CHAPTER 8

CHAPTER 8

Discussion and conclusion

Detailed structural, petrographic, geochronological and geochemical analyses of the study area reveal a complex history of the Rengali Province. Structural mapping and microstructure analysis reveals that Rengali Province is composed of several structural domains of contrasting deformational pattern, as well as metamorphic grade and is separated by several regional-scale shear/ thrust zones. The salient features regarding the geological evolution of the Rengali Province, studied from the central part of the province is discussed below.

8.1 Pressure-Temperature-time history of the Rengali Province

The centrally located Central Gneissic Belt is composed of high-grade gneisses, along with enclaves of granulite and amphibolite facies rocks. The belt is bounded by two supracrustal belts both at north and south, which are composed of low-grade sediments and volcaniclastics. The major basement rocks are the migmatitic hornblende gneiss and the felsic gneiss with occasional presence of charnockite and mafic granulite as enclaves within the basement. Few enclaves of amphibolite are also present within the felsic gneiss. Dolerite dyke relict igneous textures, suggesting low-grade metamorphism.

Textural and thermobarometric data suggest that the mafic granulite was metamorphosed at ~ 850°C and peak pressure ~10 kbar, whereas the migmatitic hornblende gneiss and amphibolite were metamorphosed to lower pressure-temperature conditions (~760ºC, 8 kbar). Geothermobarometric data and phase diagram modelling suggest a peak metamorphic stage of mafic granulite was followed by retrogression as evident replacement of orthopyroxene by hornblende. The pre-metamorphic history of the mafic granulite is obscured and there is no direct evidence of magmatic emplacement of such rocks within the basement. Metamorphic conditions for the felsic gneiss could not be determined due to lack of suitable coexisting mineral phases needed for thermobarometric calculation.

Petrological data show that rocks of the Rengali Province represent different levels of a crustal section juxtaposed together during a major orogenic event as the deeper crustal components are represented by pelitic granulite, mafic granulite and charnockite, whereas migmatitic hornblende gneiss, felsic gneiss and granitoids represent middle crustal components (Bose et al., 2015). The pelitic granulite from the eastern Rengali Province witnessed partial melting and subsequent melt extraction during peak metamorphism close to 850 °C at deep crustal conditions (Mahapatro et al., 2012; Bose et al., 2015). Mafic granulite of the eastern Rengali Province, on the contrary represents a much deeper section (34-38 km corresponding to 10-12 kbar pressure) of the crust (Bose et al., 2015). Mahapatro et al. (2012) determined the age of peak granulite metamorphism of 3058±17 Ma using texturally constrained monazite EPMA data for the eastern Rengali Province. They also estimated the age of reheating of the granulite at 2778±16 Ma. Two metamorphic ages documented by Mahapatro et al. (2012) most likely reflect the timing metamorphism in the eastern Rengali Province. The amphibolite facies metamorphism within the gneissic rocks of the central Rengali Province occurred at a P-T window which almost overlaps with that of the retrogressive stage in the granulite suite. Geochronological data in this study indicate a punctuated evolutionary history of the Rengali Province. Rocks of diverse chemical character yield complex geochronological data. Zircon ^{207}Pb/^{206}Pb data from the presently samples and samples from the eastern part of Rengali Province (Bose et al., 2016) yield multiple groups of data, all of which show an Archean history of the Rengali Province. A similar argument has also been put forward by previous workers based on geochronological records in Rb-Sr, Sm-Nd, ^{207}Pb-^{206}Pb and U-Th-Pb systematics (Misra et al., 2000; Sarkar et al., 2000; Bhattacharya et al., 2001; Mahapatro et al., 2012). Detrital zircon from both the pelitic granulite of eastern Rengali Province yields an array of Mesoarchean dates (ca. 3466-3222 Ma), which can be used to locate the provenance of pelitic sediments. Zircon data from the charnockite of the Eastern Rengali Province yield a pooled age of ca. 3058 Ma which is interpreted as the emplacement age of the charnockite magma, while younger dates represent partial recrystallization and metamorphism (Bose et al., 2016). The charnockite of the Central Gneissic Belt was emplaced at 2861± 30 Ma, whereas recrystallization of zircon occurred during metamorphism at 2818±15 Ma. The studied mafic granulite has a 2844±7 Ma protolith which represents either magmatic or metamorphic age. Protolith of the migmatitic hornblende gneiss was crystallized at 2828±9 Ma possibly as a TTG suite. The high-grade metamorphism and granitoid emplacement during ca. 2844-2828 Ma was followed by the emplacement of post-kinematic granitoids at 2807±13 Ma, 2809±13 Ma and 2776±24 Ma. Zircon grains from most of the samples show a metamorphic overprinting at ca. 2500 Ma.

