DETECTION OF OCEANIC-INDUCED VARIATIONS IN THE TELLURIC FIELD AT AN ISLAND STATION

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By

Robert R. Harvey

Thesis Committee:

George Sutton, Co-Chairman
Gaylord R. Miller, Co-Chairman
Brent Gallagher
Klaus Wyrtki

INTRODUCTION

Horizontal conductivity inhomogenities in the upper layers of the earth give rise to anomalies in magnetic and electric field variations. This effect has long been observed at magnetic and telluric observatories around the world. When applied to the ocean-land boundary this phenomenon has been termed "coastal effect," "edge effect," or "island effect."

Two sources of geomagnetic fluctuations are electric current variations in the ionosphere and the motion of conductors, such as ocean water or the ionosphere, through the earth's magnetic field. Ionospheric variations are largely dominated by effects of solar radiation and therefore manifest the periodicities of a solar day and its harmonics. However, the gravity tide in the ocean and the ionosphere is controlled by both the sun and moon, and is thus periodic at harmonics of the lunar day as well. A frequency analysis should be able to separate the effects of sun and moon.

That oceanic motion could give rise to electromagnetic induction was first noted by Faraday (1832). He made an unsuccessful attempt to detect water flow in the river Thames by the use of stationary electrodes. Large electrode potentials prevented his seeing the effects of water motion.

Not until 1946 were practical instruments built to make use of electromagnetic induction to detect oceanic water motion (von Arx, 1950). The primary application has been the GEK (geomagnetic electro-kinetograph) whereby two electrodes are towed in tandem behind a ship. The electric potential difference between the electrodes gives a measure of water current flowing perpendicular to the ship's course. Practical use of this instrument has been limited by the interpretation, which necessitates knowing the detailed conductivity structure and even the velocity profile of the environment.

The electromagnetic effect of a long coastline has been measured by Wescott (1967), Filloux (1967), and Schmucker (1964). Wescott's study in Alaska has confirmed Hessler's (1962) observations in Japan, where he noted a polarization of the electric field variations normal to the coast. Their magnetic records, however, showed very little coastal effect.

Filloux and Schmucker occupied a series of magnetic and telluric stations on the California coast ranging from 320 km inland to 630 km offshore. They found a strong two-dimensionality to both fields, in that the electric field parallel to the coast and the vertical magnetic field are best correlated with the component of horizontal magnetic field normal to the coast.

When the wavelength of the inducing field becomes comparable to the length of the coastline the entire shape of the landmass must be considered. This is the case for low frequency electromagnetic phenomena about islands.

Mason (1962, 1963) measured this "island effect" on the geomagnetic field on Christmas Island and on Oahu. Variations in Z (the vertical component of the geomagnetic field) are found to reverse polarity as one goes from one side of the island to the other. This is attributable to the disturbance field arising from a poorly conducting region in an otherwise uniform current sheet.