The reply by Clowes et al. follows this discussion, which is included for completeness.

DISCUSSIONS

LITHOPROBE—southern Vancouver Island: Cenozoic subduction complex imaged by deep seismic reflections:[1] Discussion

L. W. Sobczak

Lithosphere and Canadian Shield Division, Continental Geoscience and Mineral Resources Branch, Geological Survey of Canada, 1 Observatory Crescent, Ottawa, Ont., Canada K1A 0Y3

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Clowes *et al.* presented an informative article on the results of seismic reflection experiments conducted along four lines for LITHOPROBE on southern Vancouver Island. The various reflections indicated in the profiles, which are distributed as deep as the Mohorovičić discontinuity, formed the basis for proposing various scenarios for the tectonic development of the crust. Two of these hypotheses, outlined in Fig. 9, were discarded. In Fig. 10, schematic illustrations on the possible crustal development were presented. The selection of a preferred model was based entirely on reflection and refraction data, but no consideration was given to other parameters such as density, which influences the gravity field. Usually there is a strong relationship between densities and crustal seismic-wave velocities. Analysis of gravity data would have provided an independent means of evaluating the various evolutionary models.

The gravity field is mapped over the area of Fig. 1 (Riddihough 1979), and presumably significant density differences exist between the continental framework (Wrangellia—Paleozoic and Mesozoic rocks), Leech River schist, Eocene basalt, and core rocks (sandstone and shales). A gravity high is noted over southwestern Vancouver Island, with a peak value (over 50 mGal (1 mGal = 10 μm s^{-2})) over the exposed Eocene basalt (Riddihough 1979). This high extends inland, indicating that the basalts probably extend inland below the surface. A trend of highs and relative highs also extends southward into Washington State, roughly following the trend of exposed basalts of Fig. 1. In addition, a gravity low (minimum −75 mGal) overlies the Olympic Peninsula of Washington State, where the low-density sedimentary core rocks are exposed. In fact, excellent correlation exists between the gravity and surface geology noted in Fig. 1. It is likely, therefore, that significant density differences exist between the various lithologic units. These relationships could be utilized to derive reliable gravity−density models.

Riddihough (1979) presented a general interpretation of the gravity field but lacked adequate depth, lithological, and density control. I expressed my concern about his gravity−density model in October 1978 (personal communication) and indicated that density contrasts are more reliable than block densities when modelling large thicknesses, as shown in crustal sections by Sobczak (1975*a*, 1975*b*) and more recently by Sobczak *et al.* (1986). However, a combination of the current seismic reflection and refraction control and an analysis of the densities of the exposed rocks with respect to gravity could probably have produced a stronger case for one or other of the proposed evolutionary models. Furthermore, deeper boundaries shown in Figs. 7 and 8 could have been extended using gravity−density modelling with existing seismic depth control.

I think the authors were premature in offering an evolutionary scenario without first considering other rock parameters such as density. If gravity−density analyses were made or are in progress, then the authors should have referred to this research as well. The same arguments made for gravity may equally well apply to magnetic susceptibilities and magnetic field.

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[1]Paper by R. M. Clowes, M. T. Brandon, A. G. Green, C. J. Yorath, A. Sutherland Brown, E. R. Kanasewich, and C. Spencer. 1987. Canadian Journal of Earth Sciences, **24**: 31−51.

LITHOPROBE—southern Vancouver Island: Cenozoic subduction complex imaged by deep seismic reflections:[1] Reply[2]

R. M. CLOWES
Department of Geophysics and Astronomy, 2219 Main Mall, The University of British Columbia, Vancouver, B.C., Canada V6T 1W5

M. T. BRANDON
Department of Geology and Geophysics, Yale University, New Haven, CT 06511, U.S.A.

A. G. GREEN
Lithosphere and Canadian Shield Division, Geological Survey of Canaada, 1 Observatory Crescent, Ottawa, Ont., Canada K1A 0Y3

C. J. YORATH AND A. SUTHERLAND BROWN
Pacific Geoscience Centre, Geological Survey of Canada, P.O. Box 6000, Sidney, B.C., Canada V8L 4B2

E. R. KANASEWICH
Institute of Earth and Planetary Physics, University of Alberta, Edmonton, Alta., Canada T6G 2J1

AND

C. J. SPENCER
Lithosphere and Canadian Shield Division, Geological Survey of Canada, 1 Observatory Crescent, Ottawa, Ont., Canada K1A 0Y3

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The basis of Sobczak's discussion is that Clowes *et al.* (1987) did not consider other physical parameters such as density, variations of which are reflected in the gravity field, and thus that we were premature in proposing our schematic evolutionary model.

Simply stated, Sobczak (1987) is incorrect. Our interpretation of a final model was based primarily on the new seismic reflection results but incorporated information from as many aspects of geological and geophysical data as were available at the time; these are referenced in the text. In particular, (*i*) geological considerations (e.g., Tabor and Cady 1978*a*, 1978*b*; Muller 1977; Brandon *et al.* 1984; Massey 1986) strongly influenced our interpretation of reflective zone C-D2 as core rocks; (*ii*) the magnetotelluric results of Kurtz *et al.* (1986), which gave a two-dimensional conductivity structure along seismic line 1, affected our interpretation of reflective zone E1 – E2; and (*iii*) the wedge of high velocity above the subducting plate (Spence *et al.* 1985) played a major role in our interpretation of the lesser reflective zone D2-E1.

With respect to gravity data, Spence *et al.* (1985) included a reinterpretation of the Riddihough (1979) gravity profile across southern Vancouver Island, showing that the more complex seismic model is consistent with the profile, thus implicitly incorporating the gravity field into our interpretation. The high-velocity wedge also has a high density. As stated by Spence *et al.* (1985), this reduces the problem, noted by Riddihough (1979), of requiring low-velocity, high-density material above the subducting plate, but it does not eliminate it. As part of the LITHOPROBE project, detailed gravity measurements were made along seismic line 1 but not along the other three lines. A final interpretation of the data was not available at the time our paper was prepared, but preliminary interpretations were consistent with the basic tenets of Riddihough's (1979) model, and thus the latter was the only specific reference made. Also, in an earlier interpretation of LITHOPROBE refelction data, Green *et al.* (1986) explicitly compared the seismic reflection data along line 1 with Riddihough's (1979) gravity interpretation.

As to the possibility of extending the deeper boundaries in Figs. 7 and 8 of Clowes *et al.* (1987) by gravity – density modeling, the resolution capability of this procedure below depths of 25 km is very poor, especially for layers that are only 5 – 10 km thick. Indeed, any model based on the gravity (or refraction) data requires additional constraints such as those provided by seismicity and magnetotelluric data. Thus, realistically no additional constraints are obtained for such depths from gravity modeling, although consistency with the gravity field could be shown.

With respect to magnetic data, Sobczak may be interested to known that J. Arkani-Hamed and D. W. Strangway have inverted the aeromagnetic map of southern Vancouver Island into a magnetic susceptibility map, as reported in Clowes (1987). There is good correspondence to the geology and the interpreted models for seismic lines 2 and 4.

LITHOPROBE is a multidisciplinary earth science project to investigate the lithosphere in selected transects across Canada. As described explicitly in Clowes (1987), the Vancouver Island transect is an excellent example wherein the results of many geoscience disciplines, including gravity, have been combined to provide an integrated interpretation.

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