# Probing the Subsurface of Elysium Planitia, Mars, Using InSight Induction Vectors: Dispersion Analysis and 3D Modeling Constraints

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While Mars experienced intense volcanism and tectonics before and during the Hesperian period (~3.5–3.2 Ga), the Amazonian period (<3.2 Ga) has generally been characterized by relative inactivity with only limited volcanism. However, recent studies have challenged this view. Horvath et al. (2021) identified possible young volcanic deposits in the Cerberus Fossae region of Elysium Planitia, suggesting eruptions occurred as recently as 210 to 50 ka. Furthermore, Broquet and Andrews-Hanna (2022) demonstrated that it is difficult to explain such recent activity by conventional passive mechanisms and proposed a geophysical model of an active mantle plume. Nevertheless, substantial uncertainty remains regarding the detailed properties of this proposed plume head, including its diameter (3,600–4,000 km), uppermost depth (25–200 km), thickness (200–500 km), and physical states. Additional constraints on these properties are essential for advancing our understanding of plume origins and their relationship to Martian interior dynamics.
In this study, to further constrain the geometry and physical states of the subsurface structure, we analyzed nightside magnetic field data from the NASA InSight lander. We calculated induction vectors, which are derived from the relationship Bz = Tx Bx + Ty By. These vectors, expressed as (−Tx, −Ty), generally point toward regions of anomalously low resistivity. Our analysis revealed a systematic anticlockwise rotation in the real part of the induction vectors from southeast to northeast across periods ranging from 100 to 10,000 seconds. This period range is sensitive to depths of approximately 50–200 km (Civet and Tarits, 2014; Mocquet and Menvielle, 2000), overlapping with the estimated uppermost depth (25–200 km) of the proposed plume head.
To ensure data reliability, we first validated these observations using dispersion relations (Kramers-Kronig relations) following the approach of Marcuello et al. (2005). By verifying that the frequency dependence of the real and imaginary parts satisfies causality, we demonstrated that the observed signals arise from physical subsurface structures rather than noise. Following this validation, we performed 3D forward modeling using an edge-based finite element method (Minami et al., 2018) that incorporates actual Martian topography to derive a specific structural model. We plan to conduct a comprehensive parameter search by testing a range of low-resistivity anomaly models with varying geometries, depths, and contrasts. By comparing the calculated responses of the induction vectors, specifically their amplitude and directional rotation, with the observational data, we aim to quantitatively constrain the spatial extent and location of the conductive body beneath Elysium Planitia. Finally, we will discuss the implications of our preferred electrical conductivity models for the mantle plume hypothesis and their contribution to understanding the thermal and structural evolution of Mars.

 

キーワード：火星、比抵抗、磁場
Keywords: Mars, resistivity, magnetic field

 