Circumstances of heavy Oil from Russian Tanker "Nakhodka" in 1997

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Circumstances of Heavy Oil from Russian Tanker "*Nakhodka*" in 1997

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Abstract - Now, six years after the disaster, scientists are still in pursuit of aftermath of the wrecked Russian tanker "*Nakhodka*". The scientific data provide one of the keys to understanding what has happened in Hokuriku district, center of Japan, since the "*Nakhodka*" crashed in 1997. Situation of the heavy oil, natural condition of seawater, and how to "recovery" things on beach are important to describe for future generations.

I. Introduction

The Russian tanker "*Nakhodka*", loaded with C-typed heavy oil of 19,000 kl was divided into sections and submerged off Oki Island, Shimane Prefecture on January 2, 1997. The bow, after drifting for 4 days, was wrecked off Anto, Mikuni Town, Fukui Prefecture, and threatened throughout the various shores of Ishikawa Prefecture geographically as well. A serious heavy oil spill situation of the wrecked bow in Mikuni Town is shown in Fig. 1. Shores damaged by oil washing ashore, drifting oil in mass, and drifting oil slicks were observed by helicopter research of K. Tazaki, as of 8 Feb. 1997. An oil layer at the shore of Mikuni Town reached over 50 cm in thickness. Stormy weather continued to hamper cleanup efforts for the volunteer and the officials to remove oil from the shore and coastal water. Clean up of beach daubed with spilled oil is serious and hard problem to dissolve. We conducted field surveys in order to examine the conditions of heavy oil washing ashore on the Ishikawa coastline and the impact of oil slicks to the marine environment and water pollution. This incident caused by heavy oil spill of 6,240kl yielded serious environmental problems throughout the shores of Hokuriku district, coating a total of 400 km of shoreline which had to be cleaned manually. In Ishikawa Prefecture, more than 200,000 people volunteered to work and recover the spilled oil and the emulsified oil of 22,305 kl with seawater from the beach [1].

The tanker spilled C-heavy oil into the Japan Sea, has killed thousands of seabirds and animals. The accident was followed by various scientific studies, clarifying as the coat of thick heavy oil itself in the field and in the laboratory. Our laboratory at Kanazawa University concentrated the attention on this environmental problem, and conducted a series of environmental researches, such as the simple method to rinse the polluted beach and gravel [2]. The method using the warmed-up seawater was effective to remove oils from beach materials (Fig. 2). We had home made cleaning machines using an oil drum.

In this paper, in Hokuriku district, scientific result which shows the effectiveness of its intensive clean up as well as the evanescent quality of the oil, which is, after all, a natural substance, are described. Moreover some results of the researches are introduced, including the actual situation of "bioremediation" which is a safe technique that can be performed at a low cost and adverse affect on the environment.

II. Circumstances of oil contaminations

Exactly what the Hokuriku district was like after the oil spilled and describe on it or how it would have evolved. To a traveler visiting Hokuriku district for the first time since 1997, it appears beautiful and healthy shoreline. Although oil still liesunder the boulders and rocks on some beaches, oil is largely weathered. Popular beaches and bays, such as Mikuni rocky seashore (Fig. 1), Shioya sandy beach, Atake gravel beach, and Osawa inlet, were covered with viscous heavy oil. Continuously, more oil washed ashore, driven by northwest strong wind and flood tide. It was almost endless to cleanup the costal areas. The oil in mass damaged the famed rocky coastline of Noto peninsula, Quasi-National Park. Numerous spots of oil slicks were recognized even one month later from the incident. Nanatsu-jima designated as a national wildlife protection area was threatened by oil spill as well. In Aramiko-jima heavy damages were visible on March 14th, 1997 (Fig.3 upper). Beside that hydrocarbon-degrading bacteria are rich in the oil (Fig. 3 bottom).

