



The lower crust of the Dharwar Craton, Southern India: Patchwork of Archean granulitic domains

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ABSTRACT

U–Pb geochronological, major and trace element and isotope geochemical data identify crustal domains of contrasted petrological origins and histories in the lower crust of the Dharwar Craton, all affected by granulite facies metamorphism and deformation in the Neoarchean. Four lower crustal domains have been identified and investigated across the Neoarchean amphibolite to granulite facies transition zone. (1) In the southern part of the Western Dharwar Craton (WDC), high-grade metamorphism affects rocks formed before 3.0 Ga. High-grade metamorphism is recorded at ca 2.51 Ga, followed by possible complex cooling and/resetting until 2.2 Ga. (2) The BR Hills–MM Hills domain represents the lower crust of the Central Dharwar Province (CDP) which is here defined as a transitional crust between the old (>3 Ga) WDC and the Eastern Dharwar Province (EDP), not older than 2.7 Ga. This granulitic domain contains the oldest rocks of the Dharwar Craton with TTG suites formed at ca 3.4 Ga and ca 2.6 Ga suites of probable crustal recycling origin. Both suites are involved in 2513 ± 5 Ma granulite facies metamorphism. (3) The Nilgiri granulitic domain is tectonically juxtaposed with the deepest level of the WDC as a consequence of Neoarchean dextral slip along the Moyar shear zone. The massif consists of rocks of orogenic affinities formed between 2.70 and 2.56 Ga and overprinted by granulite facies metamorphism at 2518 ± 10 Ma. (4) The Krishnagiri domain exposes the deepest levels of the Eastern Dharwar Craton. It is composed of TTG and calc-alkaline igneous protoliths formed between 2.55 and 2.53 Ga. Migmatization in the upper part of the domain took place at 2507 ± 6 Ma and granulite facies overprint in the deepest parts of the domain is constrained at 2516 ± 5 Ma. The Krishnagiri domain was magmatically accreted to the lower crust of both the CDP and EDP by interaction with mafic magmatism, inducing reworking of the 2.7–2.6 Ga or older overlying crust. The Nilgiri granulites share several temporal and petrological properties with the Madras granulites that make the easternmost outcrop of the Dharwar Craton. We tentatively suggest that the Nilgiri and Madras granulites evolved as parts of a common Madras domain in the lower crust of the EDP before activation of the Moyar shear zone. In this sense, the Nilgiri massif may be considered as an allochthonous unit in a context of Neoarchean ultra hot orogeny in South India.

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1. Introduction

The interplay of high-grade metamorphism, magmatism and deformation in the lower crust is one of the keys to understanding

how continents have grown, how they have been amalgamated and also dislocated through time. It is thus critical to map and characterize the nature and origin of the rocks involved in granulite facies terrains in order to constrain the spatial and temporal framework of the magmatic and metamorphic events they have undergone. Granulites exposed in the wide crustal transition of the Dharwar Craton in Southern India constitute a world-class reference for the study of the Archean lower crust (e.g. Pichamuthu, 1960; Janardhan et al., 1979a, 1982; Newton, 1990). However, only a rough age and petrological/geochemical zonation pattern is established so far for the Dharwar granulites, which points to large – but poorly

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constrained spatially – heterogeneities in the lower crust of the craton (e.g. [Condie et al., 1982](#); [Buhl et al., 1983](#); [Peucat et al., 1989a,b](#)).

In this study, we present a set of new geochronological and geochemical data from samples collected over a wide area of the granulitic crust forming the southern margin of the craton. The results are interpreted in the light of recent advances made at characterizing the structure and kinematics of this part of the craton ([Chardon et al., 2008](#)). We present major and trace element results that are used to determine the nature and origin of magmatic protoliths from four areas at the southern margin of the craton, taking into account possible effects of high-grade metamorphism on the original chemistry of the rocks, some elements being strongly depleted. We also present geochronological data combining in situ U–Pb analyses of zircons (SHRIMP, IMS 1270, LA-ICPMS), TIMS analyses of monazites and Sm–Nd analyses on whole rocks and garnets. These results are used to define the main lower crustal domains and replace them within the structural framework of Neoproterozoic orogeny that affected the craton between 2.56 and 2.51 Ga.