The overall geochronological record indicates that the sediments of the Central Gneissic Belt of the Rengali Province were derived from protoliths older than ca. 3060 Ma which was followed by metamorphism and granitoid magmatism within a span of ca. 2840-2780 Ma. Charnockites show complex geochronological signatures in the eastern and central Rengali Province. Metamorphic ages also vary within their uncertainty limits. It is difficult to conceive of them as a part of same magmatic suite owing to the vast difference in their emplacement ages (ca. 3058 and ca. 2861 Ma). These two spatially separated charnockite bodies seem to represent different suites. The ca. 3058 Ma charnockite emplacement within the lower crust could also indicate an early tectonometamorphic event which was responsible for deep crustal metamorphism of mafic granulite in the eastern Rengali Province (10-12 kbar, 860 °C, Bose et al., 2015). Interestingly, Mahapatro et al. (2012) estimated monazite U-Th-Pb age of 3057±17 Ma from pelitic granulite of eastern Rengali Province, and they also suggested that this age could represent an early metamorphic event. Spot dates between 2800 and 2500 Ma possibly are mixed ones derived from two distinct age domains of zircon that are often indistinguishable. The apparent smear of data close to the concordia curve over a period of more than 300 million years is problematic. It can result from high-temperature strain-induced Pb-loss (Halpin et al., 2012) or fluid-induced resetting (Geisler et al., 2007).

Charnockites of the Rengali Province received attention from many workers (Kar et al., 2003; Bhattacharya et al., 2001) who studied the rock from the eastern part of the Rengali Province and characterized the possible origin of the rock based on metamorphic and geochemical features. Accordingly, the charnockite magma was formed due to hornblende dehydration melting at the deep crust and the variation of mineralogical and geochemical characters within the rock suite (charnockite-enderbite-mafic granulite) resulted from peritectic phase transformation (Bhattacharya et al., 2001). Relics of hornblende-bearing mafic granulite showing geochemical complementariness with the charnockite support this model. The high metamorphic pressure (~12 kbar) calculated from the mafic granulite implies onset of partial melting during decompression along a clockwise P-T trajectory at ca. 3100 Ma (Bhattacharya et al., 2001). Grantham et al. (2012) outlined two genetic models to explain the origin of magmatic charnockites: (1) crystallization from primary high-temperature magma with low a_{H2O}, and (2) melting of granulites at high pressures in the presence of a CO_2-rich fluid. The overall charnockite genesis model thus matches with that of partial melting of amphibolite facies rocks (Grantham et al., 2012 and references therein) on the eastern part, but the charnockite and mafic granulite enclaves of the Central Gneissic Belt do not show direct evidences of partial melting of amphibolite facies rocks. Textural evidences, as well as geochemical data of the charnockite and the granitoids from Central Gneissic Belt, suggests that a process of fractionation during magmatic crystallization, which resulted in the emplacement of these rock suites. It can be proposed that intraplating or underplating of basaltic magma could act as a heat source, which may lead had to partial melting, assimilation of lower crustal granulite and finally fractionation of the silicic melt. The evolved counterpart of the suite, i.e. the charnockite-granite association could be explained by the duality of fluid regime (Frost et al., 2000; Elliott, 2003; Frost and Frost, 2008; Harlov et al., 2013). Accordingly, charnockite crystallized from magma enriched in CO_2-rich fluid while the hornblende and biotite-bearing granites could be product of more hydrous fluid (H_2O)-dominated residual melt during the course of evolution in the same source magma. The deep-seated magma would dissolve more CO_2 which will be released at shallower level by exsolution during ascent. U-Pb zircon data from migmatitic hornblende gneiss and felsic gneiss records an age of ca. 2828 Ma and ca. 2776 ma respectively and these geochronological data can be correlated to the change in fluid regime theory, where CO_2 -rich melt produces charnockite and with time as the melt ascent, its character changes towards H_2O and produces felsic gneisses. REE data from charnockite and the granitoids show similar fractionation pattern and hence supports the theory that melt source is same and only change of fluid regime resulted in contrasting rock types.

Field and petrographic studies of the supracrustals suggest that these rocks suffered low-grade metamorphism. Das et al. (2017) analyzed zircon data from these supracrustals and correlate the detrital age data with available geochronological data from Singhbhum Craton. These workers argued that the sediments were derived from the Singhbhum Craton and successive sedimentary basins developed surrounding the craton during the Neoarchean-Paleoproterozoic era. Detailed discussion about the origin and evolution of these sedimentary and volcaniclastics is beyond the scope of this study.

8.2 Structural history of the Rengali Province

The central part of the Rengali Province in the Riamal-Rengali-Khamar sector is composed of several longitudinal belts of distinct lithologies, deformational histories and contrasting grades of metamorphism and these belts were separated by regional-scale faults or shear zones. The general trend of these belts and parallel regional scale faults is WNW-ESE.

