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Using Long Wavelength Gravity to Understand Continental Structure and Processes

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In most interpretations of gravity data, the long wavelength signal is removed as an unimportant regional contribution. This convention is largely historical; in the past it was difficult to model data at a variety of scales, and regional/residual separation became standard practice. This is especially true in exploration studies where near surface ore deposits are the target (e.g. LaFehr and Nabighian, 2012). With the development of a large variety of rapid 2D and 3D gravity modelling packages that are widely available, a more regional context for ore deposits and other crustal features can be considered. The inclusion of the regional long wavelength signal in the interpretation can dramatically alter the result, especially when the scale of consideration is on the order of the scale of crustal flexure. Large basins, such as the South African Karoo basin (Mesozoic) and even the smaller Witwatersrand basin (Archean), are likely to have deformed the Moho during their formation, although not all of these features appear to be preserved in present-day Moho geometry. Gravity modelling to Moho depths may dramatically alter the detailed interpretation of the deeper sections of these basins, with implications for resources such as gold, coal, gas and even carbon capture and storage (CCS). A clear cut example of this is seen in the interpretation of the gravity data of the Bushveld Complex (BC). When the crust is allowed to flex, the mafic lithologies of the BC can be allowed to connect laterally, resulting in an enormous layered intrusion 400 x 400 km across. This interpretation has been confirmed by the presence of BC xenoliths in a kimberlite near the centre of the Complex (Webb, Ashwal and Cawthorn, 2011, Contrib. Mineral. Petrol., 162: 101-107). The implication is that the BC mineral resources are also likely to be laterally connected, easily quadrupling the amount of mineralization, although the depth of the deposits remains uncertain. Due to the inherent ambiguity of gravity interpretations, inversion results tend to concentrate density variations towards the surface, making it difficult to accurately invert for Moho depth from gravity measurements. An added complication is the density variations in the uppermost mantle associated with Archaean cratonic keels. These lateral variations have similar gravity wavelengths to the gravity signal due to Moho variations; these two signals are unlikely to be resolved independently through inversion. As more crustal thickness data become available, large scale features, and even smaller mineral deposits can be more accurately evaluated.