



Monitoring the evolution of Deception Island volcano from magnetic anomaly data (South Shetland Islands, Antarctica)



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ABSTRACT

Deception Island is a young and active volcano located in the south-western part of Bransfield back-arc basin. During the last twenty years the Royal Observatory of the Spanish Navy has carried out geophysical surveys in the area. In addition, an unmanned aerial vehicle flight was conducted in 2011 at 800 m height on the northern half of Deception Island. Analysing and comparing magnetic grids obtained in different periods and tie point readings allow us to detect temporal changes and isolate signals of volcanic origin. Magnetic survey cruises performed in Deception Island's inner bay (1988, 1999 and 2008), and the study of its outer area's magnetic anomaly changes, point to a period of high variations concentrated between December 1989 and December 1999 that may be related to the two main recent periods of seismic activity (1992 and January 1999). From December 1999 to December 2008, there were no significant changes in seismic activity; nevertheless, our data show some magnetic alterations, which might signal the slow progress of a volcanic environment towards equilibrium. Interpreting these magnetic changes called for the construction of several forward models. Additionally, we put forth this kind of study as a suitable, economical and easy method for monitoring an active volcanic system whenever it is possible to measure the magnetic field with accurate positioning, and if the external field components are removed correctly.

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1. Introduction

The study of magnetic anomalies is one of the oldest techniques used in geophysics to investigate subsurface geology. This technique is based on anomalies of the magnetic field of the Earth, resulting from the magnetic properties of the underlying rocks and their sensitivity to changes in thermodynamic conditions.

Volcanic environments including intermediate and basic igneous rocks show a characteristic magnetic response (Telford and Geldart, 1990). These volcanic rocks are generally characterized by high magnetic susceptibility values and produced magnetic anomalies once magma cools below the Curie temperature. Large values and high gradient areas

are relatively common. Generally, the remanent contribution is significant and can potentially show high variability.

Deception Island (DI) constitutes the emergent part of a young active shield volcano (less than 1 Ma in age) of basaltic-andesite composition. It lies in the south-western part of the Bransfield Strait (BS), which is a backarc basin related to the oceanic subduction at the South Shetland Trench and located between the Antarctic Peninsula and the South Shetland Archipelago (Fig. 1(a)). It is a horseshoe-shaped island, which is a collapsed and drowned volcanic crater, providing a natural harbour for shipping since it was discovered by sealers in 1820. Its last eruptions took place in 1967, 1969 and 1970, destroying the British and Chilean scientific bases. There have been two additional periods of abnormal seismic activity in 1992 and 1999, described by Ortiz et al. (1997) and Ibáñez et al. (2003).

The main aim of this research is to characterize the magnetic anomalies of DI and their variation since 1987, as a support to improve the knowledge of its depth structure and the recent volcanic activity. The present study describes and interprets all magnetic data available from different scientific surveys carried out around and within the DI volcano by the Royal Observatory of the Spanish Navy between 1987 and 2008. In addition, magnetic data obtained from unmanned aerial

Abbreviations: DI, Deception Island; BS, Bransfield Strait; SSI, South Shetland Islands; PMA, Pacific Margin Anomaly; UAV, unmanned aerial vehicle; CM4, comprehensive model 4; SV, secular variation; ARC, Arctowski Observatory; LIV, Livingston Island Observatory; ARM, Antarctic Reference Model; ΔSV, delta secular variation; TRM, thermo-remanent magnetisation.