Conditions of emulsified oil were rapidly changed within a few days. It was found through field examinations, heavy oil in mass was viscous in 1-2 days, and the color of oil turned from black to dark brown, and then to light brown as the viscosity grew. Laboratory examinations recognized the "emulsified" phenomenon of heavy oil, and showed clearly that the specific gravity of heavy oil washing ashore (1.01 g/cm^3) was higher than the one of normal heavy oil (0.93 – 0.97 g/cm^3). Optical microscopic observation of emulsified heavy oil has showed that numerous bacteria inhabit in the oil. Fluorescence microscopic observation of emulsified oil showed the distinction between oil and bacteria clearly (Fig. 4). The process that emulsified oil was decomposed by the exposure of ultraviolet was also observed. SEM-EDX analyses of C-typed heavy oil showed the normal oil is almost composed of carbon hydride, and

contains several percent of sulfur. The oil samples were collected from Togi beach on January 1997, and it was identified that have already been emulsified by seawater (Fig. 4). The scientists report that a few years after the spill, the un-cleaned beaches showed healthier than did stark, cleaned sites [3]. The cleaning using detergents and high pressure of hot water has produced the damages to plants and soil microorganisms. The cleaning is disruptive, and if you clean up it is going to look like a very different shoreline.

Hokuriku residents and scientist thought the heavy oil was having a biological effect, such as oiled fishes, seaweeds, sea birds, and animals [4]. We could figure out what sort of oil they were dealing to the other life. Since January in 1997, it slapped on seabird's lives in the water along 400 km of spoiled coastline. The spilled oil had the devastating effects on about 20 species of endangered birds in the winter along the coast. The 615 seabirds had withdrawn from the coast in Ishikawa Prefecture, including 264 living. After taking care and rehabilitation by volunteer activity, only 56 seabirds were recovered. Totally 1311 seabirds had been withdrawn all through the Japan.

Ⅲ. Hydrocarbon-degrading bacteria

In this accident, remarkable microbial remediation research had been advanced. They are permitted to describe what is happening throughout the Hokuriku district for six years. We really didn't have such experiences with this. In fact, hydrocarbon-degrading microbes were found in each polluted area of the near-shore environments. Microbial degradation of petroleum is of considerable economic and environmental importance where microbial degradation is the conversion processes that dissolves and disperse hydrocarbons into oxidized products by microorganisms [5].

Ishiyama et al. [6] isolated two bacterial groups, ODB-G1 and ODB-G2, from the spilled oil from the tanker. ODB-G1 contained two genera. One was classified as *Caulobacter* sp. on the basis of its morphogenesis during the cell cycle, and the other was classified as an *Alcanivorax* sp. based on the sequence of its 16S rRNA gene. ODB-G2 also contained two bacterial genera, *Alcanivorax* sp. and *Halomonas* sp., as identified by the BIOLOG carbon substrate utilization profile. All of these bacteria were gram-negative. The results obtained by the TLC/FID method showed that the both bacterial groups degraded the saturate fraction and the aromatic fraction very well. They were also able to degrade the resin fraction and the asphaltene fraction, although their degradation rate was relatively low.

Ⅳ. Five-year bioremediation

Five-year bioremediation study on the aquatic and sedimentary/soil hydrocarbons in the Sea of Japan has been carried out since 1997 [4]. We have performed laboratory examination for bioremediation process of heavy oil with the two different treatments, namely the inside building examination and the outside building one to investigate the significantly role of hydrocarbon-degrading bacteria on them. The observations of hydrocarbon-degrading bacteria have employed by using optical microscope with DAPI staining and scanning electron microscope [7]. Hydrocarbon-utilizing bacteria isolated from coastal areas. Heavy oil samples were collected from *Nakhodka* Russian oil tanker, Katano seashore, Atake seashore, and Osawa seashore after 5 years of spilled accident (Figure 7) showing different species.

