and tail sequences are far more divergent, suggesting that the highly conserved biophysical and pharmacological properties can be accounted for largely by domains within the repeat segments. Interestingly, the brain proteins have a large (19–20K) sequence between repeats I and II, containing several consensus phosphorylation sites, that is not present in the electroplax protein. This domain could be involved in modulation, in interactions with smaller subunits or in cytoskeletal attachment. It probably does not participate directly in the 'activity cycle'. In addition, all the peptides are heavily glycosylated; in the electroplax protein sialic acids contribute up to 120 negative charges to the extracellular surface although there may be less in brain and muscle proteins. The new work suggests that for this second ion-channel prototype the striking departure from the multi-subunit design of the acetylcholine receptor may be more apparent than real.

Also worth mentioning is the discovery of a family of sodium-channel proteins in brain. Some of these may be specific for particular neurones, and some neurones may exhibit multiple species of channel; some channels may be associated with glial cells. If there are banks of genes for ionic channels, their expression in specific cells at appropriate topographical locations must involve regulatory mechanisms that influence and perhaps even respond to the flow of electrical information in neurones and neuronal networks. □

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Archaean geology

Hungry komatiites and indigestible zircons

from G.R. Edwards and E.G. Nisbet

THERE has been much recent academic interest in the rocks hosting the Kambalda nickel deposit in Western Australia. This is presumably not because salaries are so low that research workers are hoping to find a new mine, but rather because these rocks are forcing a reassessment of one of the most important dating methods in old rocks and are causing us to think again about the processes that occurred when hot lavas erupted through and onto the continental crust 2,700 million years ago .

At Kambalda, nickel sulphide ores are closely associated with komatiites, lavas with high magnesium contents that generally occur in rocks older than 2.5×10^9 years. The high Mg content implies that komatiites were very hot (up to 1,650°C) when they erupted. Interest in the Kambalda rocks has concerned the age of the komatiites as well as the way in which the sulphide deposits were formed. The debate began when an array of Sm–Nd isotope data from Kambalda was interpreted as evidence that the Kambalda lavas are 3.2×10^9 years old[2]. Another group interpreted the same data as the result of mixing of material derived from a depleted mantle source with either an undepleted mantle source or material from the lower continental crust[3]. This group went on to show that Pb–Pb isotopes defined an age of 2.73×10^9 years, and that Pb isotopes in the rocks may be dominated by the effects of contamination with crustal or surface-derived material.

Compston *et al.*[1] now provide additional evidence from zircons that not only supports the 2.7×10^9-year estimates but also provides further evidence for crustal contamination. Zircons separated from basalts at Kambalda and analysed for U, Th and Pb isotopes using the SHRIMP ion microprobe have distinct cores with minimum ages ranging from greater than 3,400 to 3,100 million years and surrounded by mantles of younger zircon.

The old zircons are thought to be xenocrysts, partly because there were also zircon mantles and whole zircons with ages less than 2,700 million years in the sample, but also because the zircons are rich in U and Th, suggesting crystallization from felsic magma or recrystallization in felsic rock rather than crystallization from basalt. Mantling of the structural cores of the complex zircons seems to have occurred in two steps: (1) metamorphic recrystallization of the zircons while in their parent rock about 3.1×10^9 years ago, probably under granulite conditions; and (2) new growth around the metamorphically mantled zircon cores after their inclusion in the mafic–ultramafic magma. From their analysis of younger zircons, Compston *et al.* suggest the age of extrusion of the lavas is $\leqslant 2.669\pm11$ million years.

What is the ultimate source of the zircons? They are soluble in high-Mg basaltic magmas and would be unlikely to survive a long journey to the surface unless protected by enclosure in small xenoliths. It is also unlikely that new zircons or zircon mantles will grow in zirconium-undersaturated high-Mg basaltic magmas. Nevertheless, zircons are notoriously resistant to melting, so they may survive these processes virtually unscathed and the mantles may thus represent an attempt at solid-state re-equilibration by zircons derived from the continental crust. Alternatively, some of the zircons may have been locally derived by assimilation of some of the zircon-bearing interflow sediments. The weight of the isotope evidence thus suggests that there was some contamination of the Mg-rich magmas at Kambalda. Contamination is greatest when heat transfer to the country rock is most rapid, as is the case during turbulent flow in hot, low-viscosity komatiitic magma[4].

Ascending hot komatiitic magmas could have thermally eroded the wall rocks of conduits to become contaminated: on eruption, komatiites could have eroded underlying strata. Trace-element evidence[5] implies that komatiite at Kambalda was contaminated by thermal erosion and assimilation of a mixture of sediment and tholeiites, whereas the high-Mg basalts at Kambalda are the result of up to 25 per cent contamination of komatiite, at depth, by material similar to upper continental crust. As for the nickel sulphide deposits — the reason why so many geologists descended on Kambalda in the first place — Groves *et al.*[6] concluded from field evidence that thermal erosion occurred, but only where concentrations of sulphide liquid (which has a high thermal conductivitiy) were present at the base of lava channels. Some of this sulphide liquid may have formed from initial thermal erosion of sediments.

What can we learn from all this? The first lesson is that Sm–Nd data from komatiite rocks must be treated with great caution. On the other hand, zircons are extremly interesting if one has an ion microprobe. More generally, the controversy may help to elucidate the mechanisms of komatiite eruption and also the history of the continental crust, which has been sampled by the erupting liquids. Thus some zircon-containing lavas may be useful geochemical probes of the ancient lower continental crust. But some komatiites (especially the most magnesian) may be little contaminated. Perhaps they erupted through conduits that split slightly older komatiite dykes and were erupted on top of komatiite flows. Other komatiitic basalts may be the highly contaminated end-products of the eruption of originally highly magnesian liquids. And as for the nickel deposits, perhaps erosional effects under komatiites are a sign of a nearby sulphide pool. □

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