Modeling of the progressive evolution of subducting slab composition by sparse modeling

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The progressive evolution of subducting rocks under intermediate high-*P/T* type metamorphism is modelled by using thermodynamic calculation combined with mass-transfer calculation. On the basis of non-negative matrix factorization analysis, Yoshida et al. (2018 J. Metamorph. Geol.) pointed out the evolutional change of the composition of metapelites collected from the Sanbagawa metamorphic belt. The evolutional change can be approximated as the increase of stoichiometric garnet, which may have resulted from the fixation of garnet and the effusion of other components by high-temperature aqueous fluids. To model this progressive compositional evolution more quantitatively, we performed mass-transfer calculation to determine a specific reference frame of the evolutionally-changing whole-rock compositions. Generally, mass-transfer calculation defines one or multiple immobile elements on the basis of petrographic observation, common knowledge of mobility of elements, deviation of the concentration among the dataset used, and so on (e.g., Baumgartner and Olsen, 1995; Ague 2011). The Data-driven Isocon analysis, newly proposed method applying a sparse modeling approach, is designed to determine reference frame of mass-transfer being mostly free from the arbitrariness to choose immobile element(s), and also applicable for the case where no elements can be assumed as a completely immobile element (Kuwatani et al., 2019 in this meeting M-GI33). This new method defines a reference frame of a series of dataset on the basis of the data structure, finding a least-mobile (not necessary to be "immobile") element. To figure out the mass gain/loss behavior of the subducting metapelites, applying the Data-driven Isocon analysis is suitable because (1) the dataset show weak but mostly monotonous compositional trend (Yoshida et al., 2018); (2) it is difficult to assume a specific immobile element on the basis of the petrographic observation provided previously. We performed the Data-driven Isocon analysis to the major component dataset of the metapelites collected from the Sanbagawa metamorphic belt of the central Shikoku (Goto et al., 1996). The Isocon analysis indicated a total of 6% of mass loss during the progressive metamorphism, which is characterized by the decrease of Na and Si and the increase of divalent cations assuming Al as the least-mobile element. This result indicated that the evolutional change of the Sanbagawa metapelites is characterized not only by mass loss possibly because of the high-temperature fluid, but also some addition of mafic components. Among the high metamorphic grade zone (> garnet zone) of the relevant area, common existence of the ultramafic blocks are observed, suggesting the previous contact with the wedge mantle (Aoya et al., 2013). The addition of the mafic components may have originated from the material transfer from the ultramafic bodies. On the basis of actual mass loss obtained from the Isocon analysis and the thermodynamic modelling, the water production rate can be calculated (e.g., Dragovic et al., 2018). From the chlorite zone (approximately 350 degC, 0.5 GPa) to the oligoclase-biotite zone (approximately 610 degC, 1.0 GPa), water production rate of 64 kg/m3/Myr, being consistent with the previously indicated values (6-90 kg/m3/Myr: Peacock, 1989; 5-20 kg/m3/Myr: Lyubetskaya and Ague, 2009), was obtained.

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