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BOTTOM SEDIMENT TRANSPORT STUDY AT HAIPHONG PORT USING RADIOACTIVE SCANDIUM GLASS AS TRACER

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ABSTRACT

A radioisotope tracer experiment was performed for investigating the bedload movement at the site near the access channel to Haiphong port, North Vietnam. The scandium glass and a number of mechanical devices were manufactured locally for the experiment. Simple and safe procedures were adopted for the production, transportation and injection of radioactive tracer materials. Five tracking experiments were carried out covering the period of 84 days in winter 1992-93. The experimental results provide a firm basis for elaborating appropriate measures against the siltation problem at Haiphong port, especially for the design of a new access channel with a better orientation with respect to the directions of the water flow and bedload transport, as proposed recently by the Port Authority.

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Introduction

Located 100km east of Hanoi, on the coast and with a number of navigable estuaries and waterways, Haiphong is a major port and an important industrial harbour in the northern part of Vietnam. Unfortunately, most part of a 38km long navigation channel through the Namtrieu estuary is suffering from heavy silting (Fig. 1), causing significant expenditures for dredging. Due to the progressive decrease of the channel depth, the allowed tonnage of vessels had to be reduced in the last years from 10,000 to 7000 tons. A number of engineering schemes were proposed to reduce the sedimentation rate along the channel. Unfortunately, they were not supported by detailed and reliable sediment transport studies [1]. Recently the Port Authority has considered the possibility of constructing a new access channel to the Namtrieu estuary with better orientation with respect to the water flow in order to reduce the sedimentation rate. The decision on such a proposal requires reliable experimental information and data on sediment transport processes prevailing in the adjacent estuarine area. Radioisotope tracer techniques [2] are being used to determine the direction and rate of the bottom sediment transport. The first experiment was carried out in the period of winter NE monsoon, December 1992 - March 1993. A second experiment is being conducted in the conditions of prevailing SE monsoon in August - September 1993. These tracer experiments are executed in the framework of the IAEA technical assistance project VIE/8/007. In this paper only the results of the first tracer experiment are reported.

Equipment and materials

Within the framework of the above mentioned project, the IAEA has provided equipment and materials, such as underwater scintillation detectors, analysers and counting systems, a pneumatic sediment corer chemicals, etc. Other equipment and radioactive tracer materials were manufactured in the Dalat Nuclear Research Institute and in factories of Hochiminh City.

Glass of 1.3% incorporated scandium element was prepared in a local glass production factory. The scandium glass was ground to fine sand and the grain size composition was adjusted to that of the natural bottom sediments at the injection site. Figure 2 show the cumulative grain size compositions of both the natural and artificial sands. 380g of scandium glass was irradiated in 50hrs in the central neutron trap of the Dalat nuclear research reactor with a thermal neutron flux of $2x10^{13}$ $n/cm^{2}.s$. After a cooling time of some weeks, irradiated materials were transferred to the transportation pot by using a loading lead container. In this operation, the loading lead container, equipped with a cutting device, broke the aluminum cans containing quartz ampoules with irradiated scandium glass, allowing each quartz ampoule to drop into its location in the inner container of the transportation pot (Fig. 3).

The transportation pot is a double-wall lead container of 15cm total thickness, as shown in Fig. 3. Such a rather thick container was designed as universally as possible, because it will be used for other experiments with higher tracer activities. In this experiment, the activity at the time of transportation and injection was about 4Ci, and the dose rate at a distance of 1m was about 1.7mR/hr. The design, construction and testing of this double-wall container were implemented satisfying the demands for class A containers for transportation of radioactive materials. In fact, the transportation by truck over 1700km from Dalat to Haiphong was absolutely safe.