The Southern Supracrustal Belt shares its margin with Eastern Ghats Belt and Gondwana sediments and is marked by the Kerajang Fault Zone which is a regional-scale dextral shear zone. From the structural analysis (S-C fabric, development of boudins, mica fish structures) dominant strike-slip kinematics is inferred from this zone. Other field evidences (presence of fault breccia, cataclasite and intense fracturing) reveals a later brittle phase of deformation within this zone (Yamamoto et al., 2017). Development of similar fault zone-parallel breccia ridges within the Gondwana rocks can be identified and constraints the timing of brittle reactivation of the Kerajang Fault Zone to be post-Jurassic period (Ghosh et al., 2016). In the northern part of this supracrustal belt, field observation and deformational study shows dominant foliation trend towards WNW-ESE. Presence of asymmetric folds and down-dip mineral lineation indicate a top-to-south reverse sense slip as the prevalent kinematics in Southern Supracrustal Belt. Rocks are mylonitized in nature, towards its northern boundary, signifying presence of a fault zone (South Riamol Splay). The basement inliers show evidence of an earlier superposed deformation, in contrast to the overlying supracrustal rocks. Although Southern Supracrustal Belt shows greenschist facies mineral assemblage, the latter changes to higher grade (quartz-muscovite-K-feldspar-sillimanite) at its northern margin along the South Riamol Splay fault. Therefore, a change in metamorphic grade is evident along the northern boundary of SSB and signifies an increase in temperature due to movement of crustal blocks along the SRS fault zone.

The high-grade gneisses of the Central Gneissic Belt contain WNW-ESE trending gneissic foliation that shows asymmetric southerly verging minor folds within gneissic layers at south (Subdomain 1), signifying a top-to-south kinematics. Within the mid zone (Subdomain 2) consisting of basement gneiss (migmatitic hornblende gneiss and felsic gneiss) presence of asymmetric Z-shaped mesoscopic fold, steep shear planes and lowly plunging sub-horizontal mineral lineation pointing due east or west, all suggest a dominant dextral strike-slip kinematics. Within the northernmost zone (Subdomain 3), charnockite (with enclaves of mafic granulite) contains dominantly E-W trending southerly dipping gneissic foliation. Intrusives like dolerite dyke and pegmatite veins provide evidences of later phases of deformation. The dolerite dyke was emplaced along the NNE trending sinistral shear plane shows mutual overprinting relationship with respect to the pegmatite vein emplaced parallel to the WNW trending dextral shear. Development of conjugate shear planes displacing mafic layers in gneiss and boudin development indicates E-W extension. Although top-to-north shearing is the prevalent kinematics, strong component of layer parallel extension is also evident from these conjugate shear planes.

The Northern Supracrustal Belt, consisting of low-grade assemblages (BIF, metachert, metaconglomerate, metagreywacke, mica schist, and quartzite) shows mylonitic fabric and asymmetric northerly verging macro-mesoscopic folds, suggesting a top-to-north shearing as the prevalent kinematics.

8.3 Tectonic evolution of the Rengali Province

Results of this study suggest that an orogenic setting was in place at the Neoarchean era from which the Central Gneissic Belt of the Rengali Province evolved. This was followed by a phase of successive basin development and sediment deposition until the Paleoproterozoic era (Das et al., 2017). A major deformation in the later period exhumed the lower and middle crust of the Rengali Province adjacent to the shallow supracrustal rock. Finally, reactivation of the southern boundary of the Rengali Province occurred during the Paleozoic, resulted in the development of Gondwana basin.

Deformation features within the deep crustal section (gneisses and granulites) suggest active kinematics during the Neoarchean time. Development of S-C fabric, prominent downdip mineral lineations, asymmetric northerly or southerly verging folds, change in metamorphic grade resulted from emplacement of hotter middle crust carrying basement along the thrust planes, all of these suggest a possible collisional orogeny. Geochemically, all the high-grade rocks of the Central Gneissic Belt show A-type granite affinity. Granitoids with A-type characters can originate in diverse tectonic setting (Loiselle and Wones, 1979; Collins et al., 1982; Whalen et al., 1987; Anderson and Bender, 1989; Eby, 1992; Frost and Frost, 1997; Rämö and Haapala, 2005; Dall'Agnol et al., 2005; Bonin, 2007; Nardi and Bitencourt, 2009). These are reported from anorogenic setting (Loiselle and Wones, 1979), extensional setting (reviewed in Frost and Frost, 2011) and from orogenic belts formed in collisional/island arc (Eby, 1992; Larin et al., 2006) or accretional settings (Windley and Garde, 2009). Larin et al. (2006) noted that for the collisional type settings, the time gap between the collision and emplacement of charnockite magma did not exceed 30 million years, and it was followed by emplacement of granite. In this case, it may be possible that the entire process belongs to a single orogenic (collisional) cycle with emplacement of charnockite took place as in an syn-collisional setting followed by post-collisional emplacement of granite. The same argument was adopted by Pouclet et al. (2006) while describing the crustal growth history of the Congo Craton along its northwestern margin. The scenario is similar for Amazonian Craton (Scandolara et al., 2014) and North China Craton (Zhao et al., 2008). Granitoids of the Central Gneissic Belt show resemblance with the vastly exposed Pal Lahara gneiss at the southern margin of the Singhbhum Craton (Saha, 1994). In a recent study, Bhattacharya et al. (2016) assigned a ca. 2.40-2.0 Ga emplacement age for the high-grade gneisses from the north-western part of Rengali Province and indicated its lineage with the westerly situated Bastar Craton. On the other hand, geological evidences from the

