth of about 300 m and be set up with a casing 4 inches in diameter. They must be water-sealed in order to be able to obtain accurate information on gas potential and productivity for comparison with the data of the "200 m reservoir."

Such information should include, for example, the data itemized below.

Gas production (m^3/d)
Water production (kl/d)

Gas-water ratio

Gas composition

Water composition

Water temperature (°C)

Production condition of gas and water (natural or pumping-up)

Water productivity index (kl/day/kg/cm^2)

To obtain the above data, gas-lifting may occasionally be found necessary, and about 20 HP (15 kW) of power will be required for gas-water lifting. It will also be necessary to install a gas-water separator having a capacity of 2 - 3 m^3 for accurate measurement of the volume of produced gas and water at the casing head.

During the drilling work, the physical properties of the penetrated formations must be made clear by electric logging (resistivity and spontaneous potential). Micropaleontological study must also be made at the wells.

After completion of the wells, periodic measurement must be made on a long-term basis to collect the data indispensable for gas field exploration. Construction of a gas holder (tank) on the land surface having a capacity of about 500 m^3 will also be required in order to make studies for economic utilization of the produced gas.

ii) Deep exploratory wells

The thickness of the Quaternary sediments in the valley as disclosed by the gravitational survey is about 600 m, which means that exploratory wells with a depth of about 600 m must be drilled in addition to the shallow exploratory wells.

The casing design of these wells will be as follows.

0 - about 300 m	Casing pipe without performation
about 300 - 600 m	Perforated pipe with an inside diameter of 4 inches

As in the case of the shallow wells, micropaleontological study and electric logging will be necessary, and completion of the wells must be followed by long-term periodic measurement.

4. Geochronological Survey

Geochronological examination of the Quaterary sediments will be required for the future exploration of natural gas, and the following studies will be found necessary for determination of geologic age.

i) Micropaleontological examination

Sediment samples to be collected from the wells and the outcrops can be used for micropaleontological study. Examination of diatom and pollen will be useful in conducting the geochronological study in the valley.

ii) Radio carbon study

For determination of the absolute age of less than 35,000 years, radio carbon (C-14) in the sediment samples of cores, cuttings and outcrops may be used.

5. Periodic Measurement at Selected Previously Drilled Wells

During the field survey, the team collected the data on the highgrade variation in the gas and water production condition at water wells. It is proposed that long-term periodic measurement of the said production condition be carried out for economic evaluation of the gas resources.

For the purpose of this periodic measurement, it is recommended that the following wells be selected as observation sites from among the 18 wells used in the present survey.

Loc. No. 1 and 15	For collection of data on the central part of the gas productive area
Loc. No. 11	For observation of the relatively low potential area
Loc. No. 8	For observation of the marginal area of the gas field
Loc. No. 9	For observation of the area with a low value of gas-water ratio

The following items will have to be covered by the long-term measurement and observation.

Gas production (m^3/d)
Water production (kl/d)
Gas-water ratio
Water temperature
Hydrogen carbonate content in water (mg/l)
Free CO_2 content in water (mg/l and ml/l)
pH and RpH
Cl^- in water (mg/l)
CO_2 in free gas (%)
H_2S in free gas (ppm)
CH_4 in free gas (%)
N_2 in free gas (%)
O_2 in free gas (%)
Ar in free gas (%)
C_2H_6 in free gas (%)
Colour of groundwater at casing head
Smell of free gas and water at casing head

Judging from the data obtained in the survey, it is considered appropriate to conduct the periodic measurement at intervals of one month.

6. Economic Study

In conclusion, it is recommended that an economic study covering all gas deposits in Kathmandu valley be made on the basis of the data given in the foregoing pages.

VIII. Summary and Conclusion

The geological and geochemical exploration of the natural gas resources in Kathmandu valley revealed that the gas reservoirs lying at a depth of about 200 m in the southern part of Kathmandu city have a high economic value.

