

**POST-LAY SURVEY OF THE BOMBAY HIGH TO BOMBAY SUBMARINE  
PIPELINES : A CASE STUDY**

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**SYNOPSIS**

**A post-lay survey of the submarine pipelines between Bassein Oil Field and Bombay High was carried out using echosounder (30 kHz), side-scan sonar (105 kHz) and shallow seismic profiler (3.5-7.5 kHz) with Shoran position fixing system. Since shoreward of Bassein Platform is virtually carpeted by unconsolidated sediments, inspection of the submarine pipelines was confined to seaward of Bassein Platform wherein the seafloor is covered with compact sands and reefs. The distance between the two submarine pipelines ranges from 65 to 100 m. The pipelines have been distinctly**

recorded in echograms and subbottom profiles at about 52 m water depth near east of Bassein Platform. However, seaward of Bassein Platform the pipelines are apparently exposed at three places - 145 km point (water depth 52.5 m), 195 km point (water depth 75 m) and 215 km point (water depth 77.5 m), from the shore whereas they are well buried below 1-3 m thick sediments along the remaining route. Trenches and exposed pipeline portions have been very well recorded in sonographs. Remedial measures were sought to protect the exposed pipeline portions to avoid unforeseen damages.

## INTRODUCTION

The stability of a pipeline depends on the characteristics and profile of the soil, geology of the site, the dimensions and weight of the pipeline, method of laying, initial tension on the pipeline and the prevailing physical and dynamic forces. It is quite important to select a pipeline route which involve no potential seafloor instability problems. It is also necessary to define the extent and characteristics of the hazards which may occur along the pipeline route.

A number of submarine pipelines are being laid in the Indian offshore environment for the transport of oil and gas and for the discharge of effluents etc. The National Institute of Oceanography carried out detailed studies along the western continental shelf to select routes for laying pipelines and assessing their post-lay status (ANONYMOUS 1976, 1980).

The Oil and Natural Gas Commission of India has laid two submarine trunk pipelines - 75 cm diameter for crude oil and 65 cm diameter for gas over a distance of 220 km from Bombay High Oil Fields through Bassein Oil Field

to an oil and gas terminal at Uran near Bombay ( Fig. 1 ). These pipelines were expected to transport roughly 30 million tonnes of oil per annum and 653 MMcfd of gas. This paper describes the results of post-lay surveys of these subsea pipelines.

### GEOLOGICAL SETTING

The study area forms a part of the western continental shelf of India and lies west of Bombay (Fig. 1 ). Here, the continental shelf is about 280 km wide and the shelf break occurs between 90 and 145 m water depth. The shelf can be divided into distinct physiographic zones - inner, middle and outer shelves. In general, the topography of the inner shelf is even and smooth with a gentle westerly slope of 1:700 to 1:3300. On the other hand, most of the middle and outer shelf show uneven to rough topography with relative variations of 2 - 20 m (VEERAYYA et al 1991).

The surficial sediment distribution along the shelf may be broadly divided into three major categories: 1) modern sands of the shore zone occur within a few kilometers of the coast and extend to water depths of 5-10 m. Succeeding this narrow sand zone 2) recent terrigenous mud zone comprising silts and clays occupy the inner shelf. This extends offshore up to a distance of about 90 km ( 60 m water depth ) and 3) the third zone succeeding the mud zone and extending to the shelf edge comprises the medium to coarse-grained relict carbonate-rich sediments containing shells and skeletal fragments of various organisms and a variety of limestones.

### METHODOLOGY

More than 640 lkm of echosounding, 185 lkm of side-scan sonar and 640 lkm of subbottom profiling were collected to assess the exactitude of the Bombay High to Bombay pipelines during May, 1980 from onboard

**R.V.GAVEGHANI.** A Kelvin & Hughes MS-45(30 kHz) echosounder in conjunction with the EG & G Mark IB side- scan sonar (105 kHz) and an ORE subbottom profiler (3.5 kHz) were used. The positions were obtained using the Shoran system. The depth of burial of the pipelines has been estimated from the subbottom profiles using 1500 m/s seismic velocity.

