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# Migmatite, charnockite and fluid flux in the lower continental crust

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Charnockite is orthopyroxene-bearing granite distinguished by dark quartz and feldspar. This is most obvious in "incipient" charnockites, which comprise dark patches of coarse-grained orthopyroxene-bearing felsic rock within a finer-grained biotite- and or hornblende-bearing gneissic host. Such patches contain variably retrogressed orthopyroxene and reduced biotite or hornblende contents compared to the orthopyroxene-absent host, suggesting that orthopyroxene grew at the expense of biotite and/or hornblende. This is often ascribed to influx of low-$a_{H2O}$ fluid based on the distribution of dark patches around orthopyroxene and an increase in $CO_2$ fluid inclusions in dark patches compared to the host, leading to suggestions that such fluids are responsible more generally for dehydration of the lower crust.

There are several features of incipient charnockite that complicate this story. Firstly, the dark hue around orthopyroxene reflects fine-grained chlorite and other iron-rich hydrous minerals that must post-date orthopyroxene, suggesting the dark patches mark passage of late hydrothermal fluids that need not reflect any fluid present during orthopyroxene growth. Secondly, the host gneisses are migmatites that contain garnet-bearing leucosome with similar grain sizes and shapes to the charnockite patches, suggesting they might have a similar origin. Perhaps both garnet and orthopyroxene grew in leucosome as peritectic products of dehydration melting, with orthopyroxene favoured in bulk compositions of lower Al or $Fe^{2+}$ than those that stabilised garnet. In this model, $CO_2$ inclusions are residual fluid after extraction of $H_2O$-rich melt. This does not explain the spatial link between orthopyroxene growth and hydrothermal retrogression. Why is dark alteration always present around orthopyroxene but never seen away from orthopyroxene? Perhaps the hydrothermal fluid passed through all rock types but only caused visible alteration if it intersected orthopyroxene causing retrogression and release of FeO and other components into adjacent rock. If so, the dark patches that dominate incipient charnockite are linked to low-temperature hydration of pre-existing orthopyroxene rather than high-temperature dehydration that stabilised orthopyroxene. This model has no need for substantial flux of externally derived low-$a_{H2O}$ fluid through the lower crust and instead requires influx of retrograde hydrothermal fluids that could be provided by granite plutons crystallising at depth.