Central Gneissic Belt occurring in the central and eastern parts of Rengali Province suggest its lineage with the northerly situated Singhbhum Craton (Mahapatro et al., 2012; Bose et al., 2015, 2016). Nelson et al. (2014) presented geochemical data of porphyritic dacite tuff from the southern margin of the Singhbhum Craton that show trace and REE pattern similar to the presently studied samples. Zircon grains from the adjacent Pal Lahara gneiss show near concordant age within the span of ca. 2790-2720 Ma which is interpreted to be the time frame for magmatic crystallization (Chattopadhyay et al., 2015). Zircon from the dacite sample of Nelson et al. (2014) also shows a concordant age of 2806 ± 6 Ma. These ages are broadly similar to the emplacement of the protolith of the granite gneiss and leucogranite within Central Gneissic Belt (present study; Bose et al., 2016). Moreover, the emplacement of the hornblende granite (migmatitic hornblende gneiss with emplacement age 2828 ± 9 Ma; present study) broadly match with the emplacement of the Tamperkola Granite (emplacement age 2836 ± 67 Ma cited in Misra, 2006) situated at the southern part of the Singhbhum Craton. In addition to this, leucogranite with emplacement ages 2804 ± 3 Ma and 2811 ± 3 Ma are also reported from the eastern part of Rengali Province (Misra et al., 2000). All these evidences converge towards the development of a convergent setting at the southern margin of the Singhbhum Craton during the time frame ca. 2860-2780 Ma. This culminated in charnockite magmatism, granulite metamorphism and subsequent late or post-orogenic granite emplacement. Based on these data, a tectonic model for the evolution of the central part of the Rengali Province has been proposed (Fig. 8.1), wherein initial subduction was followed by collision at ca. 3.0 Ga. This event is marked by an early phase of charnockite emplacement and granulite grade metamorphism. Repeated collision-accretion phase resulted in underplating of basic magma (protolith of mafic granulite), mid-crustal melting and emplacement of charnockite at ca. 2.86 Ga. This was followed by a change in fluid regime and emplacement of migmatitic and felsic gneiss from fractionated melt (Fig. 8.1).

Cross-cutting relationships among different structural systems (gneissic rocks and the supracrustals) indicate no indication of clear superposition order which suggest that these systems developed at a similar time or at least were active during the same tectonic event and the kinematic set up was akin to transpression (present study; Ghosh et al., 2016) which is shown in a cartoon block diagram (Fig. 8.2). The five longitudinal structural zones have been separated based on minor variation in foliation, lineation, fold, fabric and our interpretation of zone boundary orientations. Dominance of a particular structural style and kinematic indicator from the different zones implies that the transpressional deformation in all zones was strongly partitioned over the study area. Overall, the strike-slip component is concentrated in narrow shear zones or discrete faults; the Kerajung Fault Zone, subdomain 2 in the Central Gneissic Belt, the Riamol Shear Zone and the Akul Fault Zone are the examples of such strike-slip zones with small variations in structural details. These zones are principally characterized by sub-vertical foliation, predominantly sub-horizontal lineation and asymmetric Z-folds on surface associated with a strong dextral strike-slip deformation. Foliations in the Kerajung Fault Zone make a low angle with zone boundary being synthetic with deduced slip sense in the fault zone. The sub-horizontal to shallow plunging lineation is best explained by strike-slip displacement. Characteristic sub-vertical foliation, steeply plunging fold zones and sub-horizontal lineation in the subdomain 2 match with wrench dominant deformation. Overprinting of the sub-horizontal lineation by a sub-vertical one qualitatively points to a switch over to length perpendicular shortening with progressive deformation within the zone (Sengupta and Ghosh, 2004). The Riamol Shear Zone and the Akul Fault Zone, however, display structural features characteristic of pure strike-slip domains. Contrary to single-scale transpression model prediction of similar boundary conditions at both margins, analyses of available kinematic indicators from the boundary faults in the Rengali Province indicate dominance of dextral strike-slip in the Kerajung Fault