2. Geological setting

The Archean Dharwar Craton is divided in two sub-cratons, the Western Dharwar Craton (WDC) and the Eastern Dharwar Craton (EDC) ([Swami Nath et al., 1976](#)). The contact between the WDC and EDC has been defined as the shear zone marking the eastern boundary of the Chitradurga greenstone belt ([Chardon et al., 2008](#); 1 in [Fig. 1](#)). This boundary is not clear-cut in the southernmost and northernmost parts of the craton. The WDC is composed of migmatitic tonalitic gneisses (called Peninsular gneisses) older than 3.0 Ga ([Beckinsale et al., 1980](#); [Taylor et al., 1984](#); [Dhondial et al., 1987](#); [Peucat et al., 1989a,b, 1993](#); [Rogers and Callahan, 1989](#); [Friend and Nutman, 1991](#); [Meen et al., 1992](#); [Mahabaleswar et al., 1995](#); [Nutman et al., 1996](#); [Chardon et al., 2011](#); [Sarma et al., 2012](#)). Potassium-granites emplaced at 2.61 Ga mark the youngest magmatic activity in the WDC, which is characterized by the melting of a depleted lower crust ([Taylor et al., 1984](#); [Rogers, 1988](#); [Jayananda et al., 2006](#)). Two groups of greenstone belts are distinguished in the WDC ([Ramakrishnan et al., 1976](#); [Swami Nath et al., 1976](#); [Swami Nath and Ramakrishnan, 1981](#)). Greenstone belts of the older Sargur Group, dated at ca 3.3 Ga ([Peucat et al., 1995](#); [Jayananda et al., 2008](#)) are involved with the tonalitic gneisses in dome-and-basin diapiric structural patterns ([Bouhallier et al., 1993, 1995](#); [Chardon et al., 1996](#)). Diapiric patterns are unconformably overlaid by the Dharwar Supergroup greenstone belts dated ca 2.8–2.6 Ga ([Nutman et al., 1996](#); [Trendall et al., 1997a, 1997b](#); [Jayananda et al., 2013](#)) that were involved in early stages of sagduction during latest Neoproterozoic regional deformation ([Chardon et al., 1996, 1998](#)). Greenstone belts of the EDC are gold bearing and partly coeval with the Dharwar Supergroup ([Walker et al., 1990](#); [Nutman et al., 1996](#); [Balakrishnan et al., 1999](#); [Vasudev et al., 2000](#); [Manikyamba and Kerrich, 2012](#); [Jayananda et al., 2013](#)).

On the basis of new geochronological data ([Dey, 2013](#); [Peucat et al., in preparation](#)), the EDC is here divided in two sub-provinces, the Eastern Dharwar Province (EDP) and the Central Dharwar Province (CDP). The EDP comprises the crust east of the Kolar greenstone belt and of the Anantapur shear zone (labeled 2 in [Fig. 1](#)). The EDP is characterized by regional tonalitic magmatism at ca 2.7–2.6 Ga ([Peucat et al., in preparation](#)), syntectonic felsic juvenile magmatism at 2.55–2.53 Ga, and partial melting and granulite facies metamorphism at ca 2.52–2.51 Ga ([Peucat et al., 1989a,b, 1993](#); [Chardon et al., 2002](#)). The Central Dharwar Province (CDP) is defined here as the area between the WDC and the EDP, which comprises a large component of old crust (>3.0 Ga) having undergone the same remobilization as the EDP at 2.56–2.51 Ga

