References

Abati, J., Arenas, R., Catalán, J.R.M. and García, F.D., 2003. Anticlockwise P–T path of granulites from the Monte Castelo gabbro (Ordenes Complex, NW Spain). Journal of Petrology, 44(2), pp.305-327.

Aftalion, M., Bowes, D.R., Dash, B. and Dempster, T.J., 1988. Late proterozoic charnockites in Orissa, India: A U-Pb and Rb-Sr isotopic study. Journal of Geology, 96(6), pp.663-676.

Anczkiewicz, R., Chakraborty, S., Dasgupta, S., Mukhopadhyay, D. and Kołtonik, K., 2014. Timing, duration and inversion of prograde Barrovian metamorphism constrained by high resolution Lu–Hf garnet dating: A case study from the Sikkim Himalaya, NE India. Earth and Planetary Science Letters, 407, pp.70-81.

Andersen, D.J., Lindsley, D.H. and Davidson, P.M., 1993. QUILF: A pascal program to assess equilibria among Fe-Mg-Mn-Ti oxides, pyroxenes, olivine, and quartz. Computers & Geosciences, 19(9), pp.1333-1350.

Anderson, J.L. and Smith, D.R., 1995. The effects of temperature and $f\,O_2$ on the Al-in-hornblende barometer. American mineralogist, 80(5-6), pp.549-559.

Arima, M., Kerrich, R. and Thomas, A., 1986. Sapphirine-bearing paragneiss from the northern Grenville province in Labrador, Canada: Protolith composition and metamorphic P-T conditions. Geology, 14(10), pp.844-847.

Babu, V.R.R.M., 1998. The Nellore schist belt: an Archean greenstone belt, Andhra Pradesh, India. Gondwana Research Group Memoir, 4, pp.97-136.

Bai, J., 1993. The Precambrian geology and Pb-Zn mineralization in the northern margin of North China Platform. Beiiing: Geological Publishing Housh (in Chinese).

Ballhaus, C., 1993. Redox states of lithospheric and asthenospheric upper mantle. Contributions to Mineralogy and Petrology, 114(3), pp.331-348.

Banerjee, A., Ganguly, P., Bose, S., Kaushik, D. and Sorcar, N., 2022, July. Two-stage metamorphism of the Angul-Tikarpada area, Eastern Ghats Belt and its implications on the India-East Antarctica correlation. In 2022 Goldschmidt Conference. GOLDSCHMIDT.

Banerjee, A., Ganguly, P., Das, K., Sorcar, N. and Bose, S., 2023. Contrasting Styles of Lower Crustal Metamorphism from a Granulite Suite of Rocks from Angul, Eastern Ghats Belt, India: Implications for the India–Antarctica Correlation. Journal of Petrology, 64(9), p.egad065.

Barnes, J.D., Manning, C.E., Scambelluri, M. and Selverstone, J., 2018. The behavior of halogens during subduction-zone processes. The role of halogens in terrestrial and extraterrestrial geochemical processes: Surface, crust, and mantle, pp.545-590.

Beard, J.S. and Lofgren, G.E., 1991. Dehydration melting and water-saturated melting of basaltic and andesitic greenstones and amphibolites at 1, 3, and 6. 9 kb. Journal of Petrology, 32(2), pp.365-401.

Beard, J.S. and Lofgren, G.E., 1991. Dehydration melting and water-saturated melting of basaltic and andesitic greenstones and amphibolites at 1, 3, and 6. 9 kb. Journal of Petrology, 32(2), pp.365-401.

Belousova, E.A., Griffin, W.L., O'Reilly, S.Y. and Fisher, N.L., 2002. Igneous zircon: trace element composition as an indicator of source rock type. Contributions to mineralogy and petrology, 143, pp.602-622.

Bhadra, S., Gupta, S. and Banerjee, M., 2004. Structural evolution across the Eastern Ghats Mobile Belt–Bastar craton boundary, India: hot over cold thrusting in an ancient collision zone. Journal of Structural Geology, 26(2), pp.233-245.

Bhattacharya, A., Das, H.H., Bell, E., Bhattacharya, A., Chatterjee, N., Saha, L. and Dutt, A., 2016. Restoration of Late Neoarchean–Early Cambrian tectonics in the Rengali orogen and its environs (eastern India): The Antarctic connection. Lithos, 263, pp.190-212.

Bhowmik, S.K. and Chakraborty, S., 2017. Sequential kinetic modelling: A new tool decodes pulsed tectonic patterns in early hot orogens of Earth. Earth and Planetary Science Letters, 460, pp.171-179.

Bhowmik, S.K., Dasgupta, S., Hoernes, S. and Bhattacharya, P.K., 1995. Extremely high-temperature calcareous granulites from the Eastern Ghats, India; evidence for isobaric cooling, fluid buffering, and terminal channelized fluid flow. European Journal of Mineralogy, 7(3), pp.689-703.

Bishop, F.C., 1980. The distribution of Fe^{2+} and Mg between coexisting ilmenite and pyroxene with applications to geothermometry. American Journal of Science, 280(1), pp.46-77.

Biswal, T.K., De Waele, B. and Ahuja, H., 2007. Timing and dynamics of the juxtaposition of the Eastern Ghats Mobile Belt against the Bhandara Craton, India: A structural and zircon U-Pb SHRIMP study of the fold-thrust belt and associated nepheline syenite plutons. Tectonics, 26(4).

Black, L.P., Kinny, P.D., Sheraton, J.W., Delor, C.P., 1991. Rapid production and evolution of late Archaean felsic crust in the Vestfold Block of East Antarctica. Precambrian Research, 50, 283–310.

Boger, S.D., 2011. Antarctica—before and after Gondwana. Gondwana Research, 19(2), pp.335-371.

Boger, S.D., Carson, C.J., Wilson, C.J.L., Fanning, C.M., 2000. Neoproterozoic deformation in the Radok Lake region of the northern Prince Charles Mountains, east Antarctica; evidence for a single protracted orogenic event. Precambrian Research, 104, 1–24.

Bose, S and Gupta,S., 2020. Evolution of stretching lineations in granulite-hosted ductile shear zones, Eastern Ghats Province, India: role of temperature, strain rate and pre- existing stretching lineations, Journal of Structural Geology, vol. 138, article 104127.

Bose, S. and Dasgupta, S., 2018. Eastern Ghats Belt, Grenvillian-age tectonics and the evolution of the Greater Indian Landmass: a critical perspective. Journal of the Indian Institute of Science, 98, pp.345-363.

Bose, S. and Gupta, S., 2018. Strain partitioning along the Mahanadi Shear Zone: implications for paleo-tectonics of the Eastern Ghats Province, India. Journal of Asian Earth Sciences, 157, pp.269-282.

Bose, S., Das, K. and Fukuoka, M., 2005. Fluorine content of biotite in granulite-grade metapelitic assemblages and its implications for the Eastern Ghats granulites. European Journal of Mineralogy, 17(5), pp.665-674.

Bose, S., Das, K., Kimura, K., Hidaka, H., Dasgupta, A., Ghosh, G. and Mukhopadhyay, J., 2016a. Neoarchean tectonothermal imprints in the Rengali Province, eastern India and their implication on the growth of Singhbhum Craton: evidence from zircon U–Pb SHRIMP data. Journal of Metamorphic Geology, 34(8), pp.743-764.

Bose, S., Das, K., Ohnishi, I., Torimoto, J., Karmakar, S., Shinoda, K. and Dasgupta, S., 2009. Characterization of oxide assemblages of a suite of granulites from Eastern Ghats Belt, India: Implication to the evolution of C–O–H–F fluids during retrogression. Lithos, 113(3-4), pp.483-497.

Bose, S., Das, K., Torimoto, J. and Dunkley, D., 2020. Origin of orthopyroxene-bearing felsic gneiss from the perspective of ultrahigh-temperature metamorphism: an example from the Chilka Lake migmatite complex, Eastern Ghats Belt, India. Mineralogical Magazine, 84(5), pp.712-737.

Bose, S., Das, K., Torimoto, J., Arima, M. and Dunkley, D.J., 2016b. Evolution of the Chilka Lake granulite complex, northern Eastern Ghats Belt, India: First evidence of~ 780 Ma decompression of the deep crust and its implication on the India–Antarctica correlation. Lithos, 263, pp.161-189.

Bose, S., Dunkley, D.J., Dasgupta, S., Das, K. and Arima, M., 2011. India-Antarctica-Australia-Laurentia connection in the Paleoproterozoic–Mesoproterozoic revisited: Evidence from new zircon U-Pb and monazite chemical age data from the Eastern Ghats Belt, India. Bulletin, 123(9-10), pp.2031-2049.

Bose, S., Fukuoka, M., Sengupta, P. and Dasgupta, S., 2000. Evolution of high-Mg-Al granulites from Sunkarametta, Eastern Ghats, India: evidence for a lower crustal heating-cooling trajectory. Journal of Metamorphic Geology, 18(3), pp.223-240.

Bose, S., Ghosh, G., Kawaguchi, K., Das, K., Mondal, A.K. and Banerjee, A., 2021. Zircon and monazite geochronology from the Rengali-Eastern Ghats Province: Implications for the tectonic evolution of the eastern Indian terrane. Precambrian Research, 355, p.106080.

Bose, S., Guha, S., Ghosh, G., Das, K. and Mukhopadhyay, J., 2015. Tectonic juxtaposition of crust and continental growth during orogenesis: Example from the Rengali Province, eastern India. Geoscience Frontiers, 6(4), pp.537-555.

Bose, S., Pal, S. and Fukuoka, M., 2003. Pressure–temperature-fluid evolutionary history of orthopyroxene-bearing quartzofeldspathic and mafic granulites from northern parts of the Eastern Ghats Belt, India: implications for Indo-Antarctic correlation. Journal of Asian Earth Sciences, 22(2), pp.81-100.

Bose, S., Sorcar, N., Das, K., Ganguly, P. and Mukherjee, S., 2022. Pulsed tectonic evolution in long-lived orogenic belts: An example from the Eastern Ghats Belt, India. Precambrian Research, 369, p.106522.

Bosse, V. and Villa, I.M., 2019. Petrochronology and hygrochronology of tectono-metamorphic events. Gondwana Research, 71, pp.76-90.

