

THE RELATIONSHIP BETWEEN GRAVITY AND MAGNETIC
ANOMALIES, AS ILLUSTRATED BY OBSERVATIONS MADE
IN THE MARITIME PROVINCES, AND ONTARIO, CANADA

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GENERAL INTRODUCTION

In most of the standard books on geophysical exploration, reference is made to a relationship between gravitational and magnetic anomalies. Usually, a theorem attributed to Poisson is quoted, which indicates the connection between the gravitational and magnetic potentials of a uniformly magnetized body. Very often the discussion is limited to applications of the theorem to the calculation of the magnetic anomaly to be expected from bodies of simple form, such as spheres and cylinders. However, it is apparent that if the Poisson equation can be considered valid for geological structures, then the analysis may be generalized to include a comparison of the gravitational and magnetic effects of bodies whose form is unknown. One might predict also that an analysis of this type could yield valuable information on the properties of unknown structures. The devising of such a method of analysis, and its testing under a variety of field conditions, formed the central problem on which the research to be described in this thesis was concentrated.

It is in order here to emphasize the importance of any method of analysis which lessens

the ambiguity in the interpretation of force field measurements. The geophysicist who attempts to interpret either gravity or magnetic anomalies alone without the benefit of independent control, is confronted by the unfortunate fact that an infinite number of possible subsurface conditions could be responsible for the observed effects. One might even say that a double infinity of possibilities existed, for both the properties and the form of the anomaly-producing structure are unknown. Now the comparison of gravitational and magnetic fields will not lessen the uncertainty as to the form of the body, but it will, as shown later, place certain limits on the properties of the material comprising the body. If this material can be identified from the properties, then an important step will have been made toward the final interpretation. Even in those cases where the complete solution for the cause of the anomalies is not possible, the method of analysis to be developed may serve to rule out certain hypotheses, and to suggest the most probable solution.

The first phase of the investigation to follow is largely mathematical. Since the equation of Poisson, which represents the point of departure from previous work on the subject, deals

only with potentials, it is obvious that extensions will have to be made before force anomalies may be considered. The equations finally developed are applicable to the results of gravimeter and either vertical-component or total-field magnetometers.

The studies of actual anomalies in the field covered a wide range of geological conditions and types of structures. It is believed that the results of these investigations indicate the application of the mathematical derivations, and also throw further light on the state of magnetization of the structures studied. The latter problem is one of considerable importance, because in practically all quantitative interpretations of magnetic observations, uniform magnetization of geological bodies is assumed or implied. Among the examples studied in detail, certain structures appeared to approach this state, while others departed from it to varying degrees. The correlation of this departure from uniform magnetization with other properties of the structures proved to be an interesting and extensive problem in itself.

In the course of making the field observations, several areas of considerable size were covered by regional gravimeter traverses for the first

time. These areas included the entire province of Prince Edward Island, and portions of the interior of Nova Scotia, as well as a smaller region in southeastern Ontario. The correlation of the gravity anomalies with the geology of the respective areas as a whole was carried out primarily to provide a background for more intensive studies. However, certain of the findings of this work, especially in the Maritime Provinces, are of interest and importance in themselves. For this reason, the most important findings from all phases of the investigations are summarized and discussed in the final chapter of the thesis.