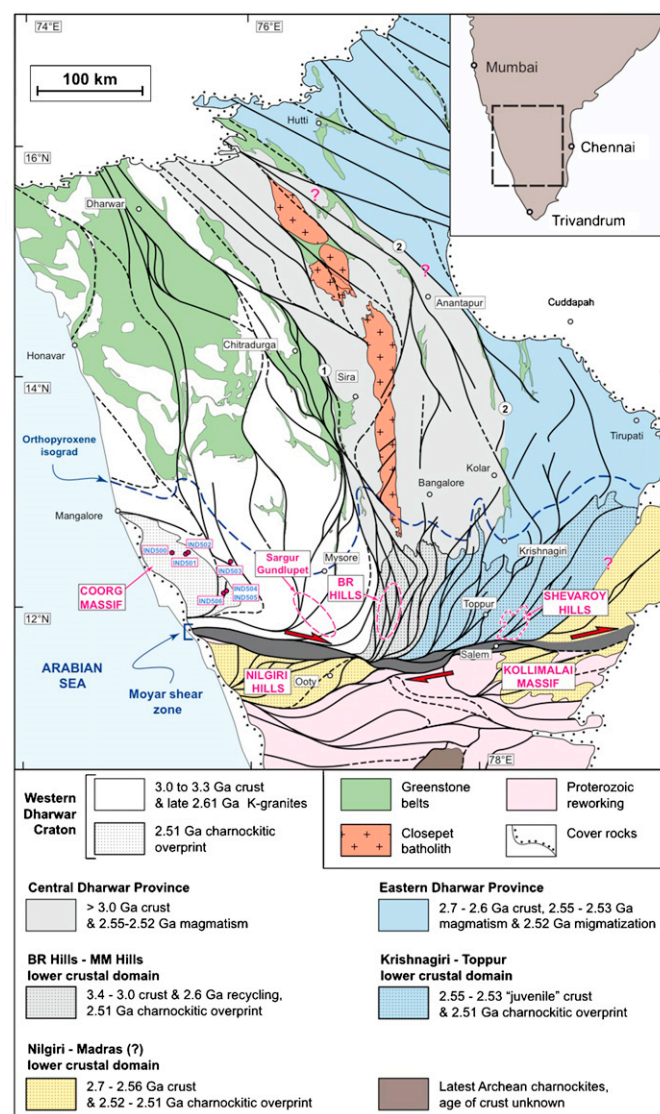


Fig. 1. Schematic geological map of the Dharwar Craton. Thick black lines are shear zones or shear zone boundaries. Sample locations from the Coorg massif are shown. 1 = Chitradurga shear zone, 2 = Anantapur–Kolar shear zone.

Adapted from [Chardon et al. \(2008\)](#).

([Jayananda et al., 2000](#); [Chardon et al., 2011](#)). The Closepet batholith is a syn-kinematic, mantle-derived intrusion emplaced in the CDP ca 2515 Ma, at the end of the Neoproterozoic orogeny ([Friend and Nutman, 1991](#); [Jayananda and Mahabaleswar, 1991](#); [Bouhallier, 1995](#); [Jayananda et al., 1995, 2000](#); [Moyen et al., 2001, 2003](#); [Chardon and Jayananda, 2008](#); [Fig. 1](#)). The Central and Eastern Dharwar Provinces have been involved in partial melting and crustal flow as part of the development of a common regional deformation and shear zone pattern that has shaped the entire craton between 2.56 and 2.51 Ga ([Chardon et al., 2008](#)). By contrast, the WDC underwent moderate or limited remobilization since formation of the latest Neoproterozoic shear zones ([Jayananda et al., 2006](#); [Chardon et al., 2008](#)).

The Dharwar Craton exposes a continuous crustal transition with an increase in Neoproterozoic P–T conditions from north to south from around 4 kb and 450 °C to 8 kb and 800 °C ([Raith et al., 1983](#); [Hansen et al., 1984a, 1995](#); [Raase et al., 1986](#)). The amphibolite–granulite transition zone is delimited in the north by the orthopyroxene isograd and in the south by the massive development of charnockites ([Fig. 1](#)). The transition zone is

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