SUBDUCTION OF THE JUAN DE FUCA PLATE AND HEAT TRANSPORT

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Terrestrial heat flux was measured in fjords, in boreholes and in offshore wells at sites across the convergent margin of southwestern British Columbia from the continental shelf landward to the Garibaldi Volcanic Belt (Lewis et al., 1988). Temperatures in the offshore wells were corrected for drilling disturbances, and formation thermal conductivities were modelled using measurements on cuttings and downhold geophysical logs. Marine measurements in fjords, first made by Hyndman (1976) were corrected for the large effects of refraction as well as aperiodic temperature variations in the bottom waters. These measurements were combined with previous ones (Lewis et al., 1985), and there was excellent agreement between marine measurements and those from nearby onshore boreholes.

The heat flux above the subducting Juan de Fuca plate steadily decreases landwards from over 50 mWm^{-2} on the shelf to 25 mWm^{-2} seaward of the Garibaldi Volcanic Belt (figure 1).

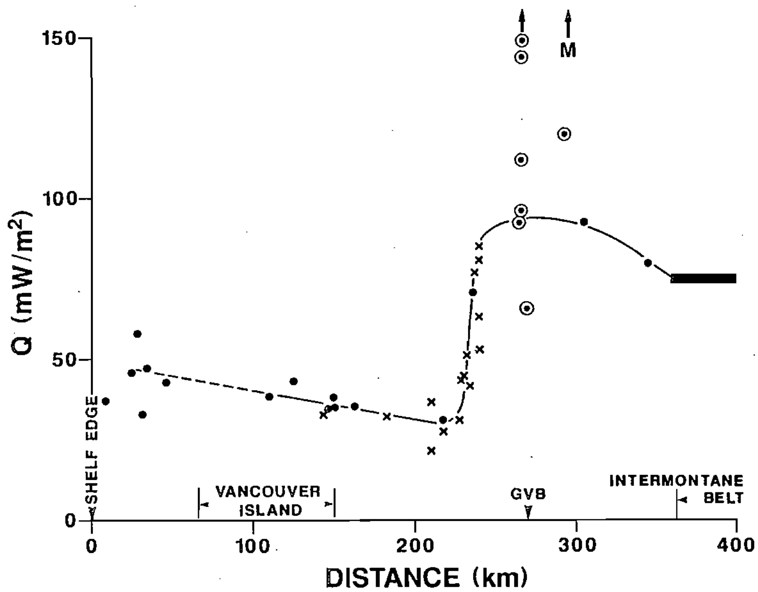

Fig. 1. Heat flux along a profile crossing the convergent margin of southwestern British Columbia. Heat flows are corrected only for topography and sediment refraction. Marine results, indicated by crosses, are also corrected for bottom water temperature changes. Circled dots are values from the Garibaldi Volcanic Belt (GVB), where some much higher heat fluxes have been measured, including many near Meager Mountain, indicated by an "M". The Intermontane average value comes from Davis and Lewis (1984).

An abrupt increase to 80 mWm^{-2} over a distance of 20 km is centered 30 km seaward of the volcanic zone. The measured heat generation of crustal samples along the entire profile is low, 0.6-0.8 μWm^{-3}.

Large amounts of uplift have produced a rugged topography in the Pleistocene volcanic area, requiring substantial topographic corrections to the heat flux where water flows through the rock have not already changed the heat flux. Very large variations in heat flux occur locally near Pleistocene edifices, the result of advective cooling of intrusive magmas. At Meager mountain temperatures of 260°C were measured in one well, but production of steam was found to be uneconomical due to low permeability within the rock penetrated.

A landward dipping, seismically reflective zone above the subducting oceanic plate beneath Vancouver Island appears to be nearly isothermal. This layer is also the top of a low electrical resistivity zone (figure 2).