The observation revealed that a large number of hydrocarbon-degrading bacteria still existed in the sites consisting of a variety of morphological form of bacteria such as coccus (*streptococcus* and *staphylococcus*), bacillus (*streptobacillus*) and filamentous. There was no significant differentiation among bacterial activities in the two treatments. Removal of heavy oil by hydrocarbon-degrading bacteria in the outside building examination was greater than in the inside one. The values of DO, pH and temperature in all of the treatments indicated that the bioremediation process took place under aerobic condition (4.8 – 11.1 mg/l), neutral – alkaline condition (7.3 – 8.6) and under condition of low temperature (6.5 – 16.5℃). A successful bioremediation process is dependent on the ability to create and maintain environmental conditions necessary for microbial growth. Microorganisms are sensitive to temperature, pH, contaminant toxicity and concentration, moisture content, nutrient concentrations, and oxygen concentration [8].

The bacterial micrographs suggest us that the local degrader bacteria inhabited everywhere with many kinds of species. Each species carries a role to resolve heavy oil under the local conditions. That is a key to understand the sustainable "bioremediation" for polluted local area. After 5 years of spilled accident, degrader bacteria were still alive to keep the activity. Microbial degradation is the conversion processes dissolved and dispersed hydrocarbons into oxidized products by microorganisms. It is one of the finest and long-lasting processes, known as bioremediation, which has received wide attention, notably after the *Exxon Valdez* accident. Bioremediation technologies have increasingly been proposed to decontaminate the polluted site in several major oil spills in the marine environment [9].

V. What we should do

The fuel released on December 21st, 2002, off the coast of Spanish northwestern region of Galicia, by the tanker *Prestige* could have long-lasting effects. Spanish soldiers and volunteers worked to clean up oil stained beach on the coast of Lira. The Spanish government has said that cold temperatures were stemmed. In 2000 Christopher M. Reddy of the Woode Hole Oceanographic Institution and his colleagues drilled a 36-centimeter-long core in a West Falmouth, Mass, marsh, near where the barge *Florida* ran a ground in 1969 and spilled its oil. The team found that petroleum contamination still persists there, more than 30 years later [10].

A marine conservation biologist at the University of Alaska, Fairbanks, who studied the 1989 *Exxon Valdez* oil spill, says that to believe the sunken oil will remain stable is "more wishful thinking than reasoned expectation." If the oil containers break, much of it could still reach the surface. Delayed effects from the *Exxon Valdez* oil spill included genetic damage in wildlife, adding that more than 13 years after that spill, only a quarter of the injured populations was fully recovered [11].

Now, six years after the disaster, scientists are still in pursuit of the wrecked Russian tanker "*Nakhodka*". The scientific data provide one of the keys to understanding what has happened in Hokuriku district, center of Japan, since the "*Nakhodka*" crashed in 1997. Therefore we have to keep a very close watch on "*Nakhodka*" spill what is happening the oil in mass damaged the famed rocky, gravel and sandy coastlines of Noto Peninsula, Hokuriku district, Japan. We, scientists in Japan, must remember the tragic accident for our future beautiful sea environment. Even though NOAA has shown that cleaning up can do more harm than good, demands to clean up persist. "Scientists waste a lot of time saying, "Do nothing" [3].

Situation of the heavy oil, natural condition of seawater and beach on how to do " recovery" things, are important to describe for future generations. All is oil spill accident that comes to our scientific studies. *Nakhodka* spill was bad luck, but we have to bring good luck for our next generation. What was obviously needed was planning prior to the incident and, one would hope, better preparation in the future. Once the oil spill had occurred, the poor coordination of the Spanish authorities has led to a very ineffective use of scientific institutions, resources, and knowledge, reflected in inexplicable delays and overlapping actions [12]. *Exxon Valdez* oil spill was *Nakhodka*'s lesson following better and wiser experiences for Japanese scientists.