Injection of radioactive tracer materials onto sea bed

At the injection site, quartz ampoules with radioactive tracer materials were crushed by turning the axial bolt of the inner container (Fig. 3). This inner container was then taken out from the transportation pot and lowered into the water to the depth of 1m from the sea bed, where radioactive tracer materials were released by switching a pump connected with the water inlet of the container. The dose rate at 2m from the inner container (5cm thickness) when suspended in the air was about 30mR/hr. This phase was lasted about 2 minutes, but it could be reduced to less than 1 minute if the winch was manipulated with better skill.

The injection took place on slack water when the depth of water was about 5m. The injection site shown in Fig. 1 was about 700m south of the access channel, where the siltation rate along a 10km stretch of the existing channel is highest. The proposed new channel will be aligned through this investigated area.

Tracking experiments

The injection took place on 17 December 1992 and tracking experiments were performed on 19, 23, 29/12/ 1992, 6/1 and 12/3/1993. A boat position fixing equipment (Micro-fix, Racal Marine System Ltd) with repeatable accuracy of typically 1m was used in the tracking experiments. Micro-fix was supplied to the Transport Engineering & Design Institute of Hanoi within the framework of another UNDP technical assistance project on hydrographic survey at Haiphong port. The tracking trajectory was traced in advance for each experiment and displayed on the screen along with the position of the boat. This allowed the steers-man easily to follow the already designed course. Attempt to interface Micro-fix with our counting system was failed, however, data on time and position of the boat were stored for every second in diskette and could be transferred later to the counting system. The speed of the boat was kept at about 2 - 2.5m/s.

...Gamma-rays of bottom sediments were detected using scintillation detectors and counting systems supplied by Italian Laben Corp.. The counting rates were recorded every three seconds. The inclusion of a multichannel analyser in the counting system provides a significant advantage in identifying the radioactive components of the natural bottom sediments, as well as in analysing the shape of the gamma spectra, which could contain information about the thickness of the ^{46}Sc-labelled moving sediment layer.

Results and discussions

Six tracking experiments for mapping the bottom sediment background and radioactive clouds were performed in winter 1992-93, providing dynamic pictures of the bedload transport in the investigated area. In the last tracking experiment, carried out on the 84-th day after tracer injection, the net counting rates were still in the range from 20 to 2000cps in an area elongated to 1500m. During the time covering four successive tracking experiments from December 19 to January 6 the radioactive cloud and its centroid moved in the direction north-south with a speed of about 10m/d. This direction makes an angle of about 50^0 with respect to the existing channel. However, in the fifth tracking experiment, taken place on March 12, the tail of the radioactive cloud was found far in the north-west direction and its centroid had came back to the injection site (Fig.4b). As illustration, Figures 4a,b show the radioactive clouds obtained in the 4-th and 5-th tracking experiments. The change in the direction of bed load movement observed in the 5-th tracking experiment was correlated with the early appearance of south-east wind in the Tonkin Gulf in February-March.

Sediment core sampling and depth profile ^{46}Sc-activity measurements were performed to estimate the average mobile bed thickness. Cores (0.8m long, 0.05m diameter) were taken over the labelled area by using a home-made manual corer. These cores were sectioned and the activity depth profiles were measured by NaI detector. The average mobile bed thickness was found to be 0.25m resulted in a calculated north-south transport rate of 5 $tm^{-1}d^{-1}$.

The "count rate balance" method and the method based on the analysis of the shape of the in-situ gamma spectra were also used to estimate the transport rate. However, much more effort must be needed to improve the reliability of these two methods. Moreover, the above cited transport rate is calculated only for the period of winter NE monsoon. The results of the second tracer experiment will provide information about the transport direction and rate in the SE monsoon conditions.

Conclusions

A first radioisotope tracer experiment was performed in Vietnam for investigating the bedload movement at the site of about 20km offshore, near the access channel to Haiphong port. Rather simple and safe experimental procedures were adopted using a number of low-cost and home-made mechanical devices and locally-produced tracer materials. Clear pictures of bed load movement obtained in this tracer experiment provide a firm basis for elaborating appropriate measures against the siltation problem, and among them there is a very promising project proposal on constructing anew access channel to Haiphong port with a better orientation with respect to the directions of water flow and sediment transport.

