INTEGRATED INTERPRETATION OF GRAVITY AND MAGNETOTELLURIC DATA TO MAP THE LITHOSPHERIC STRUCTURES OF THE CENTRAL WESTERN CORDILLERA

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Abstract

Knowing the tectonic structure of the deep subsurface is important for understanding the volcanic and seismic activities that occur on Earth. It is also important to know the deep thermal structure, which is important for geothermal resource development. The western margin of North America is characterized by an active tectonic regime that resulted from the dynamic interaction among the North American plate, the Pacific plate, and the remnants of the Farallon plate. This active interaction resulted in a mountain chain along western North America known as the western Cordillera. The western Cordillera's central part represents the United States' western margin. This area attains much interest due to its tectonic activity; nevertheless, most geophysical research focuses mainly on seismic data interpretation. This seismic data has a high resolving power but lacks a high sampling density, resulting in misinterpretation or gaps in the resulting seismic maps. On the other hand, gravity data of the study area provides a high sampling density, enabling efficient mapping capabilities. Gravity data was integrated with magnetotelluric data to maximize the interpretation accuracy and eliminate the ambiguity of data interpretation. Gravity and MT data were interpreted to map the lithospheric structures in the study area. The procedures and results of these analyses are illustrated in this thesis through eight chapters as follows:

Chapter one provides a general introduction of the research, including the geologic and tectonic setting of the study area, drawbacks of the previous analysis, aims and objectives of this research, motivations, importance of this research, a flow chart of the research methodology, and the outline of the thesis.

Chapter two provides a background about the gravity method, including the earth models and controlling factors of gravity anomaly. This chapter illustrates the processing steps applied for the gravity data to retrieve the complete Bouguer anomaly map of the study area.

Chapter three describes the methodology of estimating the depth of the Moho using Parker-Oldenburg. The isostatic state in the study area was assessed, and the residual topography was calculated. And the contribution of crust and lithospheric mantle in topography was evaluated. Moreover, the depth to the Lithosphere-Asthenosphere Boundary was calculated. Results show an eastward crust thickening with Moho depth ranging from 20 to 50 km. The estimated Moho depth showed a good correlation with previous estimates and with the physiographic provinces in the study area. The produced Moho depth map represents the first detailed insight into the Moho depth in the study area.

Chapter four illustrates the procedures and results of the three-dimensional inversion of gravity data. The 3-D density distribution model illustrates the subducting Gorda and Juan de Fuca plates. These plates appear as a dense anomaly, while the area at the southern edge of the Gorda plate appears as a less dense anomaly. This area represents the asthenospheric flow in the wake of the slab window. The density distribution model marks the transition from the active to stable tectonic regime along the west-east direction. The Snake River Plain appears as a dense anomaly, whereas the Rocky Mountains appear as a low-density anomaly. The density model shows the upper mantle

anisotropy in the study area.

Chapter five provides a background about the theory of the MT method illustrating the factors that affect the resistivity distribution. The dimensionality analysis of the MT data shows a 3-D character, especially for periods longer than one second. The directionality analysis of the MT data shows an angle of the geoelectric strike, which required data rotation of the strike angle.

Chapter six provides the methodology and results of the 3-D inversion of MT data, including the model parameters and response. The 3-D lithospheric resistivity distribution shows an eastward transition from an active to stable tectonic regime. The subducting plates appear as resistive anomalies, whereas the back-arc appears as a conductive anomaly. The resistivity model assesses the effect of the hydrothermal fluid and melting at some locations like Yellowstone National Park.

Chapter seven investigates the empirical relationship between density and resistivity, and the relationship follows a quadratic function of the second degree with a parabola that opens upward. Moreover, geostatistical joint analysis between the density and resistivity maps at different depths was performed and interpreted; the resulted map comprises all anomalies extracted from the density and resistivity maps. Noticeable features in the integrated maps are the asthenospheric flow at the southern edge of the Gorda plate, the back arcs, the subduction trench, and the Snake River plain; these features were mapped efficiently in the resulted integrated map compared to the initial density and resistivity maps.

Chapter eight provides a general discussion and conclusion of the research illustrating the study's findings and the need for more geophysical data, especially the MT array. An outlook for this research includes using more geophysical data, e.g., seismic and magnetic data, to produce a heat flow map of the study area.