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Phase equilibrium modeling, fluid inclusions and origin of charnockites in the Datian region of the northeastern Cathaysia Block, South China

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ABSTRACT

Charnockites in the Datian region of the northeastern Cathaysia Block, South China have an assemblage of garnet, clinopyroxene, orthopyroxene, plagioclase, anti-perthite, K-feldspar, biotite, quartz and ilmenite. Phase equilibrium modeling indicates that the Datian charnockite was formed at T = 845–855 °C and P = 8.2–8.4 kbar with corresponding water activity lower than 0.50. Fluid inclusions in the Datian charnockite are dominated by N_2 and CO_2 with minor CH_4. The fluids homogenized to liquid at −153.0 to −138.8 °C and 18.3–21.6 °C, respectively, showing a low-density nature. The low-density fluids could be attributed to selective leakage of water due to the affinity of water to melt and decompression-dominated retrograde process. Combined with previous studies, a two-stage formation model is proposed to interpret the petrogenesis of the Datian charnockite, viz emplaced at the Paleoproterozoic and underwent the granulite-facies metamorphism during the Phanerozoic tectonic event.

1. Introduction

Charnockite, namely orthopyroxene (or more rarely fayalite)-bearing quartzofeldspathic rock, is a minor but significant constituent of the lower continental crust (Le Maitre, 2002; Frost and Frost, 2008; Rajesh and Santosh, 2012). Several mechanisms have been proposed to interpret their origin, including: (1) cumulate from the igneous fractionation of tholeiitic basalt (Howie, 1955; Field et al., 1980); (2) a dry magma emplaced in the granulite-facies country rocks (Martignole, 1979); (3) "arrested growth" or "incipient charnockitization", specifically for the patchy charnockite, being formed by local partial melting linked to the dehydration process (Dobmeier and Raith, 2000); and (4) granulite-facies metamorphism of sedimentary or igneous rocks under low water activity conditions with or without melt loss (Martignole, 1979; Smith et al., 1979; Newton et al., 1980). The presence of a metamorphic overprint on igneous charnockite sometimes makes it impossible to distinguish from those of metamorphic origin (Rajesh et al., 2011; Touret and Huizenga, 2012a). It therefore needs a detailed study both in macroscopic and microscopic scales to decode the plausible processes (Bohlender et al., 1992; van den Kerkhof and Grantham, 1999). Meanwhile, since the charnockite normally consists of low-variance mineral assemblages, its formation and preservation are controlled by restrict intensive parameters, such as temperature, pressure and chemical potential (Frost and Frost, 2008; Touret and Huizenga, 2012a,b; Endo et al., 2012, 2013; Aranovich et al., 2014; Harlov et al., 2014 and references therein). Hence, investigating the petrogenesis of charnockites offers us a better understanding of the geological processes in the lower crust.

The South China Block formed by amalgamation of the Yangtze and Cathaysia blocks comprises several Precambrian terranes that experienced several episodes of Phanerozoic reworking (Wang et al., 2013a). The Badu Complex (Yu et al., 2009; Xia et al., 2012; Liu et al., 2014) in the Suichang-Dazhe area of southwestern Zhejiang, represents the basement of the Cathaysia Block (Fig. 1). Metamorphosed orthopyroxene-bearing granitoids in the Suichang-Dazhe area were documented as "granitic granulite" (Liu, 2009) or "charnockite" (Zhao et al., 2014), suggesting a controversy on petrogenesis. This paper presents an integrated study of phase equilibrium and fluid inclusions to constrain the formation conditions of the charnockite from a newly discovered outcrop in the Badu Complex (Fig. 1c), and then discuss its petrogenesis and possible link with the Phanerozoic reworking.

2. Geological setting and sampling

South China experienced several episodes of metamorphism during its long-standing history (Wang et al., 2013a). The basement of South China such as the Kongling Complex of the