## RESULTS AND DISCUSSION

### Pre-lay Surveys

Between March, 1976 and November, 1977 the National Institute of Oceanography had undertaken detailed hydrographic and geological and geophysical surveys followed by bottom sampling along the submarine pipeline route from Bombay High to Bombay (Fig. 1). In these surveys nearly 2050 lkm of bathymetric, 1890 lkm of side-scan sonar, 1620 lkm of shallow seismic and 1000 lkm of magnetic data were collected (ANONYMOUS 1976).

These studies revealed that the topography of the seabed varies considerably along the pipeline route. A low sandy ridge at a water depth of 60-65 m along the route marks a major change in the geomorphology and sediments. This ridge separates the recent sediments of the inner shelf from the relict sediments of the outer shelf. The route from Bombay to a depth of 60-65 m lies over an even and gently sloping seabed (1:7000 to 1:1000). Beyond this depth the area is marked by a series of NNE-SSW trending low ridges and depressions with small topographic irregularities of the order of 1-2 m including sand waves. The seafloor between Bombay and Bassein Platform is carpeted by 30 m thick weakly stratified acoustically transparent clays. The clay thickness decreases towards the west where the underlying relict sands crop out at about 60-65 m water depth. Further west, towards

the Bombay High, the route is covered by patches of relict sands and 1-5 m thick clay pockets.

### Post-lay Surveys

**Echosounding :** The echograms indicate about 14 m thick clays in the region of even topography in the east which thins out towards the west. A few echograms show very well the presence of pipelines (Fig. 3). Thirty of the 65 tracks (Fig. 2a)

showed the pipelines as short, sharp hyperbolae (from point source) mainly below the seabed in clays or in almost at the seabed (Fig. 3). In most of the tracks the pipelines are buried in 2 to 2.8 m thick clays (Fig. 3 a,b,c) excepting in 5 tracks where they lie on the seabed or close to the seabed (Fig. 3d).

**Side-scan sonar profiling:** Side-scan sonar was operated along all the 65 tracks surveyed and in 38 tracks, either the pipeline trenches or the exposed portions of the pipelines are discernible. The trenches (Fig. 4) are prominent in the area deeper than 50 m water depth. In addition, the sonographs also show sand waves, small depressions and anchor drag marks or trenches on the seafloor at some distance from the pipelines. These depressions were presumably caused on the seafloor by the vessels at the time of laying the pipelines.

**Subbottom profiling :** The data revealed that the clay thickness varied from 4 to 17 m. Fifty of the 65 tracks recorded the pipelines. Out of these, the pipelines are seen below 0.80 to 2.6 m thick clays (Fig. 5) in 45 tracks while in the remainder 5 tracks they almost lie on the seabed.

### STATUS OF THE PIPELINES

An integrated analyses of echosounding, side-scan sonar and subbottom

profiles indicate that out of 50 tracks in which the pipelines have been recorded, they are buried in 0.8 - 2.8 m clay in 45 tracks and exposed in 5 tracks. Of the 78 km stretch of the pipelines track surveyed, the pipelines are found to be covered for about 76 km and exposed for about 2 km. The distance between the pipelines varied from 65-100 m. The sonographs show that the pipeline trenches are prominent in the area deeper than 50 m. Remedial measures were sought to cover the exposed portion of the pipelines by sediments to protect against hydrodynamic forces, fishing activities etc.

