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Do the eclogites of the Variscan Malpica-Tuy shear zone in NW Spain point to continental subduction?

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High-pressure (HP: P > 10 kbar) rocks such as eclogite typically occur in suture zones of collided continental plates in Phanerozoic times. In case of an extended area at the surface of a denuded orogen with HP and even ultrahigh pressure (UHP) metamorphic rocks, they are often interpreted as the result of continental subduction. We have tested this idea for the HP-UHP area of the Malpica-Tuy zone of the Variscan orogen, which was formed by the collision of Gondwana and Laurussia. For the test, we have initially studied an eclogite and its surrounding gneiss of this zone in detail.

The eclogite contains the assemblage garnet, omphacite, amphibole, rutile, ilmenite, clinozoisite/epidote, quartz, and phengite with Si-contents as high as 3.45 per formula unit (pfu) in inner portions and 3.27-3.35 pfu in rims. Garnet exhibits chemical zonation with Gro25Alm55Pyr15Spe5, Gro29Alm57Pyr13Spe1, and Gro23Alm56Pyr20Spe1 as inner core, mantle, and outermost rim compositions, respectively. The gneiss is a former medium-grained granite now composed of quartz, plagioclase, K-feldspar, biotite, phengite, garnet, clinozoisite/epidote, titanite, apatite and ilmenite. Phengite shows Si contents between 3.40 (core) and 3.00 (rim) pfu. Garnet is chemically zoned with Gro69.6Alm27Pyr0.4Spe3, Gro65.5Alm32.5Pyr0.5Spe1.5, Gro65.7Alm31.7Pyr0.6Spe2, and Gro56.6Alm41.6Pyr1.2Spe0.6 as core, mantle, rim and outermost rim compositions, respectively. P-T pseudosections were calculated with the PERPLE_X computer program in the system Na_2O-K_2O-CaO-FeO-O_2-MnO-MgO-Al_2O_3-SiO_2-TiO_2-H_2O for the bulk-rock compositions of the studied eclogite and gneiss. These pseudosections were contoured by isopleths of various parameters such as molar fractions of garnet components. Based on this contouring a P-T path was derived that starts at HP conditions for both lithologies. Garnet began to form at 22 kbar and 565°C in the eclogite. Subsequently, the temperatures increased to 585°C and the pressure decreased to 16 kbar. Afterwards, a temperature increase by 100°C occurred at which low-Si phengite, the outermost rim of garnet, Na-pyroxene, amphibole, epidote, quartz, and rutile were in equilibrium. The core of garnet in the gneiss formed at about 11 kbar and 540°C. P-T conditions related to the garnet rim could not be well constrained but range between 14-15 kbar and 610-680°C. These conditions are virtually identical with those of the final stage of the eclogite.

The preliminary P-T data suggest that the Malpica-Tuy eclogite underwent HP metamorphism in a subduction zone, but the metagranite did not. Consequently, the idea of continental subduction could be disproved for the study area. The assumed tectonic process after subduction of the eclogite can be subdivided into three stages: (1) the eclogite was exhumed in the environment of a subduction channel; (2) the granite as part of the crustal margin of one of the colliding plates was buried below the other continental crust and came, thus, in contact with the uppermost portion of the subduction channel containing the studied eclogite; (3) both lithologies were then exhumed together in an exhumation channel as defined by Massonne (2012).