describes the prevention of graft failure in patients with immunological deficiency diseases given HLA-incompatible bone marrow transplants depleted of donor T cells. They used an anti-LFA1 (CDw18 in humans) monoclonal antibody that prevents cell adhesion and therefore interferes with the immunological reactions of a broad spectrum of immunologically competent cells.

These observations in mouse and man point the way to a resolution not only of the graft rejection problem but also resolution of the graft-versus-host disease problem. However, we must keep in mind that we cannot alter the normal human donor by such procedures as thymectomy and antibody administration as was done in the murine model of Cobbold *et al.*

Will murine monoclonal antibodies have sufficient distribution and activity in human patients or will monoclonal antibodies of human or other primate origin be necessary? Will depletion of donor T cells or administration of anti-lymphocyte monoclonal antibodies *in vivo* diminish immunological competence and result in a greater likelihood of recurrence of disease in leukaemia patients because of the lack of an anti-leukaemia immune response? Will resistance against viral illnesses fail to develop? Many biological functions require more than tolerance — they require cooperation between different cells and tissues and may be perturbed in ways not yet anticipated by these genetic disparities and manipulative procedures. □

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**Earth sciences**

# Is there water in the deep continental crust?

*from Bruce W. D. Yardley*

RECENT developments in the earth sciences provide remarkable insights into the composition of the Earth's interior and of other bodies in the Solar System, but uncertainty remains about the make-up of other parts of the Earth. The question of whether or not the continental crust, especially its deeper parts, contains water as a discrete phase is important for understanding geological processes, but is controversial because of contradictory inferences from the physical and chemical lines of evidence. D.I. Gough, on page 143 of this issue[1], puts forward a new model that seeks to meet the geophysical constraints. Is the model consistent with the chemical data?

Conventional wisdom has it that, away from areas actively undergoing metamorphic heating, the lower crust (below 15–20 km) is essentially dry with no free fluid phase present, although small amounts of hydrous minerals or carbonates may persist. This view is based on the mineralogy of rocks derived from the lower crust and now exposed in high-grade metamorphic terranes or found as volcanic xenoliths[2].

The argument for a dry lower crust is as follows: the granulite facies assemblages that predominate in lower crustal rocks are stable in the presence of an aqueous phase, if at all, only at the extreme metamorphic temperatures at which the rocks originally formed, whereas the present-day temperatures of the lower crust are generally less than this. If water penetrates granulites at normal crustal temperatures it will be entirely consumed by hydration reactions forming lower-grade, hydrous minerals[3], until the granulite facies assemblage is entirely retrograded. Furthermore it is clear both from experimental studies[4] and from reactions in geothermal fields that the hydration reactions are fast, so that the possibility of unstable persistence of water in the lower crust can be excluded. Hence the occurrence of granulite facies assemblages suggests that the lower crust remains dry and any water gaining access becomes combined into hydrous minerals.

This model does not account for the geophysical differences between the upper and lower crust, and is apparently at variance with the occurrence of anomalously high electrical conductivities at depths of 15–20 km that have been widely documented in Europe and North America and have been ascribed by several workers to the presence of an aqueous fluid phase. Gough's model[1] explicitly accounts for the major geophysical characteristics of the upper and lower crust on the basis of the different modes of occurrence of aqueous fluid in the two regions, rather than the lithological differences assumed in studies based on rock samples[5]. Gough points out that the lower crust is anomalously conductive, contains seismic reflectors and, at least in tectonically active areas, deforms in a ductile manner, whereas the crystalline upper crust is resistive, brittle and has few seismic reflectors. He suggests that this contrast can be explained if water is present as a continuous film in the lower crust but at shallower depths and lower temperature is isolated in discrete cavities held closed in the normal upper crustal stress fluid.

Does Gough's model satisfy other lines of evidence about the nature of the crust, or will it fail in the same way that the 'dry granulite' model appears to fail to meet the geophysical constraints? First, the different approaches to the lower crust do not necessarily measure quite the same thing. Geophysical measurements refer to the lower crust as it is today, whereas lower crustal rock samples have been brought to the surface often quite early in their geological history. Second, much of the information obtained from rock samples refers to their original formation rather than to the time they may have spent as stable lower crust. Despite this caveat it still appears that the geochemical arguments for a dry lower crust do preclude the existence of a free aqueous phase, unless it is restricted to totally hydrated layers within a predominantly dry crust, or unless lower crustal temperatures commonly approach those of granulite facies metamorphism. This latter suggestion does not seem likely when the metamorphic histories of granulite terranes are considered.

In the upper crust, there is in fact direct evidence for fluids flowing, most spectacularly from the deep borehole on the Kola peninsula[6], where influx of water is recorded to at least 12 km. It may also be significant that the most conspicuous features of road-cuts and quarries in crystalline rocks are often joints lined with hydrous minerals.

Clearly, there must be a flaw in one or both of the arguments if geophysically based models are so at variance with those derived from geochemical arguments. Both cases depend on an adequate understanding of the physical or chemical properties of rocks at high pressures and temperatures, where experimental data are necessarily restricted. Although there are experimental measurements of the seismic velocities of xenolith suites that confirm their lower crustal provenance[5], there are little data on electrical conductivity at deep crustal conditions. Tantilizingly, what little data that there are[7] suggests that basic granulites have a higher conductivity at elevated pressure and temperature than can be accounted for by the pore fluid that was present in the experiments alone. If this is confirmed by further work, the geophysical and geochemical viewpoints could be reconciled with a 'dry' lower crustal model. □

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