Brown, D., Ryan, P.D., Brown, D., Ryan, P.D., Afonso, J.C., Boutelier, D., Burg, J.P., Byrne, T., Calvert, A., Cook, F. and DeBari, S., 2011. Arc–continent collision: the making of an orogen (pp. 477-493). Springer Berlin Heidelberg.

Brown, M. and Johnson, T., 2018. Secular change in metamorphism and the onset of global plate tectonics. American Mineralogist, 103(2), pp.181-196.

Brown, M., 1994. The generation, segregation, ascent and emplacement of granite magma: the migmatite-to-crustally-derived granite connection in thickened orogens. Earth-Science Reviews, 36(1-2), pp.83-130.

Brown, M., 2001. Crustal melting and granite magmatism: key issues. Physics and Chemistry of the Earth, Part A: Solid Earth and Geodesy, 26(4-5), pp.201-212.

Brown, M., 2006. Duality of thermal regimes is the distinctive characteristic of plate tectonics since the Neoarchean. Geology, 34(11), pp.961-964.

Brown, M., 2007a. Metamorphic conditions in orogenic belts: a record of secular change. International Geology Review, 49(3), pp.193-234.

Brown, M., 2007b. Metamorphism, plate tectonics, and the supercontinent cycle. Earth Science Frontiers, 14(1), pp.1-18.

Brown, M., 2008. Geodynamic regimes and tectonic settings for metamorphism: relationship to the supercontinent cycle. Indian Journal of Geology, 80, pp.3-21.

Brown, M., 2009. Metamorphic patterns in orogenic systems and the geological record. Geological Society, London, Special Publications, 318(1), pp.37-74.

Brown, M., 2010b. Melting of the continental crust during orogenesis: the thermal, rheological, and compositional consequences of melt transport from lower to upper continental crust. Canadian Journal of Earth Sciences, 47(5), pp.655-694.

Brown, M., 2013. Granite: From genesis to emplacement. GSA bulletin, 125(7-8), pp.1079-1113.

Brown, M., 2014. The contribution of metamorphic petrology to understanding lithosphere evolution and geodynamics. Geoscience Frontiers, 5(4), pp.553-569.

Burnham, A.D. and Berry, A.J., 2017. Formation of Hadean granites by melting of igneous crust. Nature Geoscience, 10(6), pp.457-461.

Cameron, E.M. and Hattori, K., 1994. Highly oxidized deep metamorphic zones: occurrence and origin. Mineralogical Magazine A, 58, pp.142-143.

Carmichael, I.S., 1991. The redox states of basic and silicic magmas: a reflection of their source regions?. Contributions to Mineralogy and Petrology, 106(2), pp.129-141.

Carroll, M.R. and Rutherford, M.J., 1987. The stability of igneous anhydrite: experimental results and implications for sulfur behavior in the 1982 El Chichon trachyandesite and other evolved magmas. Journal of Petrology, 28(5), pp.781-801.

Cawood, P.A., Hawkesworth, C.J., Pisarevsky, S.A., Dhuime, B., Capitanio, F.A. and Nebel, O., 2018. Geological archive of the onset of plate tectonics. Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 376(2132), p.20170405.

Cawood, P.A., Kröner, A., Collins, W.J., Kusky, T.M., Mooney, W.D. and Windley, B.F., 2009. Accretionary orogens through Earth history. Geological Society, London, Special Publications, 318(1), pp.1-36.

Cawood, P.A., Wang, Y., Xu, Y. and Zhao, G., 2013. Locating South China in Rodinia and Gondwana: A fragment of greater India lithosphere?. Geology, 41(8), pp.903-906.

Chakrabarti, R., Basu, A.R., Bandyopadhyay, P.K. and Zou, H., 2011. Age and origin of the Chilka anorthosites, Eastern Ghats, India: implications for massif anorthosite petrogenesis and break-up of Rodinia. Topics in igneous petrology, pp.355-382.

Chatterjee, A., Das, K., Bose, S. and Hidaka, H., 2017a. Age-integrated tectonic evolution across the orogen-craton boundary: Age zonation and shallow-to deep crustal participation during Late Cambrian cratonisation of Eastern Ghats Belts, India. Lithos, 290, pp.269-293.

Chatterjee, A., Das, K., Bose, S., Ganguly, P. and Hidaka, H., 2017b. Zircon U–Pb SHRIMP and monazite EPMA U–Th–total Pb geochronology of granulites of the western boundary, Eastern Ghats Belt, India: a new possibility for Neoproterozoic exhumation history. Geological Society, London, Special Publications, 457(1), pp.105-140.

Chatterjee, C., Vadlamani, R. and Kaptan, O.P., 2016. Paleoproterozoic Cordilleran-style accretion along the south eastern margin of the eastern Dharwar craton: Evidence from the Vinjamuru arc terrane of the Krishna orogen, India. Lithos, 263, pp.122-142.

Chatterjee, N., Crowley, J.L., Mukherjee, A. and Das, S., 2008. Geochronology of the 983-Ma Chilka Lake Anorthosite, Eastern Ghats Belt, India: Implications for Pre-Gondwana Tectonics. The Journal of Geology, 116(2), pp.105-118.

Chattopadhyay, S., Upadhyay, D., Nanda, J.K., Mezger, K., Pruseth, K.L. and Berndt, J., 2015. Proto-India was a part of Rodinia: evidence from Grenville-age suturing of the Eastern Ghats Province with the Paleoarchean Singhbhum Craton. Precambrian Research, 266, pp.506-529.

Chetty, T.R.K., 2010. Structural architecture of the northern composite terrane, the Eastern Ghats Mobile Belt, India: implications for Gondwana tectonics. Gondwana Research, 18(4), pp.565-582.

Chetty, T.R.K., Vijay, P., Narayana, B.L. and Giridhar, G.V., 2003. Structure of the Nagavali shear zone, Eastern Ghats mobile belt, India: Correlation in the East Gondwana reconstruction. Gondwana Research, 6(2), pp.215-229.

Chowdhury, P., Gerya, T. and Chakraborty, S., 2017. Emergence of silicic continents as the lower crust peels off on a hot plate-tectonic Earth. Nature Geoscience, 10(9), pp.698-703.

Clark, C., Taylor, R.J., Kylander-Clark, A.R. and Hacker, B.R., 2018. Prolonged (> 100 Ma) ultrahigh temperature metamorphism in the Napier Complex, East Antarctica: A petrochronological investigation of Earth's hottest crust. Journal of Metamorphic Geology, 36(9), pp.1117-1139.

Condie, K.C., 1997. Contrasting sources for upper and lower continental crust: the greenstone connection. The Journal of Geology, 105(6), pp.729-736.

Condie, K.C., 2005. High field strength element ratios in Archean basalts: a window to evolving sources of mantle plumes?. Lithos, 79(3-4), pp.491-504.

Condie, K.C., 2007. Accretionary orogens in space and time.

Condie, K.C., Aster, R.C. and Van Hunen, J., 2016. A great thermal divergence in the mantle beginning 2.5 Ga: Geochemical constraints from greenstone basalts and komatiites. Geoscience Frontiers, 7(4), pp.543-553.

Condie, K.C., Belousova, E., Griffin, W.L. and Sircombe, K.N., 2009. Granitoid events in space and time: constraints from igneous and detrital zircon age spectra. Gondwana Research, 15(3-4), pp.228-242.

Connolly, J.A., 2005. Computation of phase equilibria by linear programming: a tool for geodynamic modeling and its application to subduction zone decarbonation. Earth and Planetary Science Letters, 236(1-2), pp.524-541.

Connolly, J.A.D., 2009. The geodynamic equation of state: what and how. Geochemistry, geophysics, geosystems, 10(10).

Corvino, A.F., Wilson, C.J., Boger, S.D., 2011. The structural and tectonic evolution of a Rodinian continental fragment in the Mawson Escarpment, Prince Charles Mountains. Antarctica. Precambr. Res. 184, 70–92.

Crawford, M.L. and Hollister, L.S., 1986. Metamorphic fluids: the evidence from fluid inclusions. In Fluid—Rock Interactions during Metamorphism (pp. 1-35). New York, NY: Springer New York.

Crowe, W.A., Nash, C.R., Harris, L.B., Leeming, P.M., Rankin, L.R., 2003. The geology of the Rengali Province: implications for the tectonic development of northern Orissa, India. Journal of Asian Earth Sciences, 21, 697–710.

Currie, C.A. and Hyndman, R.D., 2006. The thermal structure of subduction zone back arcs. Journal of Geophysical Research: Solid Earth, 111(B8).

Dalziel, I.W., 1991. Pacific margins of Laurentia and East Antarctica-Australia as a conjugate rift pair: evidence and implications for an Eocambrian supercontinent. Geology, 19(6), pp.598-601.

Darken, L.S. and Gurry, R.W., 1945. The system iron-oxygen. I. The wüstite field and related equilibria. Journal of the American Chemical Society, 67(8), pp.1398-1412.

Das, K., Bose, S., Ghosh, G., 2017a. The Neoarchean-Paleoproterozoic basin development and growth of the Singhbhum Craton, eastern India and its global implications: Insights from detrital zircon U-Pb data. Precambrian Research, 298, 123–145.

Das, K., Bose, S., Karmakar, S., Dunkley, D.J. and Dasgupta, S., 2011. Multiple tectonometamorphic imprints in the lower crust: first evidence of ca. 950 Ma (zircon U-Pb SHRIMP) compressional reworking of UHT aluminous granulites from the Eastern Ghats Belt, India. Geological Journal, 46(2-3), pp.217-239.

Das, K., Bose, S., Torimoto, J., Hayasaka, Y. and Dunkley, D., 2021. Tracking COH fluid-rock interactions in reworked UHT granulite: Tectonic evolution from ca. 990 Ma to ca. 500 Ma in orogenic interior of Eastern Ghats Belt, India. Lithos, 398, p.106287.

Das, S., Nasipuri, P., Bhattacharya, A. and Swaminathan, S., 2008. The thrust-contact between the Eastern Ghats Belt and the adjoining Bastar craton (Eastern India): evidence from mafic granulites and tectonic implications. Precambrian Research, 162(1-2), pp.70-85.

Dasgupta, A., Bhowmik, S.K. and Dasgupta, S., 2022. Transition in Thermal History and Recurring Burial-Exhumation Cycles along Colder Thermal Gradients at the Archaean-Proterozoic Boundary: New Insights from the Western Dharwar Craton, South India. Journal of Petrology, 63(6), p.egac041.

