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DISCUSSION: Spectral representation of isostatic models

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The main issue arising from Karner (1982) is whether the admittance method is capable of auto-analysis, that is, diagnosing structures. My analysis of ambiguity in marine gravimetry (Anfiloff, 1979) shows that the lack of proximity to the first interface, the sea bottom, makes marine observations inherently more ambiguous than observations on land. One of the findings is that the density profiling method should be applied routinely to assess the degree of ambiguity arising from the water/rock interface, because of its large density contrast, and the large range of possible density contrasts. It is axiomatic that if the density of marine topography cannot be deduced from the data itself, then a major source of ambiguity will pervade the entire analysis.

Karner also claims that the admittance method is applicable to the land situation, and suggests it should render the line-integration method obsolete for the purpose of general forward modelling. However, non-coplanar observations on land pose substantial problems. The equivalent layer method, on which the spectral method is based, is severely restricted by the requirement that observations be coplanar. Yet, isostasy is best studied over steep mountains, where the density of topography can be deduced from the gravity observations themselves, making interpretation less ambiguous than in other situations. For the two-dimensional case, line integration allows the problems of vertical continuation, topography density, and terrain corrections to be tackled in a unified process, (Anfiloff, 1976), resulting in Formal Interpretations (Anfiloff & Flavelle, 1979). Using this approach, the computation of synthetic free-air gravity (or topographic anomaly) has been demonstrated for real traverses across a 35-metre ridge (Anfiloff, 1981), an 800-metre ridge (Anfiloff & Flavelle, 1982), and across the Australian Alps (Anfiloff, 1982).

For forward modelling in the marine environment generally, the spectral method does not have any inherent advantages over line integration, and has the disadvantage of inaccuracies of varying degree. In the marine situation generally, the admittance method has the potential to differentiate between classes of structures, without being able to describe the structures themselves, as it is still subject to ambiguity. Like all auto-analysis methods, it must rely on a hypothetical relationship between a limited number of parameters, and, because of over-simplification, is capable of producing internally consistent but false models of structure with a minimum amount of input. Whereas marine crust may at times provide the simplicity and uniformity necessary for the admittance method, widespread and indiscriminate application could lead to major fallacies. Marine gravimetry has its own suite of problems arising from concealed sedimentary wedges, ambiguous effects of broad topography, lack of proximity to the nearest geological bodies, and a lack of good quality constraints generally. These factors should serve to decrease our expectations of marine gravimetry generally, and of auto-analysis methods in particular.

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REPLY

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Anfiloff's discussion is successful in summarising the problems that exist not only with admittance methods (Karner, 1982) and marine gravity data in particular, but *all* gravity methods (including the so-called Formal Interpretation of Anfiloff & Flavelle, 1979) and gravity data in general. However, his discussion is underlain by a number of misconceptions and prejudices towards various methods of gravity interpretation. Rather than specifically addressing the detailed criticisms made by Anfiloff, I prefer to address the basis of his discussion.

The Fourier expansion of a gravity anomaly is mathematically unique, its prime value being to highlight the spectral content of the anomaly. The fast Fourier transform, in particular, allows the rapid analysis of large quantities of data. Admittance functions use the Fourier representation of both gravity and topography data to construct filters which represent isostatic mechanisms that may operate within the lithosphere. In the paper under discussion, I attempted to summarise and describe how this can be achieved. The main advantage of admittance functions is in their computational efficiency relative to the line-integral method when calculating free-air and isostatic gravity effects for complicated topographies, isostatic schemes, or lithospheric rheologies.

A major problem in gravity modelling arises because of the non-uniqueness of gravity data. The use of gravity data for continental studies in the past has invariably been limited to a consistency check of geological structures obtained by other means, particularly reflection and refraction seismology. It is important to realise the possible contributions of gravity studies. They can place maximum limits on the depth to the top of an anomalous density structure (and are therefore useful in rejecting some hypotheses using deep bodies), and they can also show whether a given isostatic mechanism is or is not consistent with observations. Since an infinity of mass distributions can cause a given gravity anomaly, gravity modelling cannot support one model to the exclusion of all others *unless* additional information from other sources is available. Generally, the arrangement of modelled density variations, or "bodies", used in the interpretation of gravity has been made independent of the physical and mechanical properties of rocks which comprise the continental crust. This modelling philosophy, therefore, cannot address the geological processes (and hence mechanisms) giving rise either to the existence or distribution of these bodies.

Gravity, bathymetric, and seismic studies over loads emplaced on the oceanic lithosphere have been successful in defining the first-order mechanical properties of the lithosphere and hence a geological mechanism for isostasy. In particular, the lithosphere is capable of flexing in response to applied loads, because of its rheological strength, in an *analogous* manner as an elastic plate overlying a weak fluid (e.g. Barrell, 1914; Gunn, 1948; Walcott, 1976; Watts, 1978; Bodine & others, 1981). This same model, when extended to the continents (e.g. Watts & others, 1982; Karner & others, in press), helps explain a number of tectonostratigraphic features of cratonic and foreland sedimentary basins.

The admittance technique, therefore, is particularly useful in studying the mechanical properties of the lithosphere. The isostatic state (or the degree of compensation) of a geological feature is also dependent on its horizontal extent. For the rigidities which characterise flexure of the continental lithosphere, topographic features with wavelengths less than about 100 km will appear uncompensated regardless of mountain steepness or height. The topographic examples presented by Anfiloff suggest a fundamental difference in the wavelengths of interest. His examples are less than 100 km in wavelength, representing, therefore, uncompensated density variations (caused by topography or variations in geology), and so are very sensitive to the various factors he refers to. Gravity anomalies with wavelengths between 100 and 1000 km tend to be compensated within the continental crust and, therefore, are most suited for studying isostasy. These anomalies may be modelled using either the more cumbersome empirical forward modelling techniques or admittance functions.

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