Acknowledgements

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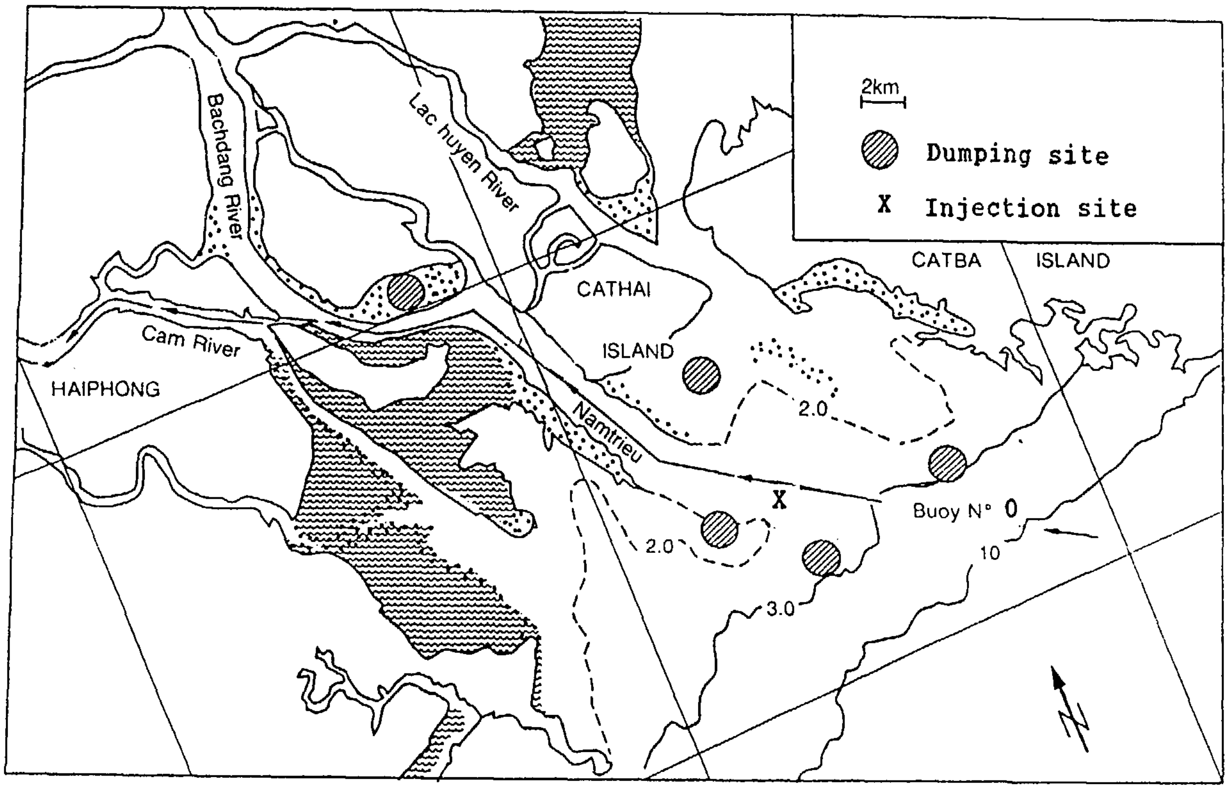
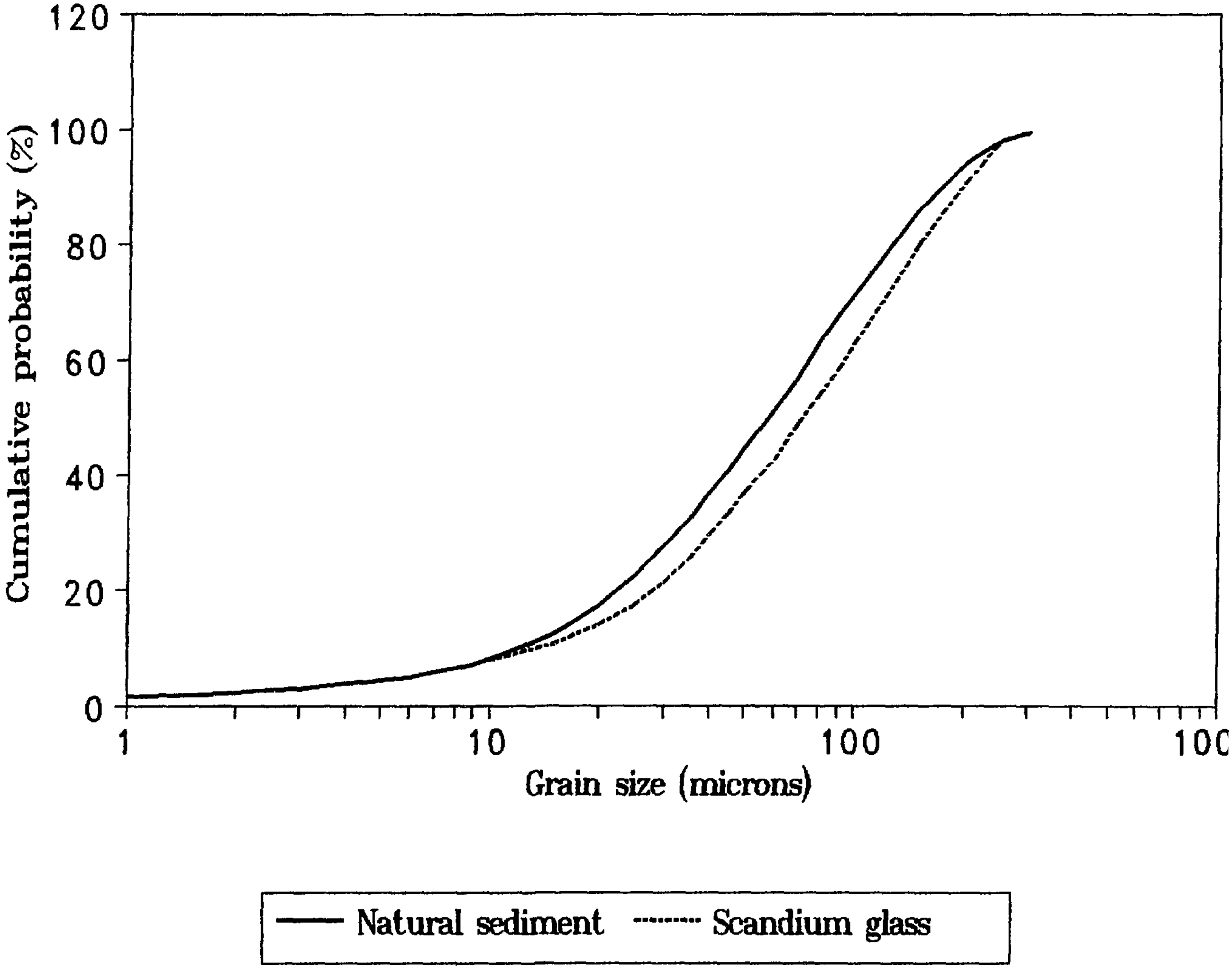


FIG. 1. The Haiphong estuarial area.

FIG. 2. ***The grain size compositions of natural sediment and scandium glass.***



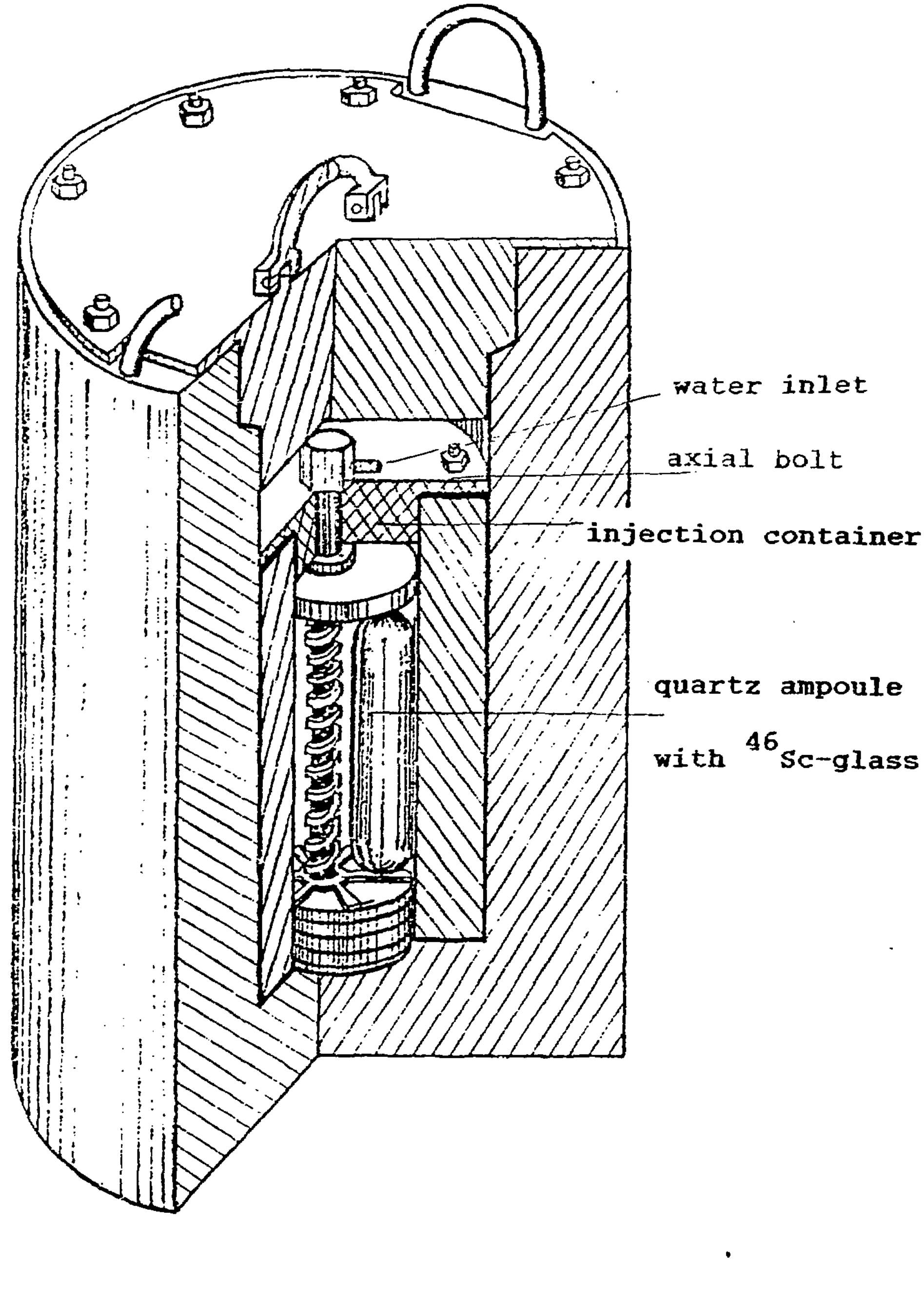


FIG. 3. *Transportation and injection (inner) lead containers*

Dimension ○ 420mm x 600mm

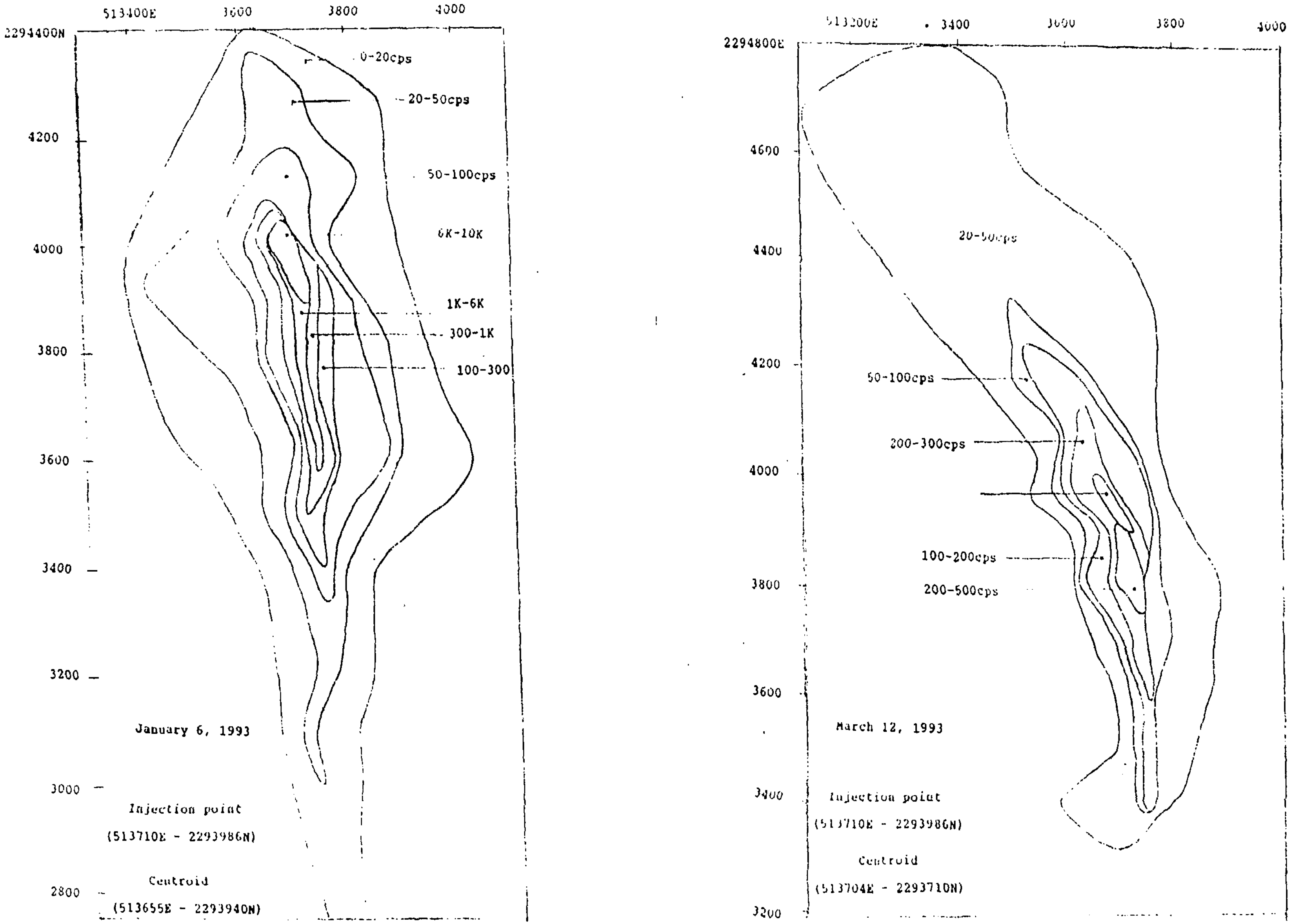


FIG. 4. *The tracer distributions detected in the 4-th (a), and 5-th (b) tracking experiments. Date of injection: 17/12/1992. The coordinates of the detector are given in (m)*