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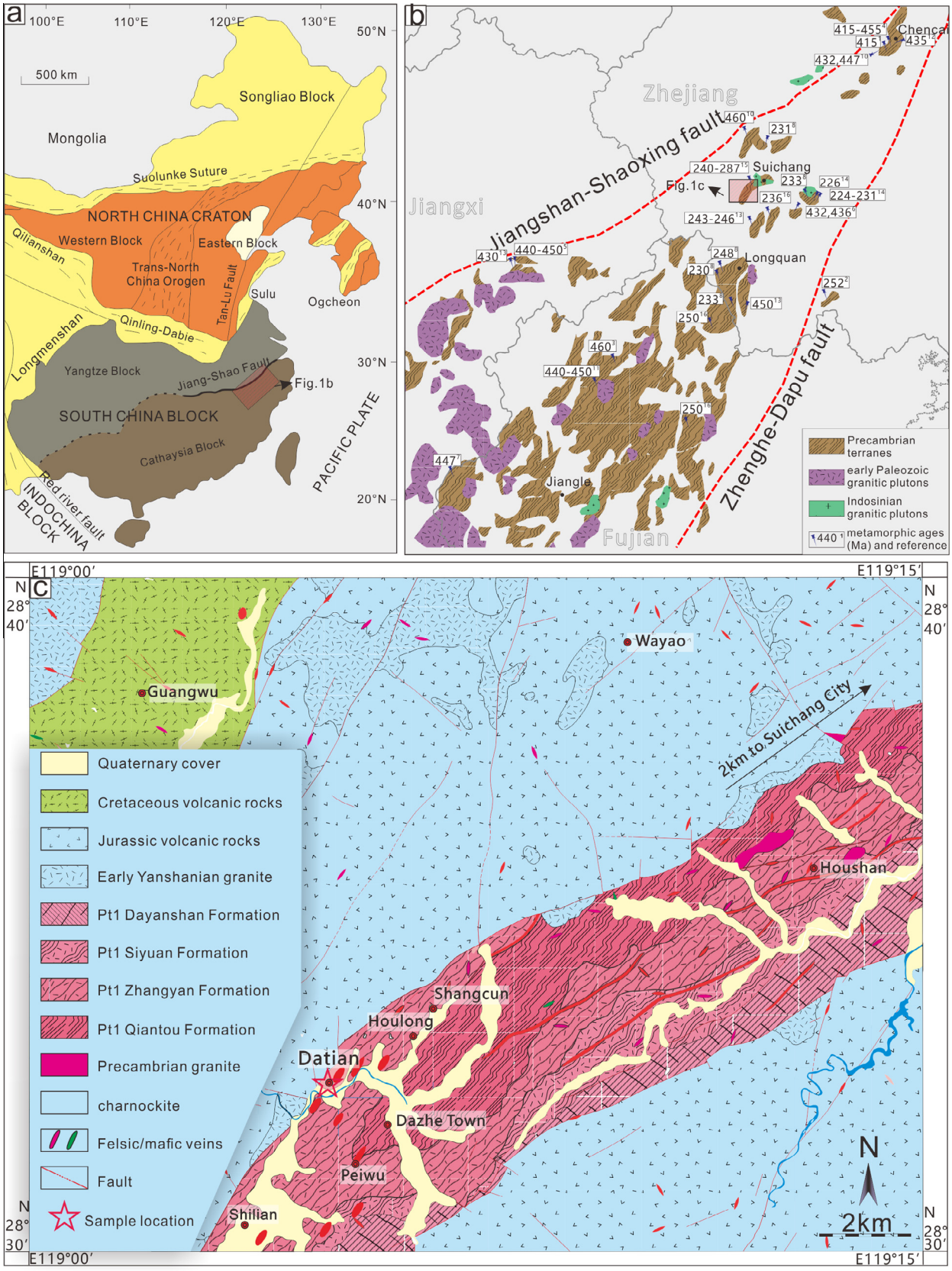

Fig. 1. (a) Simplified tectonic map of South China and its adjacent area; (b) sketch map showing the metamorphic ages of the Suichang-Dazhe and its adjacent area. Compiled from Xia et al. (2012), Mao et al. (2013), and Zhao et al. (2015). Data sources: 1: Ye et al. (1994); 2: Chen et al. (1998); 3: Wan et al. (2007); 4: Xiang et al. (2008); 5: Yu et al. (2007); 6: Chen et al. (2008); 7: Zeng et al. (2008); 8: Yu et al. (2009); 9: Wang et al. (2013a); 10: Li et al. (2010); 11: Liu et al. (2010); 12: Hu et al. (2011); 13: Wang et al. (2012); 14: Xia et al. (2012); 15: Zhao et al. (2014); and 16: Zhao et al. (2015); and (c) simplified geological map of the Suichang-Dazhe area (modified after ZJBGMR, 1989).