Dasgupta, S. and Sengupta, P., 2003. Indo-Antarctic correlation: a perspective from the Eastern Ghats granulite belt, India. Geological Society, London, Special Publications, 206(1), pp.131-143.

Dasgupta, S., 1993. Contrasting mineral parageneses in high-temperature calc-silicate granulites: examples from the Eastern Ghats, India. Journal of Metamorphic Geology, 11(2), pp.193-202.

Dasgupta, S., Bose, S. and Das, K., 2013. Tectonic evolution of the Eastern Ghats belt, India. Precambrian Research, 227, pp.247-258.

Dasgupta, S., Bose, S., Bhowmik, S.K. and Sengupta, P., 2017. The Eastern Ghats Belt, India, in the context of supercontinent assembly. Geological Society, London, Special Publications, 457(1), pp.87-104.

Dasgupta, S., Ehl, J., Raith, M., Sengupta, P., Sengupta, PR., 1997. Mid-crustal contact metamorphism around the Chirmakurthy mafic–ultramafic complex, Eastern Ghats Belt, India. Contributions to Mineralogy, 129, 182–197.

Dasgupta, S., Pal, S., 2005. Origin of grandite garnet in calc-silicate granulites: mineral–fluid equilibria andpetrogenetic grids. Journal of Petrology, 46, 1045–1076.

Dasgupta, S., Sengupta, P., Ehl, J., Raith, M., Bardhan, S., 1995. Reaction textures in a suite of spinel granulites from the Eastern Ghats Belt, India: evidence for polymetamorphism, a partial petrogenetic grid in the system KFMASH and the roles of ZnO and Fe2O3. Journal of Petrology, 36, 435–461.

Dasgupta, S., Sengupta, P., Fukuoka, M. and Bhattacharya, P.K., 1991. Mafic granulites from the Eastern Ghats, India: further evidence for extremely high temperature crustal metamorphism. The Journal of Geology, 99(1), pp.124-133.

Dev, J.A., Tomson, J.K., Sorcar, N. and Francis, K.A., 2022. Timing of UHT metamorphism and cooling in south Indian granulites: New PTt results from a sapphirine granulite. Precambrian Research, 371, p.106582.

Dev, J.A., Tomson, J.K., Sorcar, N. and Nandakumar, V., 2021. Combined U-Pb/Hf isotopic studies and phase equilibrium modelling of HT-UHT metapelites from Kambam ultrahigh-temperature belt, south India: constraints on tectonothermal history of the terrane. Lithos, 406, p.106531.

Dharma Rao, C.V., Santosh, M., Chmielowski, R. 2012. Sapphirine granulites from Panasapattu, Eastern Ghats belt, India: ultrahigh-temperature metamorphism in a Proterozoic convergent plate margin. Geoscience Frontiers, 3, 9–31.

Dharma Rao, C.V., Santosh, M., Dong, Y.P., 2011. LA-ICPMS U–Pb age data of anorthosites from Pangidi-Kondapalle Layered Intrusion, Eastern Ghats belt, India: constraints on Mesoproterozoic magmatism in a convergent margin setting. Journal of Asian Earth Science. doi. 10.1016/j.jseaes.2011.07.005

Dhuime, B., Wuestefeld, A. and Hawkesworth, C.J., 2015. Emergence of modern continental crust about 3 billion years ago. Nature Geoscience, 8(7), pp.552-555.

Dobmeier, C. and Simmat, R., 2002. Post-Grenvillean transpression in the Chilka Lake area, Eastern Ghats Belt—implications for the geological evolution of peninsular India. Precambrian Research, 113(3-4), pp.243-268.

Dobmeier, C., Lütke, S., Hammerschmidt, K. and Mezger, K., 2006. Emplacement and deformation of the Vinukonda meta-granite (Eastern Ghats, India)—Implications for the geological evolution of peninsular India and for Rodinia reconstructions. Precambrian Research, 146(3-4), pp.165-178.

Dobmeier, C.J. and Raith, M.M., 2003. Crustal architecture and evolution of the Eastern Ghats Belt and adjacent regions of India. Geological Society, London, Special Publications, 206(1), pp.145-168.

Drummond, M.S. and Defant, M.J., 1990. A model for trondhjemite-tonalite-dacite genesis and crustal growth via slab melting: Archean to modern comparisons. Journal of Geophysical Research: Solid Earth, 95(B13), pp.21503-21521.

Duchesne, J.C. and Wilmart, E., 1997. Igneous charnockites and related rocks from the Bjerkreim–Sokndal layered intrusion (Southwest Norway): a jotunite (hypersthene monzodiorite)-derived A-type granitoid suite. Journal of petrology, 38(3), pp.337-369.

Dunkl, I.T.K.H.P., Mikes, T., Simon, K., Von Eynatten, H. and Sylvester, P., 2008. Brief introduction to the Windows program Pepita: data visualization, and reduction, outlier rejection, calculation of trace element ratios and concentrations from LA-ICP-MS data. Mineralogical Association of Canada, Short Course, 40, pp.334-340.

Durrheim, R.J. and Mooney, W.D., 1991. Archean and Proterozoic crustal evolution: evidence from crustal seismology. Geology, 19(6), pp.606-609.

Dziggel, A., Diener, J.F.A., Stoltz, N.B. and Kolb, J., 2012. Role of H_2O in the formation of garnet coronas during near-isobaric cooling of mafic granulites: the Tasiusarsuaq terrane, southern West Greenland. Journal of Metamorphic Geology, 30(9), pp.957-972.

Elliott, B.A., 2003. Petrogenesis of the post-kinematic magmatism of the Central Finland Granitoid Complex II; sources and magmatic evolution. Journal of Petrology, 44(9), pp.1681-1701.

Ernst, R.E., Bleeker, W., Söderlund, U. and Kerr, A.C., 2013. Large Igneous Provinces and supercontinents: Toward completing the plate tectonic revolution. Lithos, 174, pp.1-14.

Faryad, S.W. and Hoinkes, G., 2004. Complex growth textures in a polymetamorphic metabasite from the Kraubath Massif (Eastern Alps). Journal of Petrology, 45(7), pp.1441-1451.

Faure, M., Lin, W., Monie, P. and Bruguier, O., 2004. Palaeoproterozoic arc magmatism and collision in Liaodong Peninsula (north-east China). Terra Nova, 16(2), pp.75-80.

Feio, G.R.L., Dall'Agnol, R., Dantas, E.L., Macambira, M.J.B., Gomes, A.C.B., Sardinha, A.S., Oliveira, D.C., Santos, R.D. and Santos, P.A., 2012. Geochemistry, geochronology, and origin of the Neoarchean Planalto Granite suite, Carajás, Amazonian craton: A-type or hydrated charnockitic granites?. Lithos, 151, pp.57-73.

Feisel, Y., White, R.W., Palin, R.M. and Johnson, T.E., 2018. New constraints on granulite facies metamorphism and melt production in the Lewisian Complex, northwest Scotland. Journal of Metamorphic Geology, 36(6), pp.799-819.

Ferry, J.M. and Watson, E.B., 2007. New thermodynamic models and revised calibrations for the Ti-in-zircon and Zr-in-rutile thermometers. Contributions to Mineralogy and Petrology, 154(4), pp.429-437.

Finger, F. and Clemens, J.D., 1995. Migmatization and “secondary” granitic magmas: effects of emplacement and crystallization of “primary” granitoids in Southern Bohemia, Austria. Contributions to Mineralogy and Petrology, 120, pp.311-326.

Finger, F., Gerdes, A., Krenn, E. and Quadt, V., 2003. Petrology of the Weinsberg granite in the South Bohemian Batholith: New data from the mafic end members. Journal of Geosciences, 48(1-2), pp.46-47.

Flowerdew, M.J., Tyrrell, S., Boger, S.D., Fitzsimons, I.C.W., Harley, S.L., Mikhalsky, E.V. and Vaughan, A.P.M., 2013. Pb isotopic domains from the Indian Ocean sector of Antarctica: implications for past Antarctica–India connections. Geological Society, London, Special Publications, 383(1), pp.59-72.

Foley, B.J., 2018. The dependence of planetary tectonics on mantle thermal state: applications to early Earth evolution. Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 376(2132), p.20170409.

Frost B.R., Frost C.D., Hulsebosch T.P. & Swapp S.M. 2000: Origin of the charnockites of the Louis Lake Batholith, Wind River Range, Wyoming. Journal of Petrology 41, 1759–1776.

Frost, B.R. and Chacko, T., 1989. The granulite uncertainty principle: limitations on thermobarometry in granulites. The Journal of Geology, 97(4), pp.435-450.

Frost, B.R. and Frost, C.D., 2008. On charnockites. Gondwana Research, 13(1), pp.30-44.

Frost, B.R., 2018. Introduction to oxygen fugacity and its petrologic importance. In Oxide minerals (pp. 1-10). De Gruyter.

Frost, B.R., Barnes, C.G., Collins, W.J., Arculus, R.J., Ellis, D.J. and Frost, C.D., 2001. A geochemical classification for granitic rocks. Journal of petrology, 42(11), pp.2033-2048.

Ganguly, J., 1979. Garnet and clinopyroxene solid solutions, and geothermometry based on Fe-Mg distribution coefficient. Geochimica et Cosmochimica Acta, 43(7), pp.1021-1029.

Ganguly, J., Cheng, W., Tirone, M., 1996. Thermodynamics of aluminosilicate garnet solid solution: new experimental data, an optimized model, and thermometric applications. Contrib. Mineral. Petrol. 126, 137–151.

Ganguly, P., Bose, S., Das, K., Torimoto, J. and Ghosh, G., 2017. Origin of spinel+ quartz assemblage in a Si-undersaturated ultrahigh-temperature aluminous granulite and its implication for the P–T–fluid history of the Phulbani domain, Eastern Ghats belt, India. Journal of Petrology, 58(10), pp.1941-1974.

Ganguly, P., Das, K., Bose, S., Ghosh, G., Hayasaka, Y. and Hidaka, H., 2018. U-Pb zircon and U-Th-total Pb monazite ages from the Phulbani Domain of the Eastern Ghats Belt, India: Time constraints on high-grade metamorphism and magmatism in the lower crust. Precambrian Research, 316, pp.1-23.

