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Detrital mineral age, radiogenic isotopic stratigraphy and tectonic significance of the Cuddapah Basin, India

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ABSTRACT

The Cuddapah Basin is one of a series of Proterozoic basins that overlie the cratons of India that, due to limited geochronological and provenance constraints, have remained subject to speculation as to their time of deposition, sediment source locations, and tectonic/geodynamic significance.

Here we present 21 new, stratigraphically constrained, U–Pb detrital zircon samples from all the main depositional units within the Cuddapah Basin. These data are supported by Hf isotopic data from 12 of these samples, that also encompass the stratigraphic range, and detrital muscovite $^{40}Ar/^{39}Ar$ data from a sample of the Srisailam Formation. Taken together, the data demonstrate that the Papaghni and lower Chitravati Groups were sourced from the Dharwar Craton, in what is interpreted to be a rift basin that evolved into a passive margin. The Nallamalai Group is here constrained to be deposited between 1659 ± 22 Ma and ~1590 Ma. It was sourced from the coeval Krishna Orogen to the east, and was deposited in its foreland basin. Nallamalai Group detrital zircon U–Pb and Hf isotope values directly overlap with similar data from the Ongole Domain metasedimentary rocks. Depositional age constraints on the Srisailam Formation are permissive with it being coeval with the Nallamalai Group and it was possibly deposited within the same basin. The Kurnool Group saw a return to Dharwar Craton derived provenance and is constrained to being Neoproterozoic. It may represent deposition in a long-wavelength basin forelandward of the Tonian Eastern Ghats Orogeny. Detrital zircons from the Gandikota Formation, which is traditionally considered a part of the Chitravati Group, constrain it to being deposited after 1181 ± 29 Ma, more than 700 Ma after the lower Chitravati Group. It is possible that the Gandikota Formation is correlative with the Kurnool Group.

The new data suggest that the Nallamalai Group correlates temporally and tectonically with the Somanpalli Group of the Pranhita–Godavari Valley Basin, which is tightly constrained to being deposited at ~1620 Ma. These syn-orogenic foreland basin deposits firmly link the SE India Proterozoic basins to their orogenic hinterland with their discovery filling a 'missing-link' in the tectonic development of the region.

1. Introduction

India has a remarkable record of Proterozoic sedimentation preserved in a sequence of well exposed and extensive basins that partially cover both major Archaean–Proterozoic cratons (the northern Bhundelkund craton and the composite southern Dharwar–Bastar–Singhbhum craton). These basins include the Vindhyan, Indravati, Bhima-Kaladgi, Khariar, Pranhita–Godavari, Chhattisgarh and Cuddapah Basins (Fig. 1 inset illustrates the southern and eastern basins) and have traditionally been lumped together as the 'Purana' basins, considered to comprise part of an extensive Proterozoic basin system (Kale and Phansalkar, 1991; Chaudhuri et al., 2002). However, until recently, there has been very little geochronological and sedimentological data available to test this hypothesis. Recent work in the Chhattisgarh and the Pranhita–Godavari Basins has demonstrated that significant age differences occur in different 'Purana' Basins. In the Chhattisgarh Basin, much of the succession was deposited between ~1.4 and 1.0 Ga (Patranabis-Deb et al., 2007; Bickford et al., 2011a,b), with a younger, presumably Neoproterozoic, succession unconformably overlying the Mesoproterozoic. In the Pranhita–Godavari Basin, ages from detrital zircons and authigenic glauconite (Conrad et al., 2011; Amarasinghe et al., 2014) from low in the basin succession (the Somanpalli Group)

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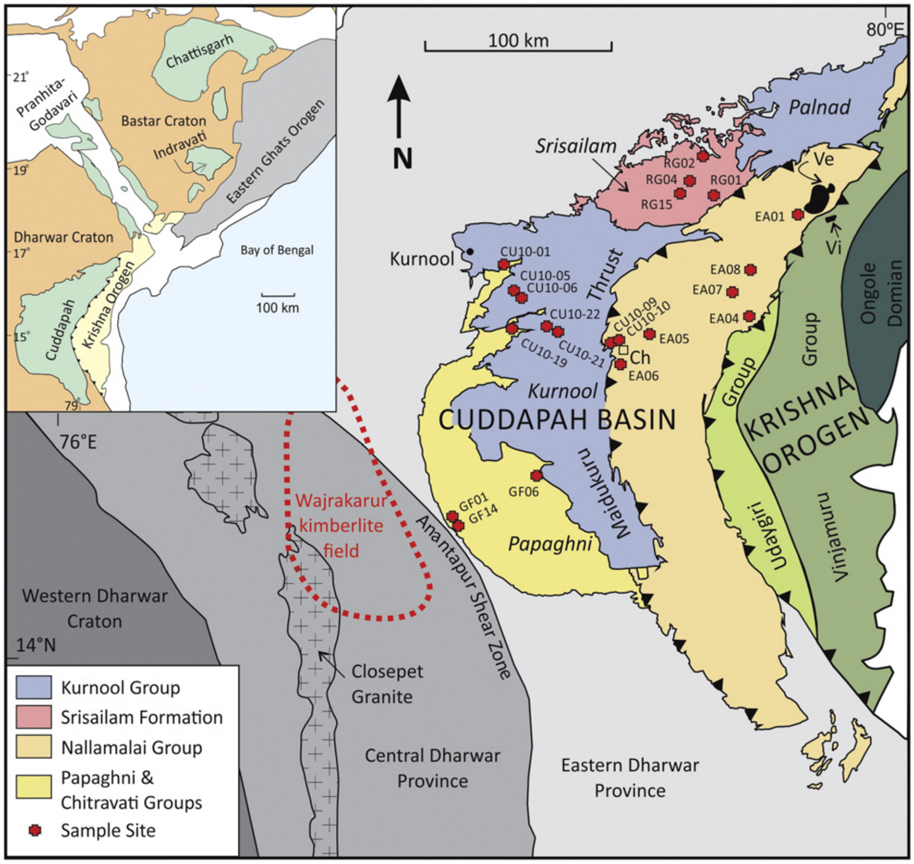