#### ACKNOWLEDGEMENTS

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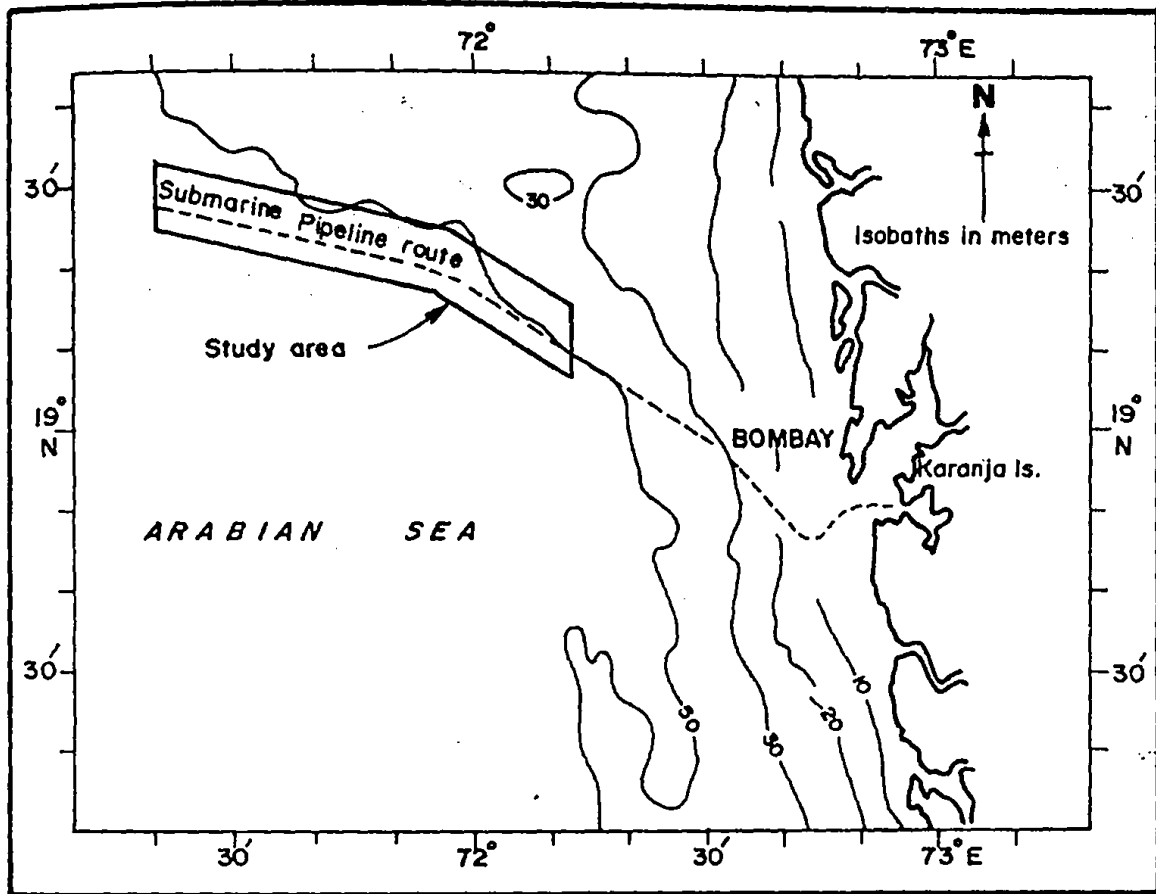


Fig.1. Location map of the study area.