Ganguly, P., Ghosh, G., Bose, S., Das, K., 2021. Polyphase deformation and ultrahigh temperature metamorphism of the deep continental crust: Implications for tectonic evolution of the northern Eastern Ghats Belt. India. J. Struct. Geol. 143, 104250.

Gao, P., Santosh, M., Yang, C.X., Kwon, S. and Ramkumar, M., 2021. High Ba–Sr adakitic charnockite suite from the Nagercoil Block, southern India: Vestiges of Paleoproterozoic arc and implications for Columbia to Gondwana. Geoscience Frontiers, 12(3), p.101126.

Gehrels, G.E., Valencia, V.A. and Ruiz, J., 2008. Enhanced precision, accuracy, efficiency, and spatial resolution of U-Pb ages by laser ablation–multicollector–inductively coupled plasma–mass spectrometry. Geochemistry, Geophysics, Geosystems, 9(3).

Geological Survey of India, 2002. District Resource Map for Bolangir, Baudh and Khandamal districts. First Edition.

Ghosh, G., Bose, S., Das, K., Dasgupta, A., Yamamoto, T., Hayasaka, Y., Chakrabarti, K. and Mukhopadhyay, J., 2016. Transpression and juxtaposition of middle crust over upper crust forming a crustal scale flower structure: Insight from structural, fabric, and kinematic studies from the Rengali Province, eastern India. Journal of Structural Geology, 83, pp.156-179.

Ghosh, G., Bose, S., Guha, S., Mukhopadhyay, J. and Aich, S., 2010. Remobilization of the southern margin of the Singhbhum Craton, eastern India during the Eastern Ghats orogeny. Indian Jour. Geol, 80, p.97â.

Giri, Y., Betts, P.G., Radhakrishna, M., McLean, M.A., Biswal, T.K. and Armit, R.J., 2023. A geophysically constrained crustal element map of East Antarctica between Enderby Land and Princess Elizabeth Land. Australian Journal of Earth Sciences, 70(3), pp.303-322.

Grantham, G.H., Mendonidis, P., Thomas, R.J. and Satish-Kumar, M., 2012. Multiple origins of charnockite in the mesoproterozoic Natal belt, Kwazulu-Natal, South Africa. Geoscience Frontiers, 3(6), pp.755-771.

Greber, N.D., Dauphas, N., Bekker, A., Ptáček, M.P., Bindeman, I.N. and Hofmann, A., 2017. Titanium isotopic evidence for felsic crust and plate tectonics 3.5 billion years ago. Science, 357(6357), pp.1271-1274.

Grew, E.S. and Manton, W.I., 1986. A new correlation of sapphirine granulites in the Indo-Antarctic metamorphic terrain: Late Proterozoic dates from the Eastern Ghats province of India. Precambrian Research, 33(1-3), pp.123-137.

Grew, E.S., Carson, C.J., Christy, A.G., Maas, R., Yaxley, G.M., Boger, S.D., Fanning, C.M., 2012. New constraints from U-Pb, Lu–Hf and Sm–Nd isotopic data on the timing of sedimentation and felsic magmatism in the Larsemann Hills, Prydz Bay, East Antarctica. Precambr. Res. 206, 87–108.

Grimes, C.B., John, B.E., Kelemen, P.B., Mazdab, F.K., Wooden, J.L., Cheadle, M.J., Hanghøj, K., Schwartz, J.J., 2007. The trace element chemistry of zircons from oceanic crust: a method for distinguishing detrital zircon provenance. Geology 35, 643–646.

Grimes, C.B., Wooden, J.L., Cheadle, M.J. and John, B.E., 2015. “Fingerprinting” tectono-magmatic provenance using trace elements in igneous zircon. Contributions to Mineralogy and Petrology, 170, pp.1-26.

Gupta, S. and Bhattacharya, A., 2000. Granulites of the'Transition Zone': implications for the western reach of the Eastern Ghats Belt. Geol. Surv. India Spec. Publ, 57, pp.57-66.

Gupta, S., Bhattacharya, A., Raith, M. and Nanda, J.K., 2000. Contrasting pressure–temperature–deformation history across a vestigial craton–mobile belt boundary: the western margin of the Eastern Ghats Belt at Deobhog, India. Journal of Metamorphic Geology, 18(6), pp.683-697.

Halpin, J.A., Clarke, G.L., White, R.W. and Kelsey, D.E., 2007. Contrasting P–T–t paths for Neoproterozoic metamorphism in MacRobertson and Kemp Lands, east Antarctica. Journal of Metamorphic Geology, 25(6), pp.683-701.

Halpin, J.A., Daczko, N.R., Clarke, G.L. and Murray, K.R., 2013. Basin analysis in polymetamorphic terranes: An example from east Antarctica. Precambrian Research, 231, pp.78-97.

Halpin, J.A., Daczko, N.R., Milan, L.A. and Clarke, G.L., 2012. Decoding near-concordant U–Pb zircon ages spanning several hundred million years: recrystallisation, metamictisation or diffusion?. Contributions to Mineralogy and Petrology, 163, pp.67-85.

Hanor, J.S., 1994. Origin of saline fluids in sedimentary basins. Geological Society, London, Special Publications, 78(1), pp.151-174.

Hanor, J.S., 2000. Barite–celestine geochemistry and environments of formation. Reviews in Mineralogy and Geochemistry, 40(1), pp.193-275.

Harley, S.L., 1989. The origins of granulites: a metamorphic perspective. Geological Magazine, 126(3), pp.215-247.

Harley, S.L., 2003. Archaean-Cambrian crustal development of East Antarctica: metamorphic characteristics and tectonic implications. Geological Society, London, Special Publications, 206(1), pp.203-230.

Harley, S.L., 2008. Refining the P–T records of UHT crustal metamorphism. Journal of metamorphic Geology, 26(2), pp.125-154.

Harley, S.L., 2016. A matter of time: the importance of the duration of UHT metamorphism. Journal of Mineralogical and Petrological Sciences, 111(2), pp.50-72.

Harley, S.L., Fitzsimons, I.C. and Zhao, Y., 2013. Antarctica and supercontinent evolution: historical perspectives, recent advances and unresolved issues. Geological Society, London, Special Publications, 383(1), pp.1-34.

Harlov, D., Tropper, P., Seifert, W., Nijland, T. and Förster, H.J., 2006. Formation of Al-rich titanite (CaTiSiO4O–CaAlSiO4OH) reaction rims on ilmenite in metamorphic rocks as a function of fH_2O and fO_2. Lithos, 88(1-4), pp.72-84.

Harlov, D.E. and Hansen, E.C., 2005. Oxide and sulphide isograds along a Late Archean, deep-crustal profile in Tamil Nadu, south India. Journal of Metamorphic Geology, 23(4), pp.241-259.

Harlov, D.E., 2012. The potential role of fluids during regional granulite-facies dehydration in the lower crust. Geoscience Frontiers, 3(6), pp.813-827.

Harlov, D.E., Newton, R.C., Hansen, E.C. and Janardhan, A.S., 1997. Oxide and sulphide minerals in highly oxidized, Rb-depleted, Archaean granulites of the Shevaroy Hills Massif, South India: Oxidation states and the role of metamorphic fluids. Journal of Metamorphic Geology, 15(6), pp.701-717.

Harlov, D.E., Van Den Kerkhof, A. and Johansson, L., 2012. The Varberg–Torpa charnockite–granite association, SW Sweden: mineralogy, petrology, and fluid inclusion chemistry. Journal of Petrology, 54(1), pp.3-40.

Harlov, D.E., Van Den Kerkhof, A., Haunschmidt, B. and Finger, F., 2023. Genesis of a synmagmatic charnockite associated with the Weinsberg granite, southern Bohemian Batholith, northern Austria. Geologica Carpathica, 74(1), pp.3-21.

Harrison, T.M., Blichert-Toft, J., Muller, W., Albarede, F., Holden, P. and Mojzsis, S.J., 2006. Response to Comment on" Heterogeneous Hadean Hafnium: Evidence of Continental Crust at 4.4 to 4.5 Ga". *Science*, *312*(5777), pp.1139-1139.

Hartel, T.H.D and Pattison, D.R.M., 1996. Genesis of the Kapuskasing (Ontario) migmatitic mafic granulites by dehydration melting of amphibolite: the importance of quartz to reaction progress. Journal of Metamorphic Geology, 14(5), pp.591-611.

Hastie, A.R., Kerr, A.C., Pearce, J.A. and Mitchell, S.F., 2007. Classification of altered volcanic island arc rocks using immobile trace elements: development of the Th–Co discrimination diagram. Journal of petrology, 48(12), pp.2341-2357.

Hastie, A.R., Law, S., Bromiley, G.D., Fitton, J.G., Harley, S.L. and Muir, D.D., 2023. Deep formation of Earth's earliest continental crust consistent with subduction. Nature Geoscience, pp.1-6.

Hattori, K. and Cameron, E.M., 1986. Archaean magmatic sulphate. Nature, 319(6048), pp.45-47.

Hawkesworth, C.J. and Brown, M., 2018. Earth dynamics and the development of plate tectonics. Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 376(2132), p.20180228.

Henderson, B., Collins, A.S., Payne, J., Forbes, C. and Saha, D., 2014. Geologically constraining India in Columbia: the age, isotopic provenance and geochemistry of the protoliths of the Ongole Domain, Southern Eastern Ghats, India. Gondwana Research, 26(3-4), pp.888-906.

Henry, D.J., Guidotti, C.V., Thomson, J.A., 2005. The Ti-saturation surface for low-tomedium pressure metapelitic biotites: Implications for geothermometry and Tisubstitution mechanisms. Am. Mineral. 90, 316–328.

Hollocher, K., Robinson, P., Walsh, E., Roberts, D., 2012. Geochemistry of amphibolitefacies volcanics and gabbros of the Støren Nappe in extensions west and southwest of Trondheim, Western Gneiss Region, Norway: a key to correlations and paleotectonic settings. Am. J. Sci. 312, 357–416.

Hoskin, P.W.O., Black, L.P., 2002. Metamorphic zircon formation by solid-state recrystallization of protolith iHuang, G., Brown, M., Guo, J., Piccoli, P. and Zhang, D., 2018. Challenges in constraining the P–T conditions of mafic granulites: An example from the northern Trans-North China Orogen. Journal of Metamorphic Geology, 36(6), pp.739-768.gneous zircon. J. Metamorph. Geol. 18, 423–439.

