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From Gabbro to Granulite and finally to Kyanite- and bimineralic Eclogite: A petrological, geochemical and mass balance approach to mantle eclogites

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In this study, we present the phase transitions from gabbro into granulite and finally into kyanite-bearing and bimineralic eclogite. The investigated rock sample is a heterogeneous coexisting kyanite-bearing and bimineralic eclogite from the earth's mantle collected at the Roberts Victor Diamond mine in South Africa. Plagioclase of the former granulite reacted completely out under low H_2O activity (fH_2O) to form these kyanite- bearing and bimineralic eclogites. To quantify the phase transitions of the original gabbroic precursor, which was first metamorphosed under *H-T* granulite facies conditions followed by metamorphism under Earth's mantle conditions into both types of eclogite, a petrological, geochemical and a mass balance approach has been made. *i)* The results from our petrological approach show that Ca-rich garnet, which is coexistent with Ca-rich omphacite are the metastable phases from the original granulite in the kyanite-bearing relict while Mg-rich garnet, coexistent with Na-rich omphacite are the stable phases in the bimineralic eclogite part which took place at ~5.5 Gpa and ~1200°C. *ii)* Our geochemical results show a positive Eu anomaly in garnet from the kyanite-bearing part, which indicates that the igneous precursor of the granulite was a gabbro, probably formed as oceanic crust. Most of the REE show an excellent correlation with the major elements of the rock forming minerals during the plagioclase-out reaction of the former granulite. The LREE in garnet are removed during the formation of the bimineralic eclogite due to liquefying of the anorthite component in plagioclase of the former granulite. Whereas the HREE are enriched in garnets in the bimineralic part of the eclogite compared to those in the kyanite zone, and correlate with the Mg-Ca exchange between both garnet populations. *iii)* The results from our mass balance approach indicate that garnet in bimineralic eclogite was formed by 0.925 mole garnet and 0.075 mole plagioclase of the former granulite precursor. Whereas omphacite in the bimineralic eclogite have been formed by 0.625 mole clinopyroxene and 0.375 mole plagioclase of the earlier granulite. Following bimineralic eclogite forming reaction was calculated from our mass balance approach: 0.625 Cpx + 0.45 Plag + 0.925 Grs + 0.89 MgO + 1.15 CO2 = 1 Pyp + 1 Omph + 0.04 Ky + 1.15 Cc. The excess of MgO during final eclogitization interpreted to be

added during mantle metasomatism. And finally, our results show that only those parts of the former granulite show the formation of bimineralic eclogite where water had access to the rock. The formation of the kyanite bearing eclogite out of the former granulite is just considered by liquefying of the anorthite component in plagioclase under very low H_2O fugacity.