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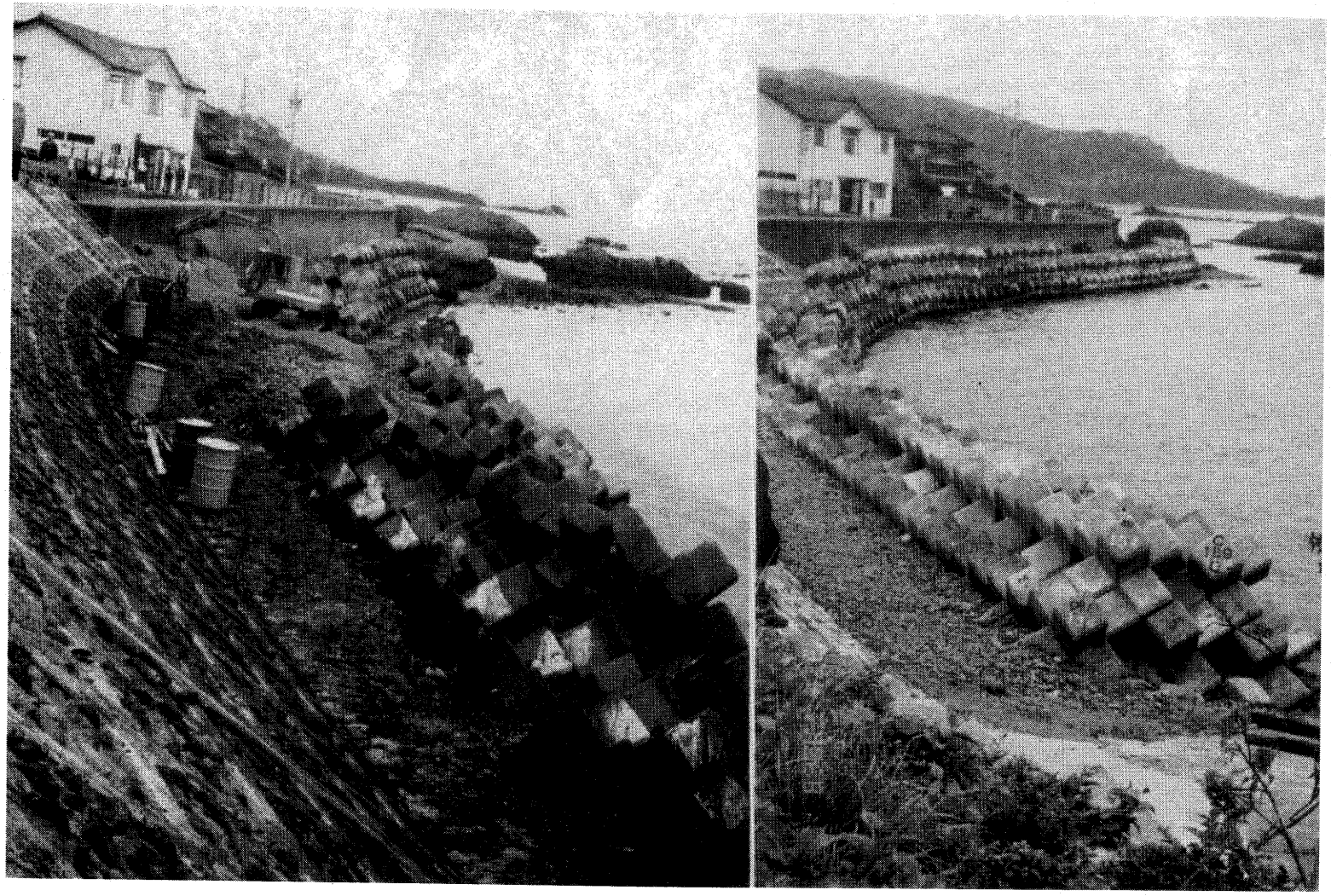

Figure 1 Contamination seashore where are heavy oil spill from Russian tanker *"Nakhodka"* on January 2nd, 1997 at Mikuni, Fukui Prefecture.
Left; during cleaning in April 8th, right; after cleaning in July 26th 1997, which is looking good, but---.

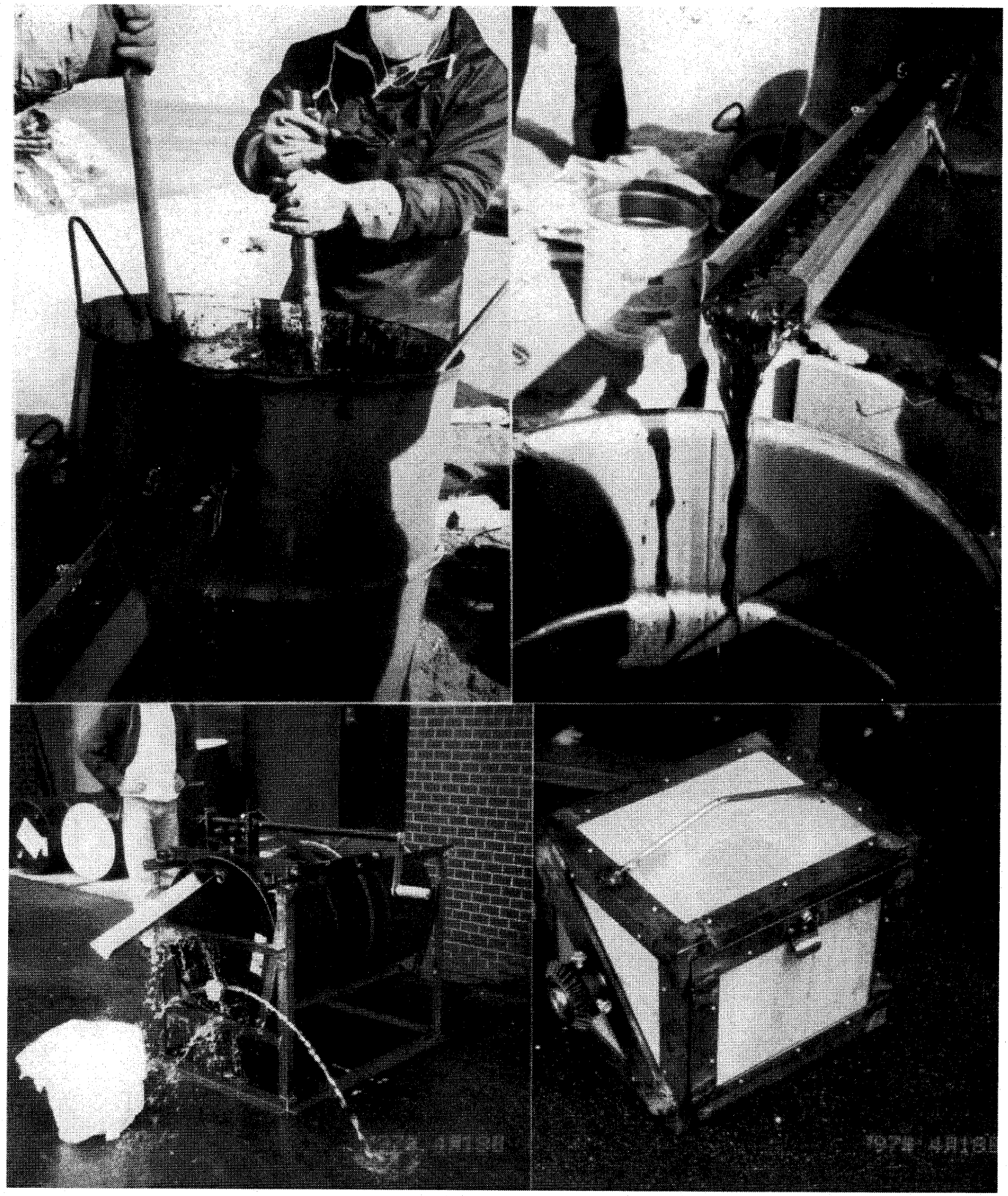

Figure 2 Simple cleaning methods to rinse the polluted beach and gravel was by using the warm seawater. This method effectively removed oil from beach materials. This method and the home made cleaning machines were our idea on February 9th (upper) and on April 18th, 1997.