Hurley, P.M. and Rand, J.R., 1969. Pre-Drift Continental Nuclei: Two ancient nuclei appear to have had a peripheral growth and no pre-drift fragmentation and dispersal. Science, 164(3885), pp.1229-1242.

Hyndman, R.D., 2015. Tectonics and structure of the Queen Charlotte fault zone, Haida Gwaii, and large thrust earthquakes. Bulletin of the Seismological Society of America, 105(2B), pp.1058-1075.

Janoušek, V., Farrow, C.M. and Erban, V., 2006. Interpretation of whole-rock geochemical data in igneous geochemistry: introducing Geochemical Data Toolkit (GCDkit). Journal of Petrology, 47(6), pp.1255-1259.

Johnson, M.R. and Harley, S.L., 2012. Orogenesis: the making of mountains. Cambridge University Press.

Kamber, B.S., Greig, A. and Collerson, K.D., 2005. A new estimate for the composition of weathered young upper continental crust from alluvial sediments, Queensland, Australia. Geochimica et Cosmochimica Acta, 69(4), pp.1041-1058.

Kelly, N.M., Clarke, G.L. and Fanning, C.M., 2002. A two-stage evolution of the Neoproterozoic Rayner Structural Episode: new U–Pb sensitive high resolution ion microprobe constraints from the Oygarden Group, Kemp Land, East Antarctica. Precambrian Research, 116(3-4), pp.307-330.

Kelsey, D.E., Morrissey, L.J., Hand, M., Clark, C., Tamblyn, R., Gaehl, A.A. and Marshall, S., 2017. Significance of post-peak metamorphic reaction microstructures in the ultrahigh temperature Eastern Ghats Province, India. Journal of Metamorphic Geology, 35(9), pp.1081-1109.

Kelsey, D.E., Wade, B.P., Collins, A.S., Hand, M., Sealing, C.R., Netting, A., 2008. Discovery of a Neoproterozoic basin in the Prydz belt in East Antarctica and its implications for Gondwana assembly and ultrahigh temperature metamorphism. Precambr. Res. 161, 355–388.

Keppler, H., 1996. Constraints from partitioning experiments on the composition of subduction-zone fluids. Nature, 380(6571), pp.237-240.

Khodorevskaya, L.I. and Aranovich, L.Y., 2016. Experimental study of amphibole interaction with H_2O–NaCl Fluid at 900° C, 500 MPa: toward granulite facies melting and mass transfer. Petrology, 24, pp.215-233.

Kilpatrick, J.A. and Ellis, D.J., 1992. C-type magmas: igneous charnockites and their extrusive equivalents. Earth and Environmental Science Transactions of the Royal Society of Edinburgh, 83(1-2), pp.155-164.

Kinny, P.D., Black, L.P., Sheraton, J.W., 1997. Zircon U-Pb ages and geochemistry of igneous and metamorphic rocks from the northern Prince Charles Mountains. Antarctica. AGSO J. Aus. Geol. Geophys. 16, 637–654.

Klaver, M., de Roever, E.W., Nanne, J.A., Mason, P.R. and Davies, G.R., 2015. Charnockites and UHT metamorphism in the Bakhuis Granulite Belt, western Suriname: evidence for two separate UHT events. Precambrian Research, 262, pp.1-19.

Klötzli, U.S., Koller, F., Scharbert, S. and Höck, V., 2001. Cadomian lower-crustal contributions to Variscan granite petrogenesis (South Bohemian Pluton, Austria): constraints from zircon typology and geochronology, whole-rock, and feldspar Pb–Sr isotope systematics. Journal of Petrology, 42(9), pp.1621-1642.

Korenaga, J., 2008. Plate tectonics, flood basalts and the evolution of Earth's oceans. Terra Nova, 20(6), pp.419-439.

Korhonen, F.J. and Johnson, S.P., 2015. The role of radiogenic heat in prolonged intraplate reworking: The Capricorn Orogen explained?. Earth and planetary science letters, 428, pp.22-32.

Korhonen, F.J., Clark, C., Brown, M., Bhattacharya, S. and Taylor, R., 2013b. How long-lived is ultrahigh temperature (UHT) metamorphism? Constraints from zircon and monazite geochronology in the Eastern Ghats orogenic belt, India. Precambrian Research, 234, pp.322-350.

Kovach, V.P., Simmat, R., Rickers, K., Berezhnaya, N.G., Salnikova, E.B., Dobmeier, C., Raith, M.M., Yakovleva, S.Z. and Kotov, A.B., 2001. The Western Charnockite Zone of the Eastern Ghats Belt, India—An Independent Crustal Province of Late Archaean (2.8 Ga) and Palaeoproterozoic (1.7—1.6 Ga) Terrains. Gondwana Research, 4(4), pp.666-667.

Krause, O., Dobmeier, C., Raith, M.M. and Mezger, K., 2001. Age of emplacement of massif-type anorthosites in the Eastern Ghats Belt, India: constraints from U–Pb zircon dating and structural studies. Precambrian Research, 109(1-2), pp.25-38.

Kretz, R., 1982. Transfer and exchange equilibria in a portion of the pyroxene quadrilateral as deduced from natural and experimental data. Geochimica et Cosmochimica Acta, 46(3), pp.411-421.

Kullerud, G., 1957. Phase relations in the Fe-SO system. Carnegie Institute of Washington Year Book, 56, pp.198-200.

Lal, R.K., Ackermand, D. and Upadhyay, H., 1987. PTX Relationships Deduced from Corona Textures in Sapphirine—Spinel—Quartz Assemblages from Paderu, Southern India. Journal of Petrology, 28(6), pp.1139-1168.

Laurent, O., Vander Auwera, J., Bingen, B., Bolle, O. and Gerdes, A., 2019. Building up the first continents: Mesoarchean to Paleoproterozoic crustal evolution in West Troms, Norway, inferred from granitoid petrology, geochemistry and zircon U-Pb/Lu-Hf isotopes. Precambrian Research, 321, pp.303-327.

Leake, B.E., Woolley, A.R., Arps, C.E., Birch, W.D., Gilbert, M.C., Grice, J.D., Hawthorne, F.C., Kato, A., Kisch, H.J., Krivovichev, V.G. and Linthout, K., 1997. Nomenclature of amphiboles; report of the subcommittee on amphiboles of the International Mineralogical Association, Commission on New Minerals and Mineral Names. The Canadian Mineralogist, 35(1), pp.219-246.

Lee, H.Y., Ganguly, J., 1988. Equilibrium compositions of coexisting garnet and orthopyroxene: experimental determinations in the system FeO-MgO-Al2O3-SiO2, and applications. J. Petrol. 29, 93–113..

Li, S. and Zhao, G., 2007. SHRIMP U–Pb zircon geochronology of the Liaoji granitoids: constraints on the evolution of the Paleoproterozoic Jiao-Liao-Ji belt in the Eastern Block of the North China Craton. Precambrian Research, 158(1-2), pp.1-16.

Li, Z.X., Bogdanova, S., Collins, A.S., Davidson, A., De Waele, B., Ernst, R.E., Fitzsimons, I.C.W., Fuck, R.A., Gladkochub, D.P., Jacobs, J. and Karlstrom, K.E., 2008. Assembly, configuration, and break-up history of Rodinia: a synthesis. Precambrian research, 160(1-2), pp.179-210.

Li, Z.X., Zhang, L. and Powell, C.M., 1996. Positions of the East Asian cratons in the Neoproterozoic supercontinent Rodinia. Australian Journal of Earth Sciences, 43(6), pp.593-604.

Lisker, F and Fachmann, S., 2001. Phanerozoic history of the Mahanadi region, India, Journal of Geophysical Research: Solid Earth, vol. 106, no. B10, pp. 22027–22050.

Liu, X., Zhao, Y., Chen, H. and Song, B., 2017. New zircon U–Pb and Hf–Nd isotopic constraints on the timing of magmatism, sedimentation and metamorphism in the northern Prince Charles Mountains, East Antarctica. Precambrian Research, 299, pp.15-33.

Liu, X., Zhao, Y., Song, B., Liu, J. and Cui, J., 2009. SHRIMP U–Pb zircon geochronology of high-grade rocks and charnockites from the eastern Amery Ice Shelf and southwestern Prydz Bay, East Antarctica: constraints on Late Mesoproterozoic to Cambrian tectonothermal events related to supercontinent assembly. Gondwana Research, 16(2), pp.342-361.

Liu, X.C., Jang, B.-M., Zhao, Y., Liu, J., Ren, L.D., 2014. Geochemistry and geochronology of Mesoproterozoic basement rocks from the eastern Amery Ice Shelf and southwestern Prydz Bay, East Antarctica: implications for a long-lived magmatic accretion in a continental arc. Am. J. Sci. 314, 508–547.

Liu, X.C., Zhao, Y., Hu, J. M. 2013. The c. 1000–900 Ma and c. 550–500 Ma tectonothermal events in the Prince Charles Mountains-Prydz Bay region, East Antarctica, and their relations to supercontinent evolution. In: Harley, S.L., Fitzsimons, I.C.W., Zhao, Y. (Eds.), Antarctica and Supercontinent Evolution. Geol. Soc. Lond. Spec. Pub. 383, pp. 95–112.

López, S. and Castro, A., 2001. Determination of the fluid–absent solidus and supersolidus phase relationships of MORB-derived amphibolites in the range 4–14 kbar. American Mineralogist, 86(11-12), pp.1396-1403.

Ludwig, K., 2008. Isoplot version 4.15: a geochronological toolkit for microsoft Excel. Berkeley Geochronology Center, Special Publication, 4, pp.247-270.

Ludwig, K.R., 2012. User's manual for Isoplot 3.75: A geochronological toolkit for Microsoft Excel. Berkeley Geochronology Center Special Publication, 5, p.75.

Madsen, J.K., 1977. Composition and microthermometry of fluid inclusions in the Kleivan granite, South Norway. American Journal of Science, 277(6), pp.673-696.

Mahapatro, S.N., Pant, N.C., Bhowmik, S.K., Tripathy, A.K. and Nanda, J.K., 2012. Archaean granulite facies metamorphism at the Singhbhum Craton–Eastern Ghats Mobile Belt interface: implication for the Ur supercontinent assembly. Geological Journal, 47(2-3), pp.312-333.