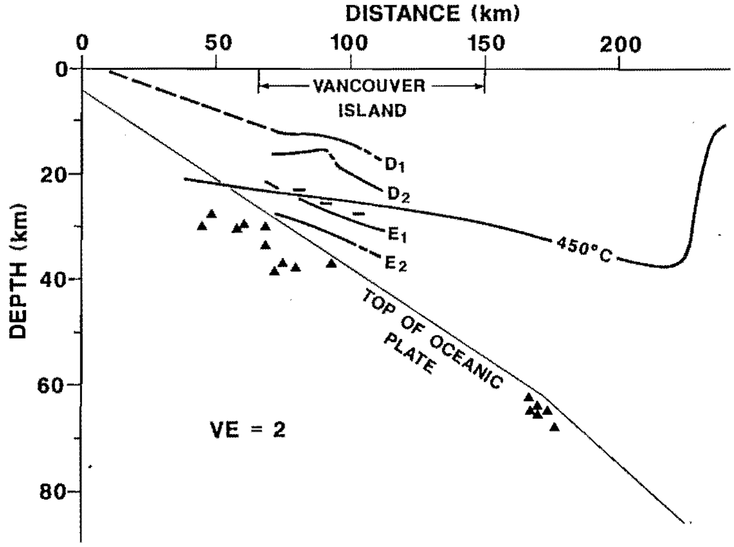

Fig. 2. The subducting oceanic crust with locations of earthquakes indicated by triangles, the zones of seismic reflectors bounded by D1 and D2, and E1 and E2, the high electrical conductivity layer indicated by short horizontal lines near E1 (Kurtz et al., 1986), and the 450-°C isotherm from this study.

It is postulated that dehydration of the subducting oceanic crust at and above approximately 450°C absorbs heat and produces water which flows updip along this zone in the overlying subduction complex, effectively redistributing the heat seaward to where the water is re-absorbed in hydration processes. This process is metamorphosing a large crustal wedge at high pressures and relatively low temperatures. At the thick, landward side of this wedge, the abrupt increase in surficial heat flux must be caused by a shallow (10 km depth) heat source produced by the convective cooling of magma (figure 3).

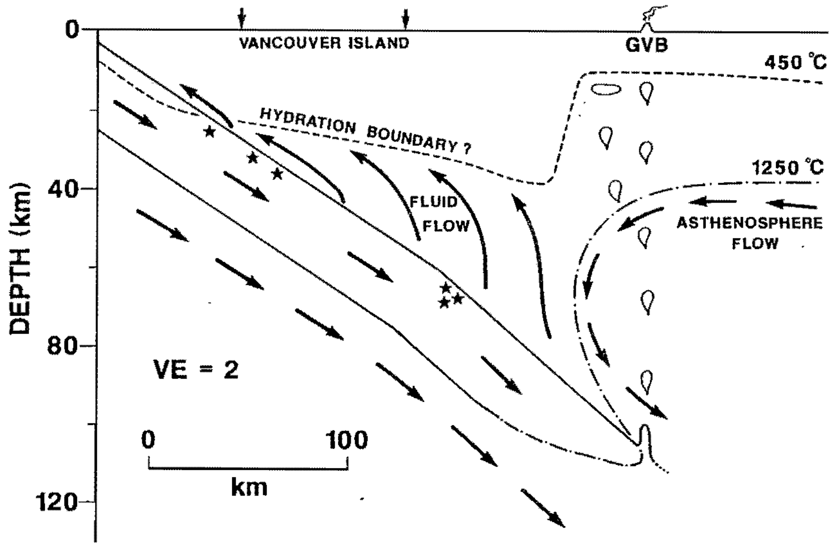

Fig. 3. A model of the subducting oceanic crust being consumed, showing water flow updip from the dehydration of the oceanic crust. Asterisks indicate earthquake focii.

REFERENCES

Davis, E.E. and Lewis, T.J., Heat flow in back-arc environment: Intermontane and Omineca Crystalline Belts, southern Canadian Cordillera, Can. J. Earth Sci., 21, 715-726, 1984.

Hyndman, R.D., Heat Flow measurements in the inlets of southwestern British Columbia. J. Geophys. Res., 81, 337-349, 1976.

Kurtz, R.D., DeLaurier, J.M. and Gupta, J.C., A Magnetotelluric Sounding Across the Subducting Juan de Fuca Plate, Nature, 321, 596-599, 1986.

Lewis, T.J., Bentkowski, W.H., David, E.E., Hyndman, R.D., Souther, J.G. and Wright, J.A., Subduction of the Juan de Fuca Plate: thermal consequences, accepted for publication, J. Geophys. Res., 1988.

Lewis, T.J., Jessop, A.M. and Judge, A.S., Heat Flux Measurements in Southwestern British Columbia: the Thermal Consequences of Plate Tectonics, Can. J. Earth Sci., 22, 1262-1273, 1985.