The gas deposits in the valley have originated from the Quaternary fluvio-lacustrine sediments. According to the gravity survey, the sediments have a thickness of about 600 m, overlying the Palaeozoic and Precambrian bedrocks in an area of about 250 km^2. The Quaternary sediments can be clasified into two groups, one composed of coarse clastics deduced from fluvial, lake-delta, marsh and piedmont-fan, and the other consisting of finer clastistics deduced from a proper lake in quiet water. The finer clastics, having a thickness of about 200 m, are distributed in the southern part of the valley, whereas the coarser clastics are distributed in the northern part of the valley. It must be noted, however, that according to the data of electric logging, the finer clastics are intercalated in the lower part of the sediments exceeding 200 m in depth even in the southern part of the valley.

The survey covered an area of 60 km^2 out of the valley's total area of 250 km^2, and 18 water wells previously drilled in this area were used for hydrogeochemical exploration of natural gas deposits. The gas reservoirs, having a depth of about 200 and extending in an area of 4 km^2 in the southern part of Kathmandu city, have relatively high productive potential, namely, the value of gas-water ratio at the wells is about 1 : 2 (0.5). The maximum gas production rate of a well is about 70 m^3/day, and the total gas production from the ten observed wells in Kathmandu city is about 500 m^3/day. The gas composition is 75 - 80% for CH_4, 14 - 23% for CO_2, and 1.5 - 6% for N_2, and the calorific value is 6,200 - 7,000 Kcal/N m^3. The mineral content in the grounwater associated with natural gas is low.

Tentative calculation of gas reserves of the "200 m reservoir" produced a value of about 4.2×10^7 m^3 for an area of about 4 km^2. This corresponds to the value of the Suwa gasfield, Central Japan, from which about 1,000 m^3/day of natural gas has been produced economically since about 100 years ago.

In the future, it is necessary to conduct further surveys to clarify the areal and vertical extension of the gas resources and obtain relevant economic information. Drilling of new exploratory wells, having depths of about 300 and 600 m, will also be required for collection of accurate data of the "200 m reservoir" and the reservoirs deeper than 300 m.

The gas deposits in the valley have a high economic value, although they are not so large in scale as many oil and structural gas deposits in other parts of the world, and it is necessary to collect more economic data on the gas resources in the valley by periodic measurement of gas and water production to be conducted on a long-term basis at some of the previously drilled water wells.

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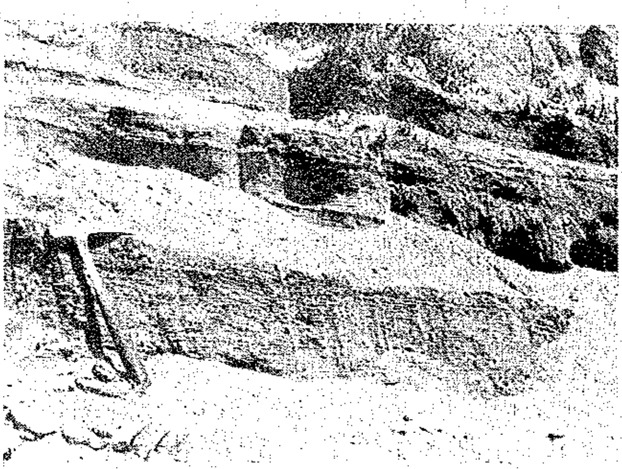
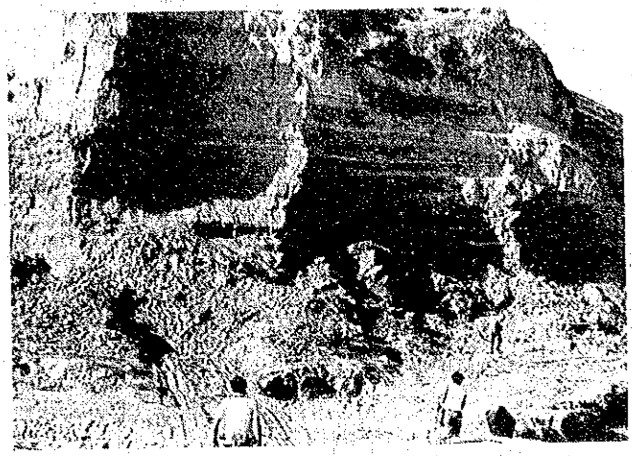
Kathmandu valley looking towards Kathmandu city from Burhanilkanth on the northwestern part of the valley.

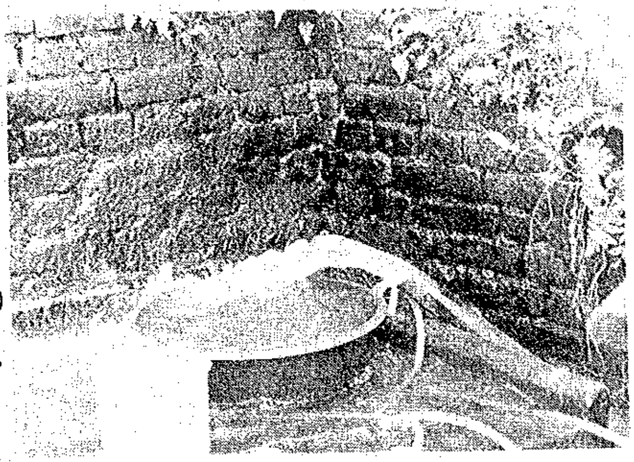
Fluvial deposits (Facies I) of coarse-grained sand in the lower part and silt and clay in the upper part, near Baralgau.



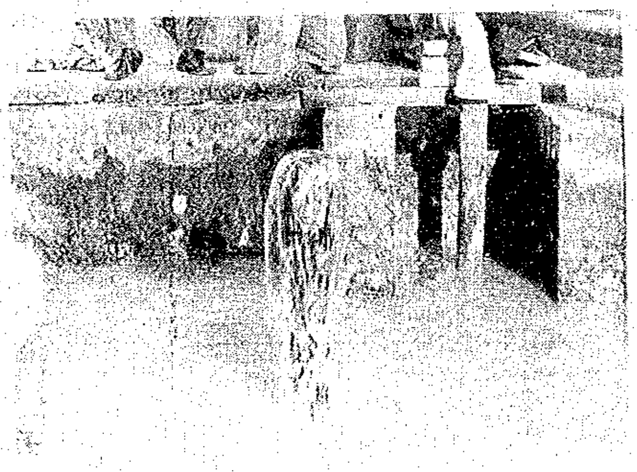
Fine to medium sand with current laminations (ripple-cross and parallel) in the lake-delta deposits (Facies II) near Baneswar.



Sand-mud alternation of the proper lake deposits (Facies III-a) near Thimi.

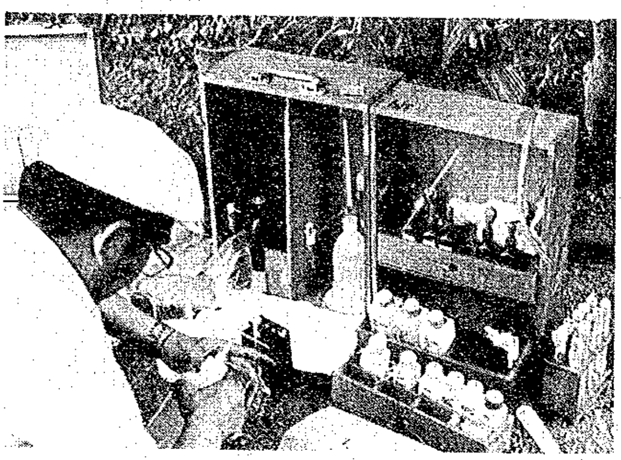


Manually drilled artesian well (NPC-05) with a casing pipe of $1\frac{1}{2}$ inch diameter on the southern part of Kathmandu city.