Manikyamba, C., Ganguly, S., Santosh, M., Saha, A., Chatterjee, A. and Khelen, A.C., 2015. Neoarchean arc–juvenile back-arc magmatism in eastern Dharwar Craton, India: geochemical fingerprints from the basalts of Kadiri greenstone belt. Precambrian Research, 258, pp.1-23.

Manning, C.E. and Aranovich, L.Y., 2014. Brines at high pressure and temperature: thermodynamic, petrologic and geochemical effects. Precambrian Research, 253, pp.6-16.

Manning, C.E., 2004. The chemistry of subduction-zone fluids. Earth and Planetary Science Letters, 223(1-2), pp.1-16.

Manning, C.E., 2018. Fluids of the lower crust: deep is different. Annual Review of Earth and Planetary Sciences, 46, pp.67-97.

Martin, H. and Moyen, J.F., 2002. Secular changes in tonalite-trondhjemite-granodiorite composition as markers of the progressive cooling of Earth. Geology, 30(4), pp.319-322.

Martin, H., 1986. Effect of steeper Archean geothermal gradient on geochemistry of subduction-zone magmas. Geology, 14(9), pp.753-756.

McDonough, W.F., Sun, S.S., 1995. The composition of the Earth. Chem. Geol. 120, 223–253.

McLelland, J., Morrison, J., Selleck, B., Cunningham, B., Olson, C. and Schmidt, K., 2002. Hydrothermal alteration of late-to post-tectonic Lyon Mountain Granitic Gneiss, Adirondack Mountains, New York: Origin of quartz–sillimanite segregations, quartz–albite lithologies, and associated Kiruna-type low-Ti Fe-oxide deposits. Journal of metamorphic Geology, 20(1), pp.175-190.

Mezger, K. and Cosca, M.A., 1999. The thermal history of the Eastern Ghats Belt (India) as revealed by U–Pb and 40Ar/39Ar dating of metamorphic and magmatic minerals: implications for the SWEAT correlation. Precambrian Research, 94(3-4), pp.251-271.

Middlemost, E.A., 1994. Naming materials in the magma/igneous rock system. Earth-science reviews, 37(3-4), pp.215-224.

Mikhalsky, E.V., Leitchenkov, G.L., Kiselev, A.V., Popov, S.V., Vorobiev, D.M., 2018. Explanatory notes to geological map of Mac Robertson Land, Princess Elizabeth Land, and Prydz Bay (East Antarctica) scale 1:1 000000. In: Mikhalsky, E.V., Leitchenkov. G.L., SPb.: FSBI "VNIIOkeangeologia", 82 p.

Mikhalsky, E.V., Sheraton, J.W., Hahne, K., 2006. Charnockite Composition in relation to the Tectonic Evolution of East Antarctica. Gond. Res. 9, 379–397.

Misra, S. and Gupta, S., 2014. Superposed deformation and inherited structures in an ancient dilational step-over zone: Post-mortem of the Rengali Province, India. Journal of Structural Geology, 59, pp.1-17.

Mitchell, R.J., Johnson, T.E., Clark, C., Gupta, S., Brown, M., Harley, S.L. and Taylor, R., 2019. Neoproterozoic evolution and Cambrian reworking of ultrahigh temperature granulites in the Eastern Ghats Province, India. Journal of Metamorphic Geology, 37(7), pp.977-1006.

Moecher, D.P., Essene, E.J. and Anovitz, L.M., 1988. Calculation and application of clinopyroxene-garnet-plagioclase-quartz geobarometers. Contributions to Mineralogy and Petrology, 100, pp.92-106.

Mohan, A., Sachan, H.K. and Singh, P.K., 2003. High-density carbonic fluid inclusions in charnockites from Eastern Ghats, India: petrologic implications. Journal of Asian Earth Sciences, 22(2), pp.101-113.

Mohan, A., Tripathi, P. and Motoyoshi, Y., 1997. Reaction history of sapphirine granulites and a decompressional PT path in a granulite complex from the Eastern Ghats. Proceedings of the Indian Academy of Sciences-Earth and Planetary Sciences, 106, pp.115-129.

Möller P., Weise S. M., Althaus E., Bach W., Behr H. J., Borchardt R., Bräuer K., Drescher J., Erzinger J., Faber E., Hansen B. T., Horn E. E., Huenges E., Kämpf H., Kessels W. and Kirsten T., 1997. Paleofluids and recent fluids in the upper continental crust: Results from the German continental deep drilling program (KTB); Journal of Geophysical Research: Solid Earth 102 18233–18254.

Montanini, A. and Tribuzio, R., 2001. Gabbro-derived granulites from the Northern Apennines (Italy): evidence for lower-crustal emplacement of tholeiitic liquids in post-Variscan times. Journal of Petrology, 42(12), pp.2259-2277.

Morrissey, L.J., Hand, M. and Kelsey, D.E., 2015. Multi-stage metamorphism in the Rayner–Eastern Ghats Terrane: P–T–t constraints from the northern Prince Charles Mountains, east Antarctica. Precambrian Research, 267, pp.137-163.

Moyen, J.F. and Van Hunen, J., 2012. Short-term episodicity of Archaean plate tectonics. Geology, 40(5), pp.451-454.

Muan, A., 1958. Phase equilibria at high temperatures in oxide systems involving changes in oxidation states. American Journal of Science, 256(3), pp.171-207.

Munksgaard, N.C., Thost, D.E., Hensen, B.J., 1992. Geochemistry of Proterozoic granulites from northern Prince Charles Mountains, East Antarctica. Ant. Sci. 4, 59–69.

Nanda, J., Gupta, S. and Hacker, B., 2018. U-Pb zircon and titanite ages from granulites of the Koraput area–evidence for Columbia, Rodinia and Gondwana from the Eastern Ghats Province, India. Precambrian Research, 314, pp.394-413.

Neogi, S. and Das, N., 2000. Lithotectonic domains and metamorphic history of the boundary zone of the Eastern Ghats mobile belt and the Bastar craton, Deobhog area, Central India. Geol. Surv. India, Spec. Publ, 57, pp.180-204.

Newton, R.C. and Manning, C.E., 2005. Solubility of anhydrite, CaSO4, in NaCl–H2O solutions at high pressures and temperatures: applications to fluid–rock interaction. Journal of Petrology, 46(4), pp.701-716.

Ni, H., Zhang, L., Xiong, X., Mao, Z. and Wang, J., 2017. Supercritical fluids at subduction zones: Evidence, formation condition, and physicochemical properties. Earth-Science Reviews, 167, pp.62-71.

O'brien, P.J., 2008. Challenges in high-pressure granulite metamorphism in the era of pseudosections: reaction textures, compositional zoning and tectonic interpretation with examples from the Bohemian Massif. Journal of Metamorphic Geology, 26(2), pp.235-251.

Ohmoto, H. and Skinner, B.J., 1983. The Kuroko and related volcanogenic massive sulfide deposits. Society of Economic Geologists.

O'Neill, C. and Debaille, V., 2014. The evolution of Hadean–Eoarchaean geodynamics. Earth and Planetary Science Letters, 406, pp.49-58.

O'Neill, C., Lenardic, A., Moresi, L., Torsvik, T.H. and Lee, C.T., 2007. Episodic precambrian subduction. Earth and Planetary Science Letters, 262(3-4), pp.552-562.

Padmaja, J., Sarkar, T., Dasgupta, S., Dash, J.K., Bhutani, R. and Chauhan, H., 2021. High pressure granulite facies metamorphism at the interface of the Archean Bastar craton and the Proterozoic Eastern Ghats Belt, India. Precambrian Research, 363, p.106330.

PatiñoDouce, A.E. and Beard, J.S., 1995. Dehydration-melting of biotite gneiss and quartz amphibolite from 3 to 15 kbar. Journal of Petrology, 36(3), pp.707-738.Pattison, D.R.M., 1991. Infiltration-driven dehydration and anatexis in granulite facies metagabbro, Grenville Province, Ontario, Canada. Journal of Metamorphic Geology, 9(3), pp.315-332.

Paton, C., Hellstrom, J., Paul, B., Woodhead, J. and Hergt, J., 2011. Iolite: Freeware for the visualisation and processing of mass spectrometric data. Journal of Analytical Atomic Spectrometry, 26(12), pp.2508-2518.

Pattison, D.R., Chacko, T., Farquhar, J., McFarlane, C.R., 2003. Temperatures of granulite-facies metamorphism: constraints from experimental phase equilibria and thermobarometry corrected for retrograde exchange. J. Petrol. 44, 867–900.

Pattison, D.R.M., 2003. Petrogenetic significance of orthopyroxene-free garnet+ clinopyroxene+ plagioclase±quartz-bearing metabasites with respect to the amphibolite and granulite facies. Journal of metamorphic Geology, 21(1), pp.21-34.

Paul, D.K., Barman, T.R., McNaughton, N.J., Fletcher, I.R., Potts, P.J., Ramakrishnan, M. and Augustine, P.F., 1990. Archean-Proterozoic evolution of Indian charnockites: isotopic and geochemical evidence from granulites of the Eastern Ghats Belt. The Journal of Geology, 98(2), pp.253-263.

Pearce, J.A., Harris, N.B. and Tindle, A.G., 1984. Trace element discrimination diagrams for the tectonic interpretation of granitic rocks. Journal of petrology, 25(4), pp.956-983.

Pearce, N.J., Perkins, W.T., Westgate, J.A., Gorton, M.P., Jackson, S.E., Neal, C.R. and Chenery, S.P., 1997. A compilation of new and published major and trace element data for NIST SRM 610 and NIST SRM 612 glass reference materials. Geostandards newsletter, 21(1), pp.115-144.

Petersen, J.S., 1980. The zoned Kleivan granite—an end member of the anorthosite suite in southwest Norway. Lithos, 13(1), pp.79-95.

Pownceby, M.I., Wall, V.J., O'Neill, H., St, C., 1987. Fe–Mn partitioning between garnet and ilmenite: experimental calibration and applications. Contrib. Mineral. Petrol. 97, 116–126.

Racek, M., Štípská, P. and Powell, R., 2008. Garnet–clinopyroxene intermediate granulites in the St. Leonhard massif of the Bohemian Massif: ultrahigh-temperature metamorphism at high pressure or not?. Journal of Metamorphic Geology, 26(2), pp.253-271.