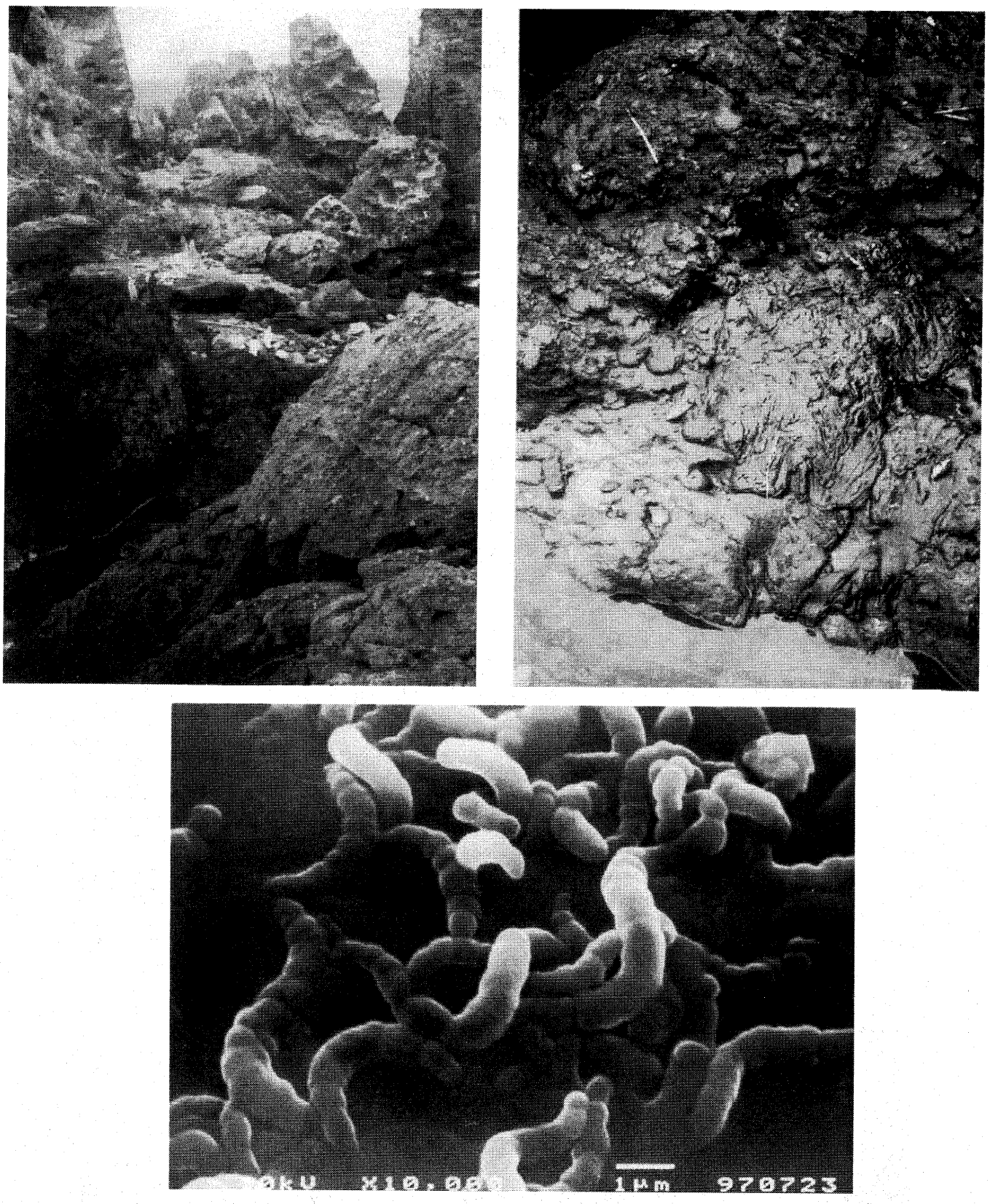

Figure 3 Oil mass damaged the famed rocky coastline of Aramiko-jima, Quasi-National Park. Numerous oily mats were recognized (upper two pictures). Aramiko-jima designated as a national wild life protection area was threatened by oil spill on March 14th, 1997. In this oil mass, hydrocarbon-degrading bacteria have found by using scanning electron microscope (bottom).