Zone and top-to-north thrust slip features in Barkot Shear Zone. Thus, the present study shows clearly varying boundary conditions from strike-slip at the southern margin to dip slip dominated motion at the northern margin. The Southern Supracrustal Belt with adjoining subdomain 1 and the Northern Supracrustal Belt with subdomain 3 comprise oppositely verging thrust sheets symmetrically disposed with respect to the transpressional boundaries as well as the centrally placed subdomain 2 of the Central Gneissic Belt. The latter, showing dominant dextral strike-slip, appears as the root zone within the transpressional belt from where oppositely verging thrust sheets emanated carrying mid-crustal gneissic basements over upper crustal low-grade supracrustals (Fig. 8.2). The sharp change in metamorphic grade across the North Riamol Splay and the South Riamol Splay marking the supracrustal- Central Gneissic Belt contacts suggests vertical extrusion and thrust loading from transpression. The change in metamorphic grade must have resulted from emplacement of hotter middle crust carrying basement along the thrust planes over upper crust and resulting thermal gradient thereof. The overall geometric cum kinematic framework thus appears as a crustal-scale positive flower structure characterized by oppositely verging supracrustal-gneiss slices emanating from a steep central root zone and bounded between two subparallel fault systems (Woodcock and Schubert, 1994; Merle and Gapais, 1997). Monazite grains from the sheared leucogranite in Kerajung Fault Zone yield a well constrained ca. 498 Ma age indicating this to be the probable age of dextral shearing along this shear zone. Monazite from the micaceous quartzite from the southerly verging thrust zone yields a well-constrained age of ca. 521 Ma indicating it to be the timing of thrusting. Thus, the two samples from the dextral strike slip zone and thrust zone provide crucial time constraints for the transpressive event in the Rengali Province at ca. 498-521Ma. It unequivocally establishes the transpressional deformation to be Neoproterozoic and correlatable with the Pan-African orogeny.

8.4 Rengali Province as a craton-margin orogenic belt

Available geochronological data (Sarkar et al., 1998; Misra et al., 2000; Bhattacharya et al., 2001; Mahapatro et al., 2012; this study) indicate episodic growth of the Singhbhum Craton at its southern margin during ca. 2840-2780 Ma and ca. 2500-2480 Ma. Protolith ages of pelitic granulites of the eastern Rengali Province have matching precursors at the Singhbhum Craton, either as clastic sedimentary rocks (ca. 3120-3090 Ma; Misra, 2006) or as granitic intrusives (ca. 3400-3100 Ma; Saha, 1994; Misra, 2006). The oldest zircon spot date from the Rengali Province (ca. 3528 Ma, Bose et al., 2016) is close to the emplacement age of dacitic lava (ca. 3510 Ma U-Pb SHRIMP age) within the southern Iron Ore Group sediments of the Singhbhum Craton (Mukhopadhyay et al., 2008). The youngest spot date from detrital zircon (ca. 3058 Ma, Bose et al., 2016) is again close to the emplacement age of the last phase of Singhbhum granite and Mayurbhanj granite (Paul et al., 1991; Misra et al., 1999). In addition, ca. 3300-3000 Ma protolith history was reported from detrital zircon of low-grade quartzite from the southern margin of the Singhbhum Craton (Mukhopadhyay et al., 2013, 2014). Tectonometamorphic events in the Rengali Province during the ca. 2840-2780 Ma have contemporaneous granitic magmatism at the Singhbhum Craton, both at the cratonic interior (ca. 2810 Ma Tampercola granite; Bandyopadhyay et al., 2001) as well as its southern margin (ca. 2800 Ma Bhuban leucogranite; Misra et al., 2000). The Dhanjori volcanics extruded at ca. 2800 Ma (Misra and Johnson, 2005) and a dacitic tuff from the southern part of the Singhbhum Craton crystallized at 2806±6 Ma (Nelson et al., 2007). All these records suggest that a significant crustal growth of the Singhbhum Craton occurred at ca. 2840-2780 Ma. Petrological, geochemical and geochronological data from this province thus suggest its evolution through episodic orogenic pulses since the Neoarchean time (Fig. 8.3). Mahapatro et al. (2012) argued that granulite facies rocks within the eastern part of the Rengali Province represent the thrusted deep crustal section of the Singhbhum Craton, was also supported by later study (Bose et al., 2015). This is in sharp contrast to the argument of Misra and Gupta (2014) who infer consanguinity of the Rengali Province with the Bastar Craton lying farther west.

8.5 The Ur connection

It is postulated that several cratonic nuclei assembled for the first time in Earth's history to form the supercontinent Ur (Rogers, 1996; Rogers and Santosh, 2003). The major part of Ur was stabilized at ca. 3000 Ma, but its components continued to grow through repeated tectonothermal processes until ca. 2500 Ma when the configuration of 'Expanded Ur' was achieved. Major cratonic blocks of Ur exhibit similar growth history during the Neoarchean time and they remained entangled until the breakup of Pangea (Rogers and Santosh, 2004). The initial configuration of Ur involved the Kaapvaal, Dharwar, Singhbhum and Pilbara cratons, but geological evidence from cratonic blocks of Madagascar, Aravalli, Bundelkhand, Napier, Grunehogna, Vestfold, Gawler and Yilgarn support their inclusion within the supercontinent (Santosh et al., 2009). These cratonic blocks were believed to have grown through juvenile crustal addition, orogeneses and anorogenic plutonism at the continental margins. Five major cratonic blocks from India are believed to be included within Ur and orogenic activities in these blocks during the time span ca. 3000-25,000 Ma should be considered as part of the assembly of Ur. In this context, present geochronological data from the Rengali Province furnish compelling evidence for the shared Neoarchean history of Ur.

8.6 Conclusion

The central part of Rengali Province in Riamal-Rengali-Khamar sector is characterized by complex metamorphic, structural and geochronological evolution. These rock units are separated by a number of tectonic zones. The gneissic rocks exposed along the Central

Gneissic Belt represent the lower to middle-crustal section that was metamorphosed and intruded by several phases of granitoids in the time frame of ca. 2860-2780 Ma. The major part of the province forms the gneissic basement for the overlying low-grade supracrustals that was stabilized at ca. 2800 Ma, but its components continued to grow through repeated tectonothermal processes until ca. 2500 Ma. The protoliths of the orthogenesis rocks were emplaced in the deep to middle crust during the orogenic cycle of the Rengali Province. This meta-igneous rock suite constitutes a part of the vastly exposed granitoid body along the southern margin of the Singhbhum Craton and preserves the growth history of the craton through multiple orogenic cycles. Deformation features of the basement imply an older history (Neoarchean), but the last phase (ca. 500 Ma) of transpressive deformation was responsible for extrusion of the deeper section of the Rengali Province to shallow crustal level showing a positive flower structure. It is interesting to see that the strong ca. 1000-900 Ma tectonothermal events of the southerly placed EGB is almost absent in the gneissic rocks of the Rengali Province, but Pan-African (ca. 550-500 Ma) shearing eventually juxtaposed all the blocks in the present day configuration.