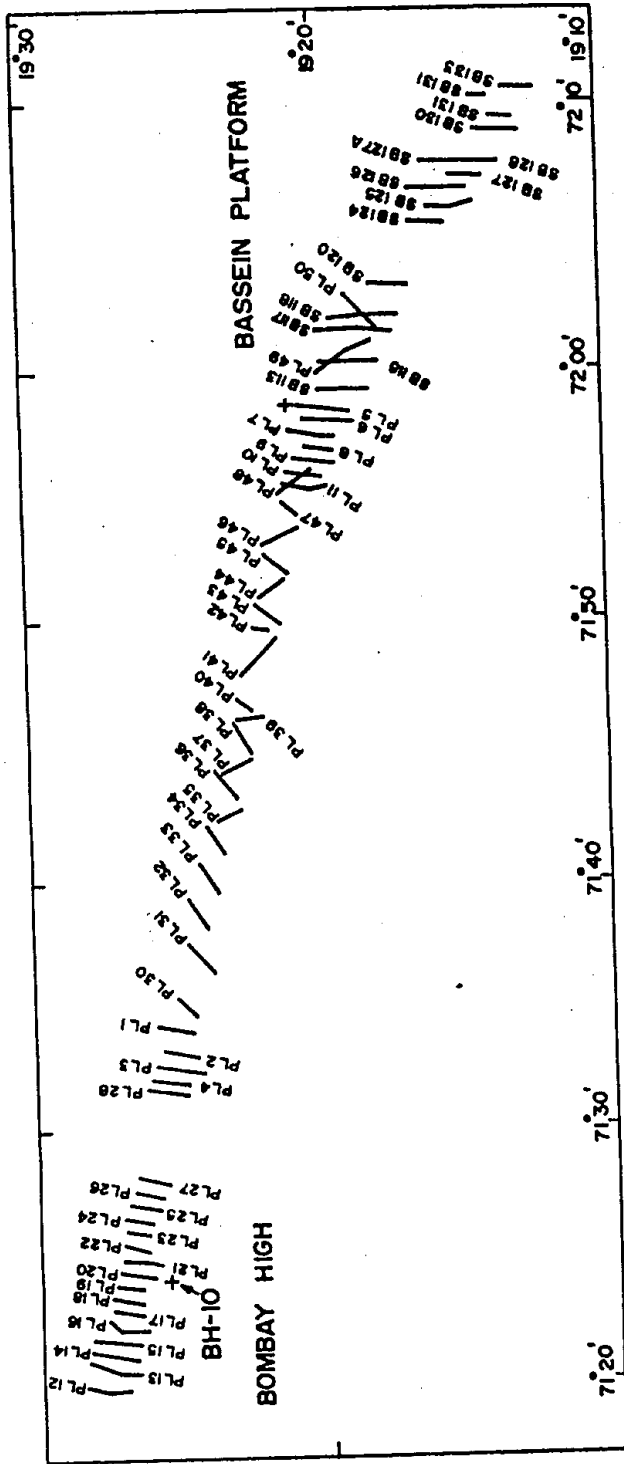


Fig. 2a Map showing the positions of the lines surveyed.

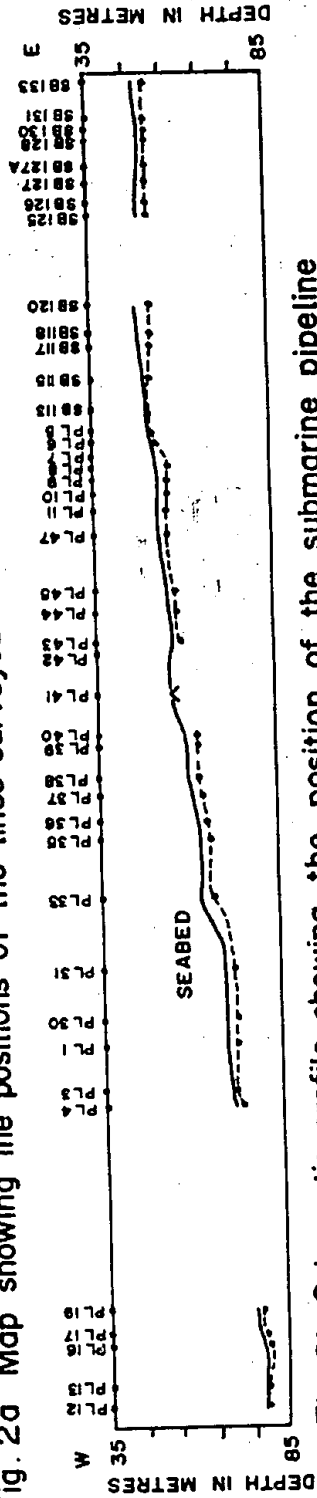


Fig. 2b Schematic profile showing the position of the submarine pipeline



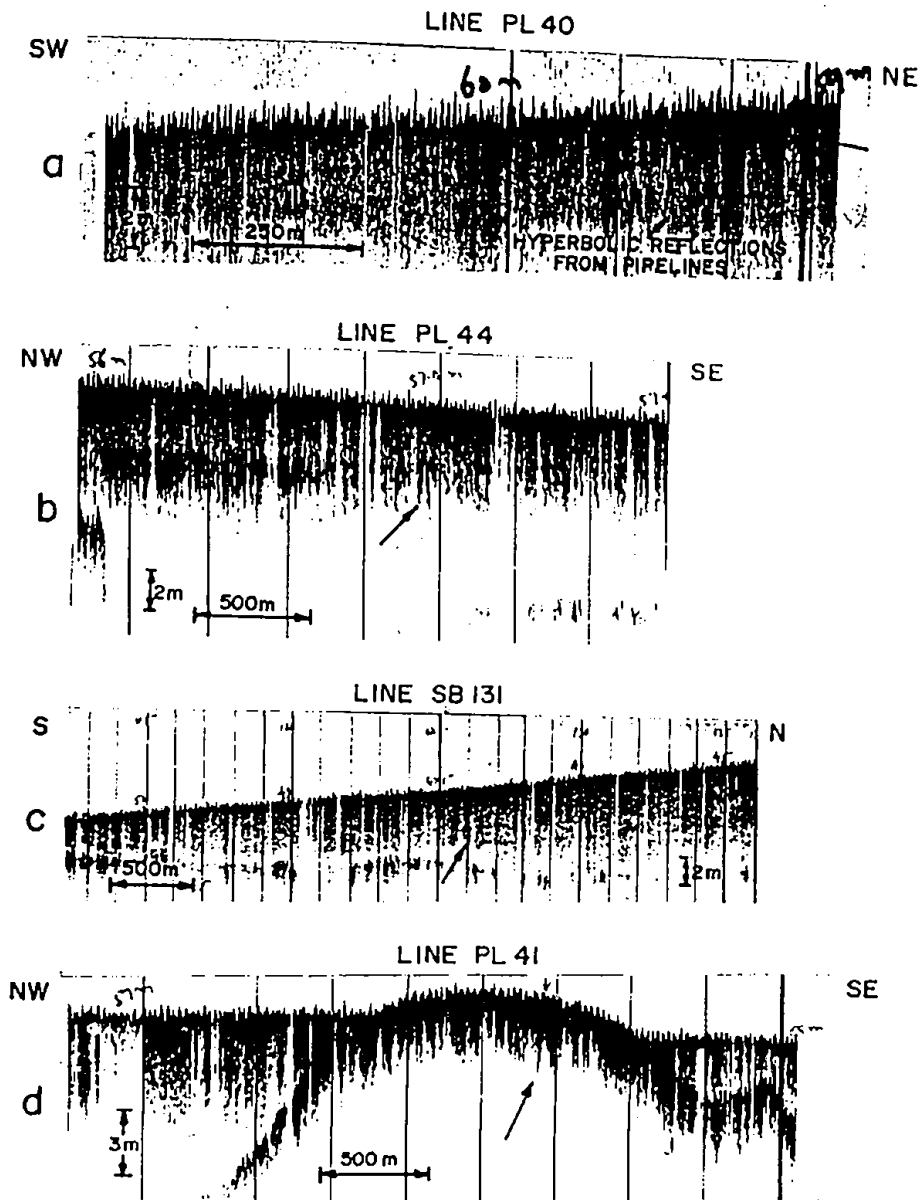


Fig.3 Echograms showing the pipelines buried in clays (a,b,c) and exposed on the seabed (d). Arrow indicates hyperbolic reflections from pipelines.

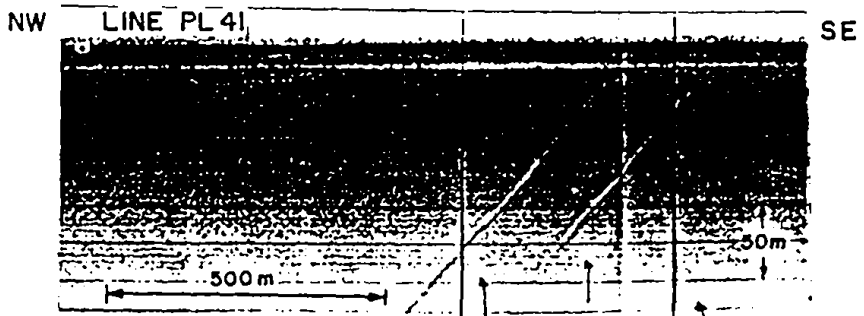


Fig. 4 Sonograph showing the exposed pipelines within the trenches.

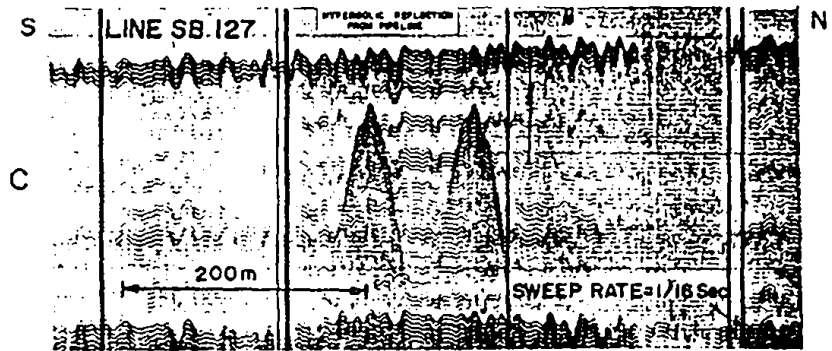
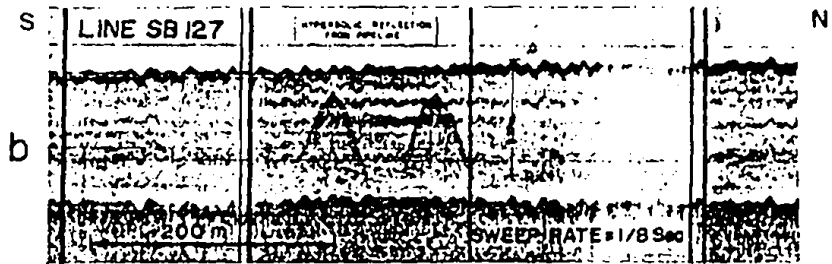
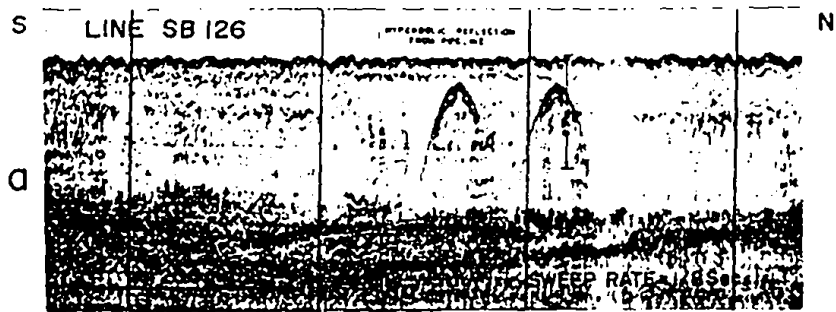


Fig. 5 3.5 kHz seismic profile (a,b,c) showing the pipelines covered by 1-3 m thick clays.