Airborne Gravity and Magnetic data in Turner Valley, AB: What structures can they resolve?

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Turner Valley, located 50 km southwest of Calgary, was the site of the first oil & gas boom in Canada. The study area represents the easternmost limit of the Canadian Cordillera, and the termination of the foreland fold-thrust belt. Although seismic methods are the standard geophysical exploration tools for petroleum reservoirs, the high cost and ground contact requirements outweigh other geophysical methods such as gravimetry and magnetometry, which can be performed from airborne platforms. High-resolution airborne gravity and magnetic line data was processed to create 2D maps and selected profiles to assess the ability to resolve geological structures and areas of interest, especially the two dominant structures; the Turner Valley Structure and the Highwood Structure. Simple gravity and magnetic inversion modelling was performed as well. The first vertical derivative of the gravity data successfully outlines the general trend of the main structures and the presence of offsets, but with a low resolution of approximately 10-15 km. In the magnetic data, the first vertical derivative shows much finer detail and a spatial resolution of approximately 925m, but locations of offsets are difficult to determine. When both datasets are used together in composite maps, important features are highlighted and new features appear that are not easily visible on the individual maps. The derivation of pseudo-gravity and pseudo-magnetic maps reveal features which include correlating maxima, and contrasting polarities of anomalies within the datasets. These contrasts reveal more detailed information on the material properties of the geological units. This is demonstrated near the Turner Valley upper detachment, where a magnetically intense contact surface creates a positive magnetic anomaly in the same location as a negative gravity anomaly. The inversion models estimate the geometric and material parameters to unknown anomalies within thrust segments, and supported the hypothesis that small shallow anomalies are contributing to short-wavelength peaks and troughs in the data. Airborne gravity and magnetic datasets are high-resolution and are good options for preliminary exploration surveys, especially when used in conjunction with each other. The resolution is increased when the two datasets are used in combination, and reveal more information about structural features and material properties. The combination of the two primary datasets was achieved at the visualization level, however, a cooperative inversion or a joint inversion may present additional information and is thus proposed as a next step to exploit the high-resolution dataset at Turner Valley.