Crystallization of anhydrite in tonalite seems to be probable explanation for later crystallization of cummingtonite instead of hornblende. Although anhydrite was not found in the Gęsiniec tonalite it could have been easily removed by post-magmatic or weathering processes (Carroll – Rutherford 1987). Moreover sudden decrease in anorthite content in third type of plagioclase grains indicates Ca depletion of the melt possibly due to anhydrite crystallization. The source of sulfur necessary for crystallization of anhydrite was supposedly mafic magma or late mafic melts intruding only into the dark tonalite.

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Development and exhumation of an inverted metamorphic sequence: Example of the Champtoceaux Complex (Massif Armoricain, France)

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A common feature of orogenic belts caused by continental collision is the presence of crustal-scale thrusts that superpose high-grade metamorphic units over lower-grade ones. The result is an inverted metamorphic zoning. Structural elements associated to these thrusts are often overprinted by later tectonic events (late-orogenic extension, etc.), and the inverted metamorphism is often the only trace of continental collision in old orogens. Despite numerous studies, the development of inverted metamorphic zoning, its preservation and exhumation remain still poorly understood, although it is a key-point in understanding of orogenic processes.

Such a zoning is preserved in the Champtoceaux Complex (Massif Armoricain, France). From the bottom to the top of the metamorphic rock pile, the following sequence is observed: chlorite + biotite-bearing metagreywackes (para-autochthonous), micaschists with chloritoid + chlorite + garnet, staurolite + biotite + garnet (with chloritoid inclusions), kyanite + staurolite + biotite + garnet, and finally migmatites. Numerous layers of leptynitic gneiss are interlayered with the metasediments and prevent the continuous paragenetic evolution to be studied. Therefore, we concentrated our efforts on constraining the PT evolution of several pelitic samples suitable for a detailed petrological analysis. Average PT calculations performed with the software thermocalc yielded 520–570 °C and 10–14 kbar for the Cld-Chl-Grt-bearing micaschists, and 590–630 °C, 9–10 kbar for the St-Bt-Grt±Ky-bearing o1nes, whereas the overlying migmatites recorded temperatures in excess of 700 °C. The field metamorphic gradient is therefore inverted in temperatures, but not in pressures. We compare the PT paths inferred from these units, based among others on the thermodynamic analysis and modeling of the chemical zoning of garnets in the model systems NCKFMASH and MnNCKFMASH.

The presence of a major thrust at the top of the para-autochthonous is suggested by the presence of eclogite lenses in all units with the exception of this basal one. Lenses of serpentinised peridotites mark the boundary between the micaschists and the overlying migmatites, suggesting the presence of another major thrust. It's under this latter contact that the inverted metamorphic zoning develops. On the basis of these observations and the petrological data we discuss the various models of development of inverted metamorphic zoning. The proposed model suggests a dynamic view where the temperature inversion is due to the overriding nappe and the crustal units record thermal reequilibration during the propagation of the Variscan thrusts.