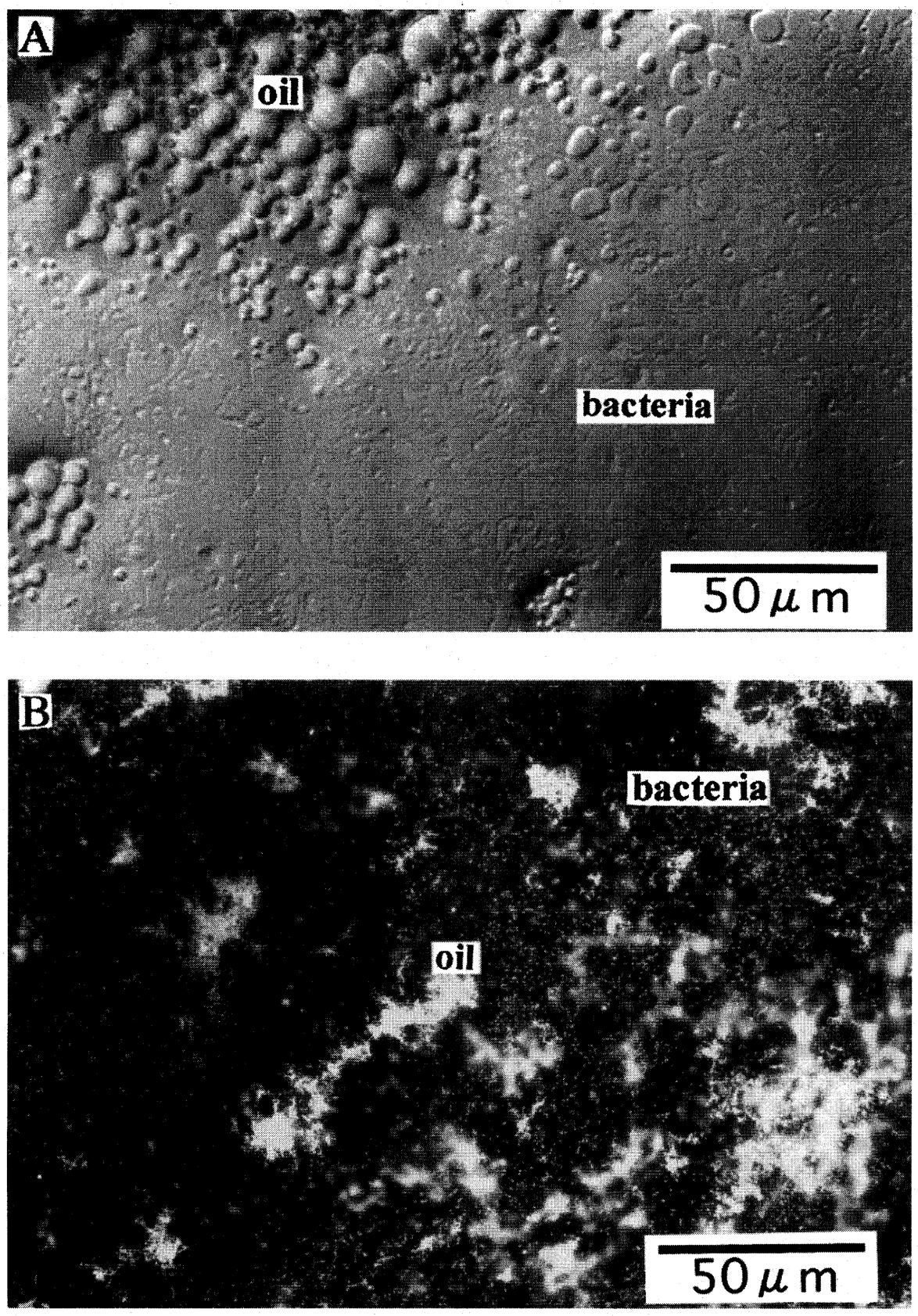

Figure 4 Observations of hydrocarbon-degrading bacteria have employed by using optical microscope (A) and fluorescence (B). The oil sample was collected from Togi beach in Noto Peninsula on January 10th, 1997.