Geophysical Investigations to Image Crustal Features and Potential Mineralization in the Philippine Island Arc System

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(フィリピン島弧系における地殻の特徴と潜在的な鉱化作用を画像化するための地球物理学的調査)

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論　文　内　容　の　要　旨

When using geophysical surveys to explore mineral deposits, it is important to conduct both wide-area explorations to narrow the prospective areas and localized exploration to examine detailed information such as the size and depth of the deposit in the prospective areas. This paper describes a wide-area exploration using gravity prospecting for mineralization (e.g., regional geology, structures) in the Philippines and a detailed exploration in Eastern Labo, Bicol, which was chosen as one prospective area.

The Philippine archipelago is a complex island arc system where many regions still lack geophysical studies. Earlier gravity studies generated and presented maps based on limited local and regional data. In the first half of this paper, this research used the isostatic and free-air anomaly grids from World Gravity Map (WGM) to investigate the regional gravity anomalies in the Philippine island arc system and to identify regional geologic and tectonic features that may not have been previously delineated on gravity anomaly maps. This paper also investigates the subsurface geophysical anomalies over a thick overburden using cost-effective and time-efficient electrical resistivity and induced polarization methods. The second half of this paper presents new geophysical field data and yields new information about the local subsurface features to help search for promising targets for Cu-Au exploration in Eastern Labo, Bicol, Philippines. This dissertation has four chapters and can be generally subdivided into two: the application of gravity techniques for imaging crustal features and Moho depths in the Philippine island arc system and the application of Electrical Resistivity – Induced Polarization (ER-IP) and Very Low Frequency – Electromagnetics (VLF-EM) techniques for the characterization of potential Cu-Au mineralization in Eastern Labo, Camarines Norte, Philippines.

Chapter 1 presents the background and rationale of this research. This chapter also reviews the past published gravity and ER–IP studies in the Philippines and their applications. The objectives and structure of this dissertation are included in this section.

Chapter 2 focuses on the regional investigation of gravity signatures in the Philippine island arc system. The first part presents the theory of gravity method followed by the regional geologic and tectonic setting of the Philippines. The enhancement and inversion techniques used were discussed before presenting the results

of the methodologies. The gravity signatures (e.g., basement rocks, basins) over the Philippine island arc system were initially presented to give a general overview of their corresponding regional geologic and tectonic features. The results reveal negative gravity anomaly zones corresponding to the surrounding trenches that border the Philippine Mobile Belt (PMB) and thick sedimentary basins. Metamorphic belts are linked with moderate gravity anomalies, whereas high gravity anomalies define ophiolitic basement rocks. The upward continuation of gravity data indicates a comparatively low gravity anomaly (20 to 35 mGal) in the continental central Philippines compared to the island arc PMB's gravity highs (45 to 200 mGal). This dissertation also gives a new estimate of the average Moho (12 to 22 km) and basement (5 to 11 km) depths along the Sulu Sea using the 2-D radially-averaged power spectrum analysis. Using 3-D gravity inversion in major sedimentary basins in the Philippines provides an efficient technique to characterize significant crustal density distributions and visualize regional subsurface density differences. These methodologies may be used for future structural and geologic (e.g., prospecting for mineralization) studies in the Philippines and other places with similar geologic and tectonic settings.

Chapter 3 uses ER-IP and VLF-EM methods to characterize potential mineralization in Eastern Labo, Camarines Norte, Philippines. This chapter begins with presenting ER-IP theories and exploration history in Camarines Norte. The theory section follows an overview of the geologic, tectonic, and metallogenic settings on regional and local scales. The presentations of the applied methodologies (e.g., Hjelt and Fraser derivatives, 2-D and 3-D ER-IP inversions) and the corresponding results and discussion are also included in this section. The last part offers a combined discussion of the ER-IP and VLF-EM results and exploration implications of this research. The analysis of the resistivity and chargeability distribution in the research region yielded new results that classified the underlying lithology into eight zones. Zones C–F depict potentially mineralized zones distinguished by relatively high chargeability and varying resistivity values. Zones A and B (overburden) and Zones G and H (underlying lithology) are the non-mineralized zones. These subsurface lithological properties were confirmed using borehole data from the calibration area. To better understand the continuity of the anomalous features and geologic structures associated with the mineralization potential, 3-D resistivity and IP models were generated. The VLF-EM and 2-D and 3-D ER-IP data show that the regional geologic structure (NW-SE lineament) influences the mineralization potential in the study area. The geometry of these potentially mineralized zones was well identified by the 3-D resistivity and IP models, which supported the individual interpretation of the 2-D resistivity and IP models. Because of the widespread occurrence of high chargeability zones and relatively low resistivity anomalies, suitable areas for further detailed exploration (e.g., drilling and other detailed geophysical surveys) were identified on the study area's northeastern flank (Zone C). Identifying ER-IP signals associated with possibly mineralized zones allows for delineating new promising areas for further in-depth geophysical and geological assessments. This strategy can be used in other mining districts concealed by thick overburden.

Chapter 4 concludes this dissertation by summarizing the two main chapters and offering the possible future studies that can be initiated from this research.