Inversion of Gravity Anomalies Using Primal-Dual Interior Point Methods

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Structural inversion of gravity datasets based on the use of density anomalies to derive robust images of the subsurface (delineating lithology and their boundaries) constitutes a fundamental non-invasive tool for geological exploration. The use of gravity data to estimate and interpret the substructure based on its density properties have proven efficient; however, the inherent non-uniqueness associated with most non-seismic geophysical datasets make this the ideal scenario for the use of recently developed robust constrained optimization techniques. We present a constrained optimization approach for a least squares inversion problem to characterize 2-Dimensional Earth density structure models based on gravity anomalies. The formulation inverts Bouguer gravity anomalies using polygons along with Primal-Dual Interior-Point methods for the optimization of the results, which include equality and inequality physical and structural constraints. We validate our results using synthetic density crustal structure models with varying complexity and illustrate the behavior of the algorithm using different initial density structure models and increasing noise levels in the observations. Moreover, we apply the approach to the Southern Rio Grande Rift (SRGR) region using previously obtained receiver function results as constraints for the inverted density profiles. We produce constrained crustal models that characterize the SRGR showing a shallower Moho (30 km) in the region, which is thicker than previously suggested. Based on its validation and implementation, we conclude that the algorithm using Primal-Dual Interior-Point methods is robust and always honors the geophysical constraints. Advantages of using this approach for structural inversion of gravity data are the incorporation of a priori information related to the model parameters (coming from actual physical properties of the subsurface) and the reduction of the solution space contingent on these boundary conditions.

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