

## Prograded low-temperature alteration zones, Forrestania, Western Australia

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Zones of low-temperature metasomatism are widespread in igneous and sedimentary or metasedimentary terranes. Such zones are commonly associated with base metal and precious metal mineralization, and are readily identified by having relatively simple mineral assemblages, such as quartz-chlorite-sericite-ankerite associated with gold. However, if such zones are subjected to further metamorphism, the resulting assemblages may become more complex. This abstract discusses zones of alteration in the Forrestania greenstone belt in Western Australia, that have been further metamorphosed to amphibolite facies, with the development of complex amphibole assemblages, staurolite-bearing assemblages and calc-silicate assemblages.

The areas studied are part of a zone formerly explored by Amax, in two prospects named Hang Dog and North Endeavour. This area consists of two thick layers of amphibolites derived from largely tholeiitic basalts and an intervening unit with komatiites, pelitic and psammitic metasediments, BIF layers and metabasalt. Shear zones seem to be roughly layer-parallel but have more varied structures than the amphibolites and metasediments, most of which have a single schistosity.

The alteration zones in the more northerly area (Hang Dog) have relatively Fe-Mn-rich compositions and garnet-rich assemblages with staurolite and biotite or with hornblende  $\pm$  gedrite  $\pm$  cummingtonite and in Ca-poor rocks, but hornblende, clinopyroxene, epidote and calcite in Ca-rich rocks. There is usually also some plagioclase. Less iron-rich lithologies in the North Endeavour area include chlorite-rich samples, some of which contain spinel, as well as garnet, hornblende, biotite, gedrite, cummingtonite, calcite and plagioclase in different proportions in different samples. Analyses are restricted to the Hang Dog shear and show highly variable compositions with constant ratios involving Al, Ti, Zr, Ga and Nb as well as unrelated but constant K/Rb ratios. Comparison with adjacent metabasalts shows that the most likely protolith is basalt with 7-8% MgO. Such basalts have  $\text{Al}_2\text{O}_3/\text{TiO}_2$  ratios of about 12, as seen in the alteration zone, and about 1.22 weight %  $\text{TiO}_2$ . Changes from the original composition have been calculated by normalizing the composition to 1.22%  $\text{TiO}_2$ . Samples with  $<1.22\%$   $\text{TiO}_2$  have been diluted, but others have  $>1.22\%$   $\text{TiO}_2$  and have lost more material than they have gained (at least after further metamorphism and loss of water and  $\text{CO}_2$ ). Most of the diluted

samples have either abundant quartz veins or are rich in Ca, Fe and Mn, suggesting introduced hydrothermal carbonate.

The abundance of chlorite in the North Endeavour alteration zone suggests that chlorite was also abundant in the Hang Dog zone, but has been removed by prograde metamorphic reactions. On an ACF diagram, the Hang Dog sample seem to define linear trends from Ca-poor to Ca-rich compositions similar to pelite-dolomite mixtures but without normal pelite end-members. Calculated Ca-free end members are seen to be composed of uniform chlorite with quartz and sericite,  $\pm$  albite or paragonite. This calculated chlorite composition is mostly less magnesian and slightly poorer in aluminium [ $Mg_{2.68}Fe_{6.54}Mn_{0.08}^{vi}Al_{2.70}^{iv}Al_{2.70}Si_{5.30}O_{20}(OH)_{16}$ ] compared to the mean analysed chlorite at North Endeavour [ $Mg_{5.67}Fe_{3.28}Mn_{0.02}^{vi}Al_{2.92}^{iv}Al_{2.79}Si_{5.21}O_{20}(OH)_{16}$ ]. Na was assigned to albite and K to muscovite, although some Na may have occurred as paragonite. The projected Al-free component is composed of carbonate, rutile or anatase and quartz. Calculated carbonate compositions are mostly ankerite with an Mg number of 40-60, with calcite as an additional mineral in three samples and excess Fe  $\pm$  Mg in another three, two of which contain sulphides (as much as 7% pyrrhotite and 1% arsenopyrite).

From this I conclude that the original alteration was of low temperature origin and formed quartz-chlorite-sericite-ankerite schists, locally with calcite or siderite, and also with albite and/or paragonite. Prograde metamorphism has formed various assemblages, the most important being biotite-plagioclase-garnet-staurolite  $\pm$  spinel, quartz-biotite-cummingtonite-gedrite-hornblende-plagioclase-ilmenite, hornblende-plagioclase-biotite-garnet-ilmenite and quartz-hornblende-clinopyroxene-epidote-garnet-titanite  $\pm$  biotite. The most Fe and Mn-rich is quartz-garnet-actinolite-calcite-pyrrhotite-arsenopyrite-magnetite.