Raith, M.M., Dobmeier, C. and Mouri, H., 2007. Origin and evolution of FeAl-granulite in the thermal aureole of the Chilka Lake anorthosite, Eastern Ghats Province, India. Proceedings of the Geologists' Association, 118(1), pp.87-100.

Raith, M.M., Mahapatro, S.N., Upadhyay, D., Berndt, J., Mezger, K. and Nanda, J.K., 2014. Age and P–T evolution of the Neoproterozoic Turkel Anorthosite Complex, Eastern Ghats Province, India. Precambrian research, 254, pp.87-113.

Rajesh, H.M. and Santosh, M., 2004. Charnockitic magmatism in southern India. Journal of Earth System Science, 113, pp.565-585.

Rajesh, H.M., 2007. The petrogenetic characterization of intermediate and silicic charnockites in high-grade terrains: a case study from southern India. Contrib. Mineral. Petrol. 154, 591–606.

Rajesh, H.M., 2012. A geochemical perspective on charnockite magmatism in Peninsular India. Geoscience Frontiers, 3(6), pp.773-788.

Rajesh, H.M., Santosh, M., Wan, Y., Liu, D., Liu, S.J. and Belyanin, G.A., 2014. Ultrahigh temperature granulites and magnesian charnockites: evidence for Neoarchean accretion along the northern margin of the Kaapvaal Craton. Precambrian Research, 246, pp.150-159.

Ramakrishnan, M., Nanda, J.K. and Augustine, P.F., 1998. Geological evolution of the Proterozoic Eastern Ghats mobile belt. Geol. Surv. India, Spec. Publ, 44, pp.1-21.

Ramam, P.K., 1997. Geology of Andhra Pradesh. Geological Society of India.

Ranjan, S., Upadhyay, D., Abhinay, K., Pruseth, K.L. and Nanda, J.K., 2018. Zircon geochronology of deformed alkaline rocks along the Eastern Ghats Belt margin: India–Antarctica connection and the Enderbia continent. Precambrian Research, 310, pp.407-424.

Ravikant, V., 2019. Cambrian garnet Sm-Nd isotopic ages from the polydeformed Bolangir anorthosite complex, Eastern Ghats Belt, India: implications for intraplate orogeny coeval with Kuunga orogeny during Gondwana assembly. The Journal of Geology, 127(4), pp.437-456.

Rickers, K., Mezger, K. and Raith, M.M., 2001. Evolution of the continental crust in the Proterozoic Eastern Ghats Belt, India and new constraints for Rodinia reconstruction: implications from Sm–Nd, Rb–Sr and Pb–Pb isotopes. Precambrian Research, 112(3-4), pp.183-210.

Rino, S., Komiya, T., Windley, B.F., Katayama, I., Motoki, A. and Hirata, T., 2004. Major episodic increases of continental crustal growth determined from zircon ages of river sands; implications for mantle overturns in the Early Precambrian. Physics of the Earth and Planetary Interiors, 146(1-2), pp.369-394.

Rittenhouse, G., 1967. Bromine in oil-field waters and its use in determining possibilities of origin of these waters. AAPG Bulletin, 51(12), pp.2430-2440.

Rogers, J.J. and Santosh, M., 2003. Supercontinents in Earth history. Gondwana Research, 6(3), pp.357-368.

Rogers, J.J. and Santosh, M.J.G.R., 2002. Configuration of Columbia, a Mesoproterozoic supercontinent. Gondwana Research, 5(1), pp.5-22.

Rudnick, R.L. and Presper, T., 1990. Geochemistry of intermediate/-to high-pressure granulites. In Granulites and crustal evolution (pp. 523-550). Dordrecht: Springer Netherlands.

Rudnick, R.L., 1995. Making continental crust. Nature, 378(6557), pp.571-578.

Rushmer, T., 1991. Partial melting of two amphibolites: contrasting experimental results under fluid-absent conditions. Contributions to Mineralogy and Petrology, 107(1), pp.41-59.

Rushmer, T., 1993. Experimental high-pressure granulites: some applications to natural mafic xenolith suites and Archean granulite terranes. Geology, 21(5), pp.411-414.

Saha, D., 2011. Dismembered ophiolites in Paleoproterozoic nappe complexes of Kandra and Gurramkonda, South India. Journal of Asian Earth Sciences, 42(3), pp.158-175.

Saha, D., Sain, A., Nandi, P., Mazumder, R. and Kar, R., 2015. Chapter 18 Tectonostratigraphic evolution of the Nellore schist belt, southern India, since the Neoarchaean. Geological Society, London, Memoirs, 43(1), pp.269-282.

Saha, S., Das, K., Hidaka, H., Kimura, K., Chakraborty, P.P. and Hayasaka, Y., 2016. Detrital zircon geochronology (U–Pb SHRIMP and LA-ICPMS) from the Ampani Basin, Central India: Implication for provenance and Mesoproterozoic tectonics at East Indian cratonic margin. Precambrian Research, 281, pp.363-383.

Sai, V.S., 2013. Proterozoic granite magmatism along the terrane boundary tectonic zone to the east of Cuddapah basin, Andhra Pradesh—petrotectonic implications for precambrian crustal growth in Nellore schist belt of eastern Dharwar craton. Journal of the Geological Society of India, 81, 167–182.

Saikia, D., Nasipuri, P. and Bhattacharya, A., 2018. In situ U–Th–Pbtotal dating of polychronous monazite in the Koraput anorthosite pluton, Eastern Ghats Granulite Belt (India), and implications. Geological Magazine, 155(1), pp.209-228.82.

Sain, A. and Saha, D., 2018. Structure and tectonics of a Mesoproterozoic ophiolite–insight from Kanigiri Ophiolite with a mélange zone, southern India. Tectonophysics, 744, pp.177-204.

Sain, A., Saha, D., Joy, S., Jelsma, H. and Armstrong, R., 2017. New SHRIMP age and microstructures from a deformed A-type granite, Kanigiri, Southern India: constraining the Hiatus between orogenic closure and postorogenic rifting. The Journal of Geology, 125(2), pp.241-259.

Santos, M.M., Lana, C., Scholz, R., Buick, I., Schmitz, M.D., Kamo, S.L., Gerdes, A., Corfu, F., Tapster, S., Lancaster, P. and Storey, C.D., 2017. A new appraisal of Sri Lankan BB zircon as a reference material for LA-ICP-MS U-Pb geochronology and Lu-Hf isotope tracing. Geostandards and Geoanalytical Research, 41(3), pp.335-358.

Sarkar, M., Gupta, S. and Panigrahi, M.K., 2007. Disentangling tectonic cycles along a multiply deformed terrane margin: Structural and metamorphic evidence for mid-crustal reworking of the Angul granulite complex, Eastern Ghats Belt, India. Journal of Structural Geology, 29(5), pp.802-818.

Sarkar, S., Santosh, M., Dasgupta, S. and Fukuoka, M., 2003. Very high density CO2 associated with ultrahigh-temperature metamorphism in the Eastern Ghats granulite belt, India. Geology, 31(1), pp.51-54.

Sarkar, T. and Schenk, V., 2014. Two-stage granulite formation in a Proterozoic magmatic arc (Ongole domain of the Eastern Ghats Belt, India): Part 1. Petrology and pressure–temperature evolution. Precambrian Research, 255, pp.485-509.

Sarkar, T. and Schenk, V., 2016. Early Mesoproterozoic (1.6–1.5 Ga) granulite facies events in the Ongole domain: geodynamic significance and global correlation. Journal of Metamorphic Geology, 34(8), pp.765-784.

Sarkar, T., Schenk, V. and Berndt, J., 2015. Formation and evolution of a Proterozoic magmatic arc: geochemical and geochronological constraints from meta-igneous rocks of the Ongole domain, Eastern Ghats Belt, India. Contributions to Mineralogy and Petrology, 169, pp.1-27.

Sawyer, E.W., 1999. Criteria for the recognition of partial melting. Physics and Chemistry of the Earth, Part A: Solid Earth and Geodesy, 24(3), pp.269-279.

Schorn, S., Diener, J.F., Sorger, D. and Clark, C., 2020. The contribution of charnockite magmatism to achieve near-ultrahigh temperatures in the Namaqua–Natal Metamorphic Province, South Africa. Lithos, 368, p.105585.

Sen, S.K., Bhattacharya, S. and Acharyya, A., 1995. A multi-stage pressure—temperature record in the Chilka Lake granulites: the epitome of the metamorphic evolution of Eastern Ghats, India?. Journal of Metamorphic Geology, 13(2), pp.287-298.

Sengupta, P. and Raith, M.M., 2002. Garnet composition as a petrogenetic indicator: An example from a marble—calc-silicate granulite interface at Kondapalle, Eastern Ghats Belt, India. American Journal of Science, 302(8), pp.686-725.

Sengupta, P., Dasgupta, S., Bhattacharya, P.K., Fukuoka, M., Chakraborti, S. and Bhowmick, S., 1990. Petro-tectonic imprints in the sapphirine granulites from Anantagiri, Eastern Ghats mobile belt, India. Journal of Petrology, 31(5), pp.971-996.

Sengupta, P., Dasgupta, S., Bhui, U.K., Ehl, J. and Fukuoka, M., 1996. Magmatic evolution of mafic granulites from Anakapalle, Eastern Ghats, India: implications for tectonic setting of a Precambrian high-grade terrain. Journal of Southeast Asian Earth Sciences, 14(3-4), pp.185-198.

Sengupta, P., Dasgupta, S., Dutta, N.R. and Raith, M.M., 2008. Petrology across a calcareous rock–anorthosite interface from the Chilka Lake Complex, Orissa: Implications for Neo-Proterozoic crustal evolution of the northern Eastern Ghats Belt. Precambrian Research, 162(1-2), pp.40-58.

Sengupta, P., Karmakar, S., Dasgupta, S. and Fukuoka, M., 1991. Petrology of spinel granulites from Araku, Eastern Ghats, India, and a petrogenetic grid for sapphirine-free rocks in the system FMAS. Journal of Metamorphic Geology, 9(4), pp.451-459.