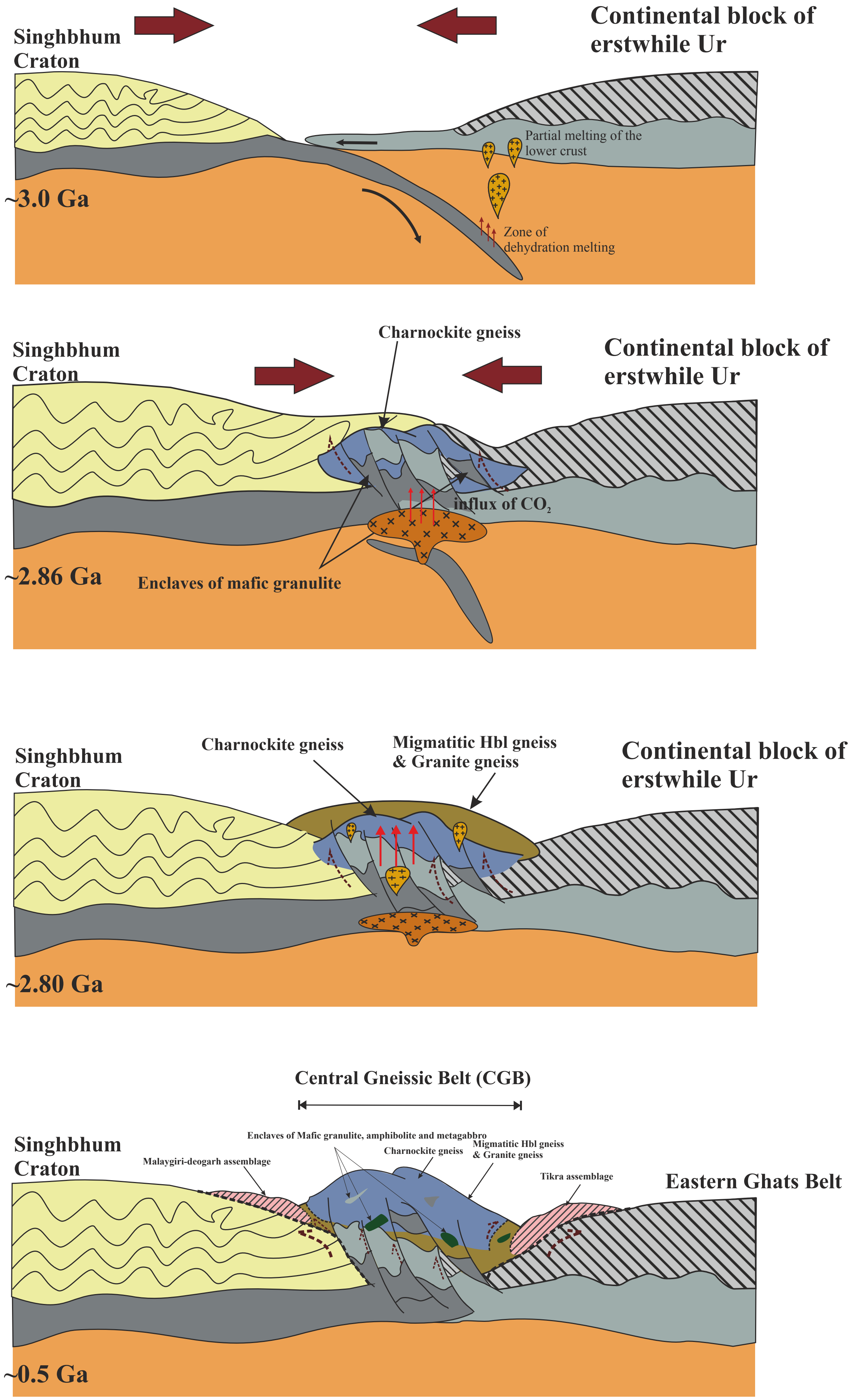

Fig. 8.1: Schematic diagram representing the tectonic evolution of the Central Gneissic Belt (CGB), Rengali Province (a) Intiation of subduction at ca 3.0 Ga followed by collision of Singhbhum Craton with another continental block of erstwhile supercontinent Ur . An early event of granulite metamorphism and charnockite emplacement occurred at this time. (b) At ca. 2.86 Ga, repeated collision/accretion took place with underplating of basic magma which acted as the heat source for mid crustal melting and magma production. Assimilation-fractionation of the melt; influx of CO2 resulted in production of charnockite of the CGB. (c) At ca. 2.80 Ga, fractionation and emplacement of post-collision granitoids of CGB. A change in the fluid regime from dominantly CO2-rich to more H2O-rich occurred when the melt moved up. (d) Reactivation of Rengali Province at ca. 0.5 Ga Pan-African event produced a positive flower structure, where the mid-crustal rocks of CGB were juxtaposed against the upper crustal rocks.