Fig. 1. Location of the Cuddapah Basin. Inset – map of the Proterozoic basins that overlie the Southern and Eastern Dharwar and Bastar Cratons – locations of the Cuddapah, Chhattisgarh, Indravati and Pranhita–Godavari Valley basins are indicated, along with the Krishna and Eastern Ghats orogens of Dobmeier and Raith (2003). Main figure — major tectonic units of the Krishna Orogen (in green) and sedimentary units of the Cuddapah Basin in blue, pink, orange and yellow (modified from Patranabis-Deb et al., 2012). Sub-basins of Nagaraja Rao et al. (1987) are indicated in italic script. Locations of the Vellaturu Granite (Ve), Vinikondu Granite (Vi) and Chelima lamproites (Ch) are indicated as are locations of the samples discussed in this paper. The major tectonostratigraphic units of the Dharwar Craton are also indicated in gray-scale (after Peucat et al., 2013).

demonstrate that early deposition occurred at ~1620 Ma. The upper part of the basin includes the Sullavai Group, which contains many Tonian detrital zircons constraining it to being deposited after this time (Amarasinghe et al., 2014).

The Cuddapah Basin is one of the largest of the Indian cratonic basins, covering 46,000 km^2 of the Eastern Dharwar Craton, and reaching depths of over 5 km towards its eastern margin (Kaila et al., 1987). Until now, very little has been known about the ages of the voluminous sedimentary rocks within the basin, the provenance of the original sediments and, particularly, the change of provenance through time. Because of this, the existing basin evolution models lack essential constraints and, therefore, the significance of this basin for the tectonic evolution of Proterozoic India is unknown.

Here we present detrital zircon U–Pb (LA-ICP-MS) data on 21 samples throughout the succession, Hf isotope data on a subset (12) of the detrital zircon samples, and detrital muscovite ^{40}Ar/^{39}Ar ages from one key sample. These data are the basis of a new tectonostratigraphic model for the Cuddapah Basin and revised correlations with the other Purana basins.

2. Geological setting

The Cuddapah Basin was first mapped in the 19th century (King, 1872; Ball, 1877), but gained significant attention only during the mid-20th century. The majority of the studies were focused on the classification of the Cuddapah succession and reconstruction of the stratigraphy (King, 1872; Sen and Narasimha Rao, 1967; Rajurkar and Ramalingaswami, 1975; Meijerink et al., 1984; Nagaraja Rao et al., 1987; Ramakrishnan and Vaidyanadhan, 2008; Saha et al., 2009; Patranabis-Deb et al., 2012) (Table 1). The outcrops of the basin-fill successions cover an area of about 46,000 km^2 on the eastern part of the Eastern Dharwar Craton (Fig. 1). Nagaraja Rao et al. (1987) suggested that the Cuddapah Basin is a composite of four subbasins, the Papaghni, Kurnool, Srisailam and Palnad sub-basins (Fig. 1).

The Papaghni sub-basin has an arcuate western boundary, which is primarily depositional, and is bordered on the south and the west by granites and gneisses of the basement complex (Peninsular Gneiss), which includes slivers of Archaean greenstone belts. The fill of the sub-basin is represented by the Papaghni Group and the Chitravati Group (Fig. 2), which are separated by an unconformity (Lakshminarayana et al., 2001; Chaudhuri et al., 2002; Saha and Tripathy, 2012). The age of sedimentation for the Papaghni Group is constrained by 1891–1883 Ma volcanic rocks and dolerite dykes that are interbedded with, and cut through, the group (Bhaskar Rao et al., 1995; Anand et al., 2003; French et al., 2008). The intensely deformed Nallamalai Group has long been considered to be a part of the Cuddapah Supergroup (King, 1872; Narayanswami, 1966; Meijerink et al., 1984; Lakshminarayana et al., 2001). However, recent studies demonstrate that a major thrust – the Maidukuru Thrust (the Rudravaram line of Saha et al., 2010) – at the base of the Nallamalai Group has juxtaposed it against the Kurnool and Papaghni–Chitravati Groups (Saha and Chakraborty, 2003; Saha et al., 2010). The complexity of the lithostratigraphy of the Cuddapah Basin is reflected in widely divergent stratigraphic classifications that have been proposed so far and are summarized in Patranabis-Deb et al. (2012). We use the stratigraphy proposed by Saha and Tripathy (2012), which is presented in Fig. 2.