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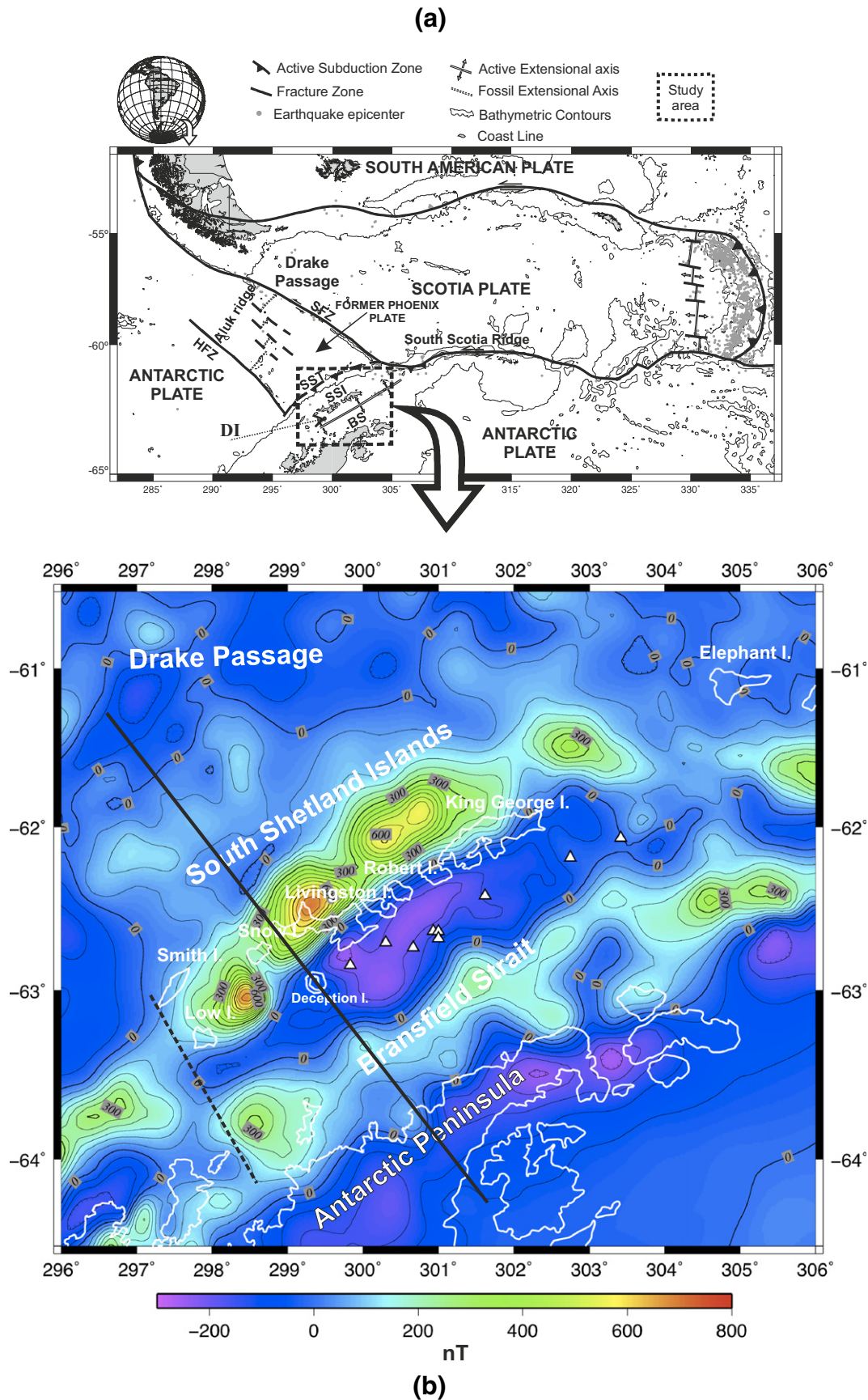


Fig. 1. Geological setting. (a) Regional geotectonic framework of the area and location of the South Shetland Islands. Main geological features are included. (b) Magnetic map obtained from ADMAP database (Golynsky et al., 2001, 2002). This map refers to an average levelling surface of 1500 m. White triangles mark the presence of sub-aerial and submarine volcanoes. Thick black line represents geographical location of profile modelled in Fig. 7. Contour interval: 50 nT. SFZ: Shackleton Fracture Zone, BS: Bransfield Strait, HFZ: Hero Fracture Zone, SSI: South Shetland Islands. SST: South Shetland Trench in panel (a) an arrow marks the presence of Deception Island (DI).

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