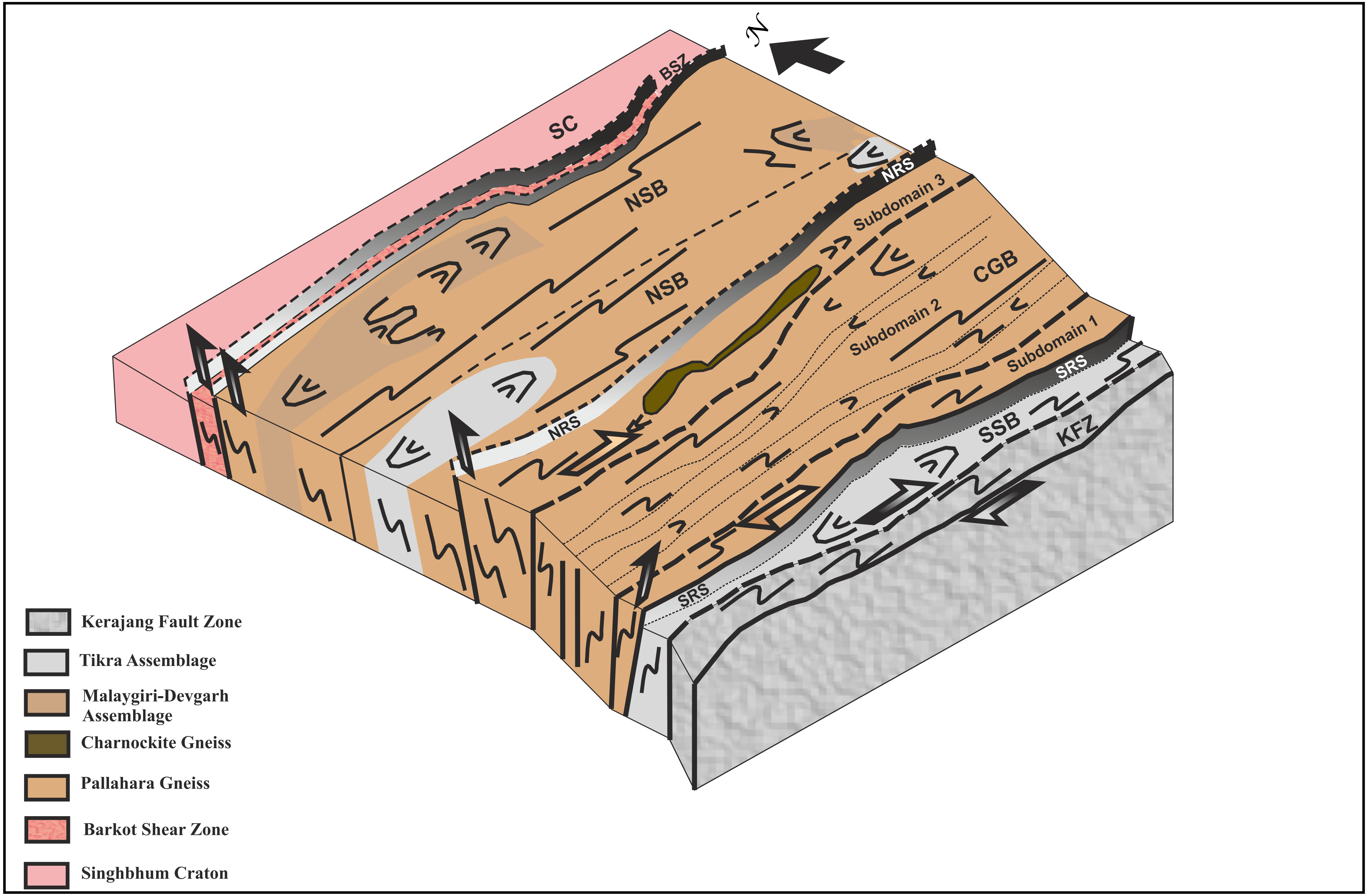

Fig. 8.2: Cartoon block diagram showing the kinematic model for the study area with general fold pattern depicted on plan and in section. The overall transpressional deformation and the positive flower structure, resulting in juxtaposition of deep crust with supracrustal, at the central part of Rengali Province is also shown in this cartoon.

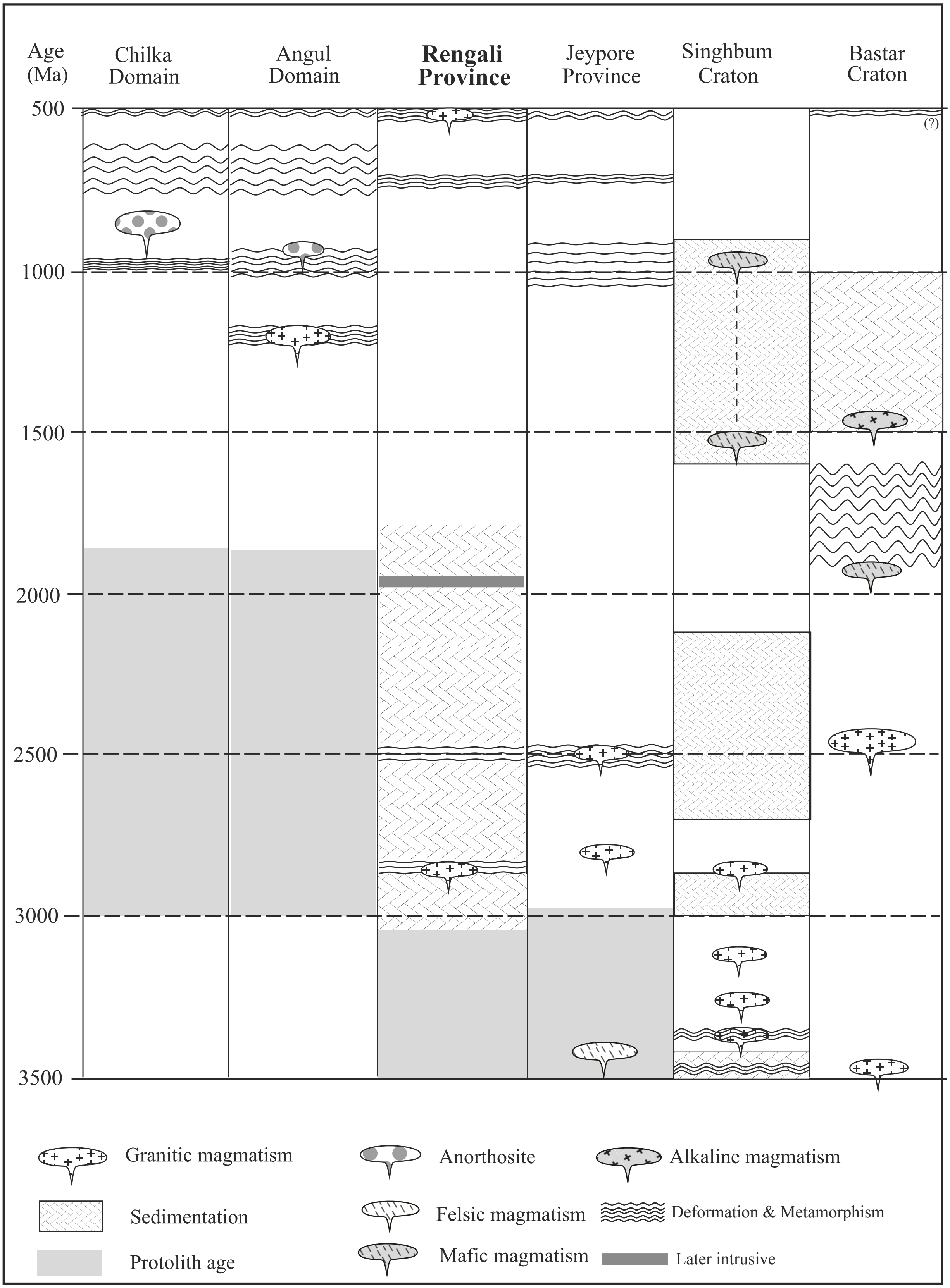

Fig 8.3: Diagram showing geochronological record of the Rengali Province with respect to the adjacent cratons and orogenic belts.