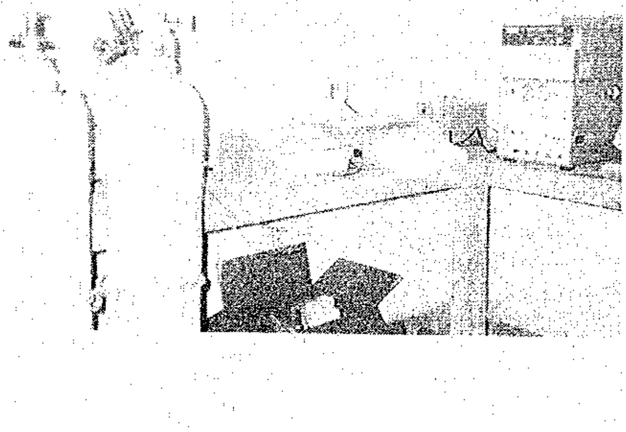


Pumping well of Yak & Yete Hotel (NPC-11).

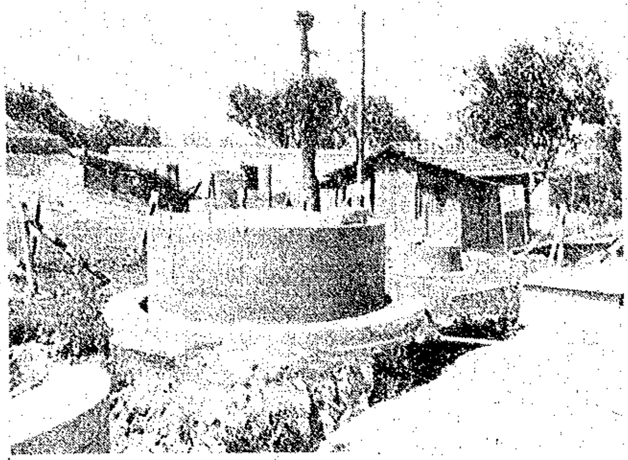
Artesian well near Balaju (NPC-8).



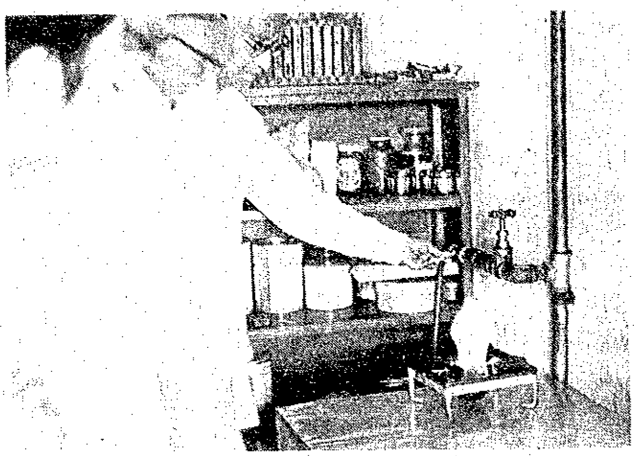
Chemical analysis of gas and water at a well-site.



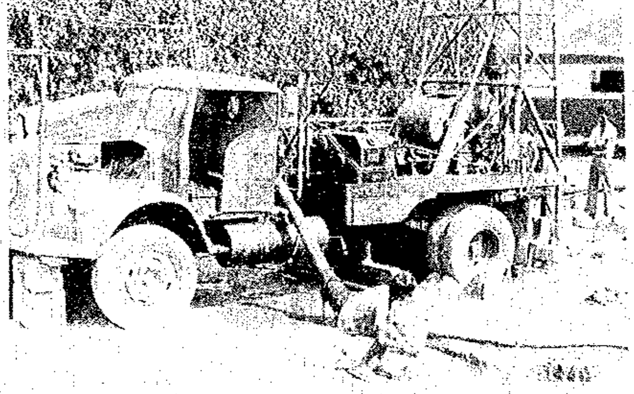
Gaschromatograph (Shimazu GC-4CPT) for analysis of natural gas.



Gas-water separator of RSS Office (NPC-15).



Utilization of dissolved-in-water gas.



Holmaster 1500 drilling a water well near Tribhuwan University.

JICA