Sengupta, P., Sen, J., Dasgupta, S., Raith, M., Bhui, U.K. and Ehl, J., 1999. Ultra-high temperature metamorphism of metapelitic granulites from Kondapalle, Eastern Ghats Belt: implications for the Indo-Antarctic correlation. Journal of Petrology, 40(7), pp.1065-1087.

Shaw, R.K., Arima, M., Kagami, H., Fanning, C.M., Shiraishi, K. and Motoyoshi, Y., 1997. Proterozoic events in the Eastern Ghats granulite belt, India: evidence from Rb-Sr, Sm-Nd systematics, and SHRIMP dating. The Journal of Geology, 105(5), pp.645-656.

Sheppard, S., Rasmussen, B., Zi, J.W., Soma Sekhar, V., Srinivasa Sarma, D., Ram Mohan, M., Krapež, B., Wilde, S.A. and McNaughton, N.J., 2017. U–Pb dating of metamorphic monazite establishes a Pan-African age for tectonism in the Nallamalai Fold Belt, India. Journal of the Geological Society, 174(6), pp.1062-1069.

Sheraton, J.W., Black, L.P. and Tindle, A.G., 1992. Petrogenesis of plutonic rocks in a Proterozoic granulite-facies terrane—the Bunger Hills, East Antarctica. Chemical Geology, 97(3-4), pp.163-198.

Sheraton, J.W., Black, L.P., 1988. Chemical evolution of granitic rocks in the East Antarctic Shield, with particular reference to post-orogenic granites. Lithos 21, 37–52.

Sheraton, J.W., Tindle, A.G. and Tingey, R.J., 1996. Geochemistry, origin, and tectonic setting of the Prince Charles Mountains, Antarctica. AGSO Journal of Australian Geology and Geophysics, 16, pp.345-370.

Shikazono, N., Holland, H.D. and Quirk, R.F., 1983. Anhydrite in Kuroko deposits: mode of occurrence and depositional mechanisms.

Shirey, S.B. and Richardson, S.H., 2011. Start of the Wilson cycle at 3 Ga shown by diamonds from subcontinental mantle. Science, 333(6041), pp.434-436.

Shmulovich, K.I. and Graham, C.M., 2004. An experimental study of phase equilibria in the systems H 2 O–CO 2–$CaCl_2$ and H_2O–CO_2–NaCl at high pressures and temperatures (500–800° C, 0.5–0.9 GPa): geological and geophysical applications. Contributions to Mineralogy and Petrology, 146, pp.450-462.

Silver, P.G. and Behn, M.D., 2008. Intermittent plate tectonics?. science, 319(5859), pp.85-88.

Simmat, R. and Raith, M.M., 2008. U–Th–Pb monazite geochronometry of the Eastern Ghats Belt, India: timing and spatial disposition of poly-metamorphism. Precambrian Research, 162(1-2), pp.16-39.

Singh, A. and Singh, C., 2019. Seismic imaging of the deep crustal structure beneath Eastern Ghats Mobile Belt (India): Crustal growth in the context of assembly of Rodinia and Gondwana supercontinents. Precambrian Research, 331, p.105343.

Sizova, E., Gerya, T. and Brown, M., 2014. Contrasting styles of Phanerozoic and Precambrian continental collision. Gondwana Research, 25(2), pp.522-545.

Skjerlie, K.P. and Douce, A.P., 1995. Anatexis of interlayered amphibolite and pelite at 10 kbar: effect of diffusion of major components on phase relations and melt fraction. Contributions to Mineralogy and Petrology, 122(1-2), pp.62-78.

Sláma, J., Košler, J., Condon, D.J., Crowley, J.L., Gerdes, A., Hanchar, J.M., Horstwood, M.S., Morris, G.A., Nasdala, L., Norberg, N. and Schaltegger, U., 2008. Plešovice zircon—a new natural reference material for U–Pb and Hf isotopic microanalysis. Chemical Geology, 249(1-2), pp.1-35.

Spencer, C.J., Kirkland, C.L. and Taylor, R.J., 2016. Strategies towards statistically robust interpretations of in situ U–Pb zircon geochronology. Geoscience Frontiers, 7(4), pp.581-589.

Spencer, C.J., Partin, C.A., Kirkland, C.L., Raub, T.D., Liebmann, J. and Stern, R.A., 2019. Paleoproterozoic increase in zircon δ18O driven by rapid emergence of continental crust. Geochimica et Cosmochimica Acta, 257, pp.16-25.

Springer, W. and Seck, H.A., 1997. Partial fusion of basic granulites at 5 to 15 kbar: implications for the origin of TTG magmas. Contributions to Mineralogy and Petrology, 127(1-2), pp.30-45.

Stacey, J.T. and Kramers, 1., 1975. Approximation of terrestrial lead isotope evolution by a two-stage model. Earth and planetary science letters, 26(2), pp.207-221.

Stober, I. and Bucher, K., 2005. The upper continental crust, an aquifer and its fluid: hydaulic and chemical data from 4 km depth in fractured crystalline basement rocks at the KTB test site. Geofluids, 5(1), pp.8-19.

Stormer Jr, J.C. and Whitney, J.A., 1977. Two-feldspar geothermometry in granulite facies metamorphic rocks: sapphirine granulites from Brazil. Contributions to Mineralogy and Petrology, 65(2), pp.123-133.

Stout, M.Z., Crawford, M.L. and Ghent, E.D., 1986. Pressure-temperature and evolution of fluid compositions of Al_2SiO_5-bearing rocks, Mica Creek, BC, in light of fluid inclusion data and mineral equilibria. Contributions to Mineralogy and Petrology, 92(2), pp.236-247.

Subba Rao, M.V., Charan, S.N. and Rao, D., 1998. Geochemical signatures of the charnockite suite of rocks of the Machkund region, Orissa: Implications for their petrogenesis and constraints on the evolutionary processes of the Eastern Ghats Mobile Belt. India Memoir, 44, pp.256-267.

Sui, Q.L., Wang, Q., Zhu, D.C., Zhao, Z.D., Chen, Y., Santosh, M., Hu, Z.C., Yuan, H.L. and Mo, X.X., 2013. Compositional diversity of ca. 110 Ma magmatism in the northern Lhasa Terrane, Tibet: implications for the magmatic origin and crustal growth in a continent–continent collision zone. Lithos, 168, pp.144-159.

Sun, S.S. and McDonough, W.F., 1989. Chemical and isotopic systematics of oceanic basalts: implications for mantle composition and processes. Geological Society, London, Special Publications, 42(1), pp.313-345.

Suzuki, S., Ishizuka, H., Kagami, H., 2008. Early to middle Proterozoic dykes in the Mt. Riiser-Larsen area of the Napier Complex, East Antarctica: tectonic implications as deduced from geochemical studies. In: Satish-Kumar, M., Motoyoshi, Y., Osanai, Y., Hiroi, Y., Shiraishi, K. (Eds.), Geodynamic evolution of East Antarctica: A key to the East-West Gondwana connection. Geol. Soc. London, Spec. Publ. 308, 195–210.

Tang, M., Chen, K. and Rudnick, R.L., 2016. Archean upper crust transition from mafic to felsic marks the onset of plate tectonics. Science, 351(6271), pp.372-375.

Tang, Q., Li, C., Zhang, M. and Lin, Y., 2015. U–Pb age and Hf isotopes of zircon from basaltic andesite and geochemical fingerprinting of the associated picrites in the Emeishan large igneous province, SW China. Mineralogy and Petrology, 109, pp.103-114.

Thieblemont, D. and Tegyey, M., 1994. Geochemical discrimination of differentiated magmatic rocks attesting for the variable origin and tectonic setting of calc-alkaline magmas. Comptes Rendus De L Academie Des Sciences Serie II, 319(1), pp.87-94.

Tomson, J.K., Rao, Y.B., Kumar, T.V. and Choudhary, A.K., 2013. Geochemistry and neodymium model ages of Precambrian charnockites, Southern Granulite Terrain, India: Constraints on terrain assembly. Precambrian Research, 227, pp.295-315.

Tomson, J.K., Rao, Y.B., Kumar, T.V. and Rao, J.M., 2006. Charnockite genesis across the Archaean–Proterozoic terrane boundary in the South Indian Granulite Terrain: Constraints from major–trace element geochemistry and Sr–Nd isotopic systematics. Gondwana Research, 10(1-2), pp.115-127.

Török, K., Bali, E., Szabó, C. and Szakál, J.A., 2003. Sr–barite droplets associated with sulfide blebs in clinopyroxene megacrysts from basaltic tuff (Szentbékkálla, western Hungary). Lithos, 66(3-4), pp.275-289.

Toulmin III, P. and Barton Jr, P.B., 1964. A thermodynamic study of pyrite and pyrrhotite. Geochimica et Cosmochimica Acta, 28(5), pp.641-671.

Touret J L and Nijland T 2013 Prograde, peak and retrograde metamorphic fluids and associated metasomatism in upper amphibolite to granulite facies transition zones. Metasomatism and the chemical transformation of rock; Springer, Berline, Heidelberg, pp. 415–469.

Touret, J.L. and Huizenga, J.M., 2012. Fluid-assisted granulite metamorphism: a continental journey. Gondwana Research, 21(1), pp.224-235.

Touret, J.L., 1985. Fluid regime in southern Norway: the record of fluid inclusions. The deep proterozoic crust in the north Atlantic provinces, pp.517-549.

Touret, J.L.R., 2009. Mantle to lower-crust fluid/melt transfer through granulite metamorphism. Russian Geology and Geophysics, 50(12), pp.1052-1062.

Turner, S., Rushmer, T., Reagan, M. and Moyen, J.F., 2014. Heading down early on? Start of subduction on Earth. Geology, 42(2), pp.139-142.

Upadhyay, D., Gerdes, A. and Raith, M.M., 2009. Unraveling sedimentary provenance and tectonothermal history of high-temperature metapelites, using zircon and monazite chemistry: a case study from the Eastern Ghats Belt, India. The Journal of Geology, 117(6), pp.665-683.

Upadhyay, D., Raith, M.M., Mezger, K., Bhattacharya, A. and Kinny, P.D., 2006. Mesoproterozoic rifting and Pan-African continental collision in SE India: evidence from the Khariar alkaline complex. Contributions to Mineralogy and Petrology, 151, pp.434-456.

Valenza, K., Moritz, R., Mouttaqi, A., Fontignie, D. and Sharp, Z., 2000. Vein and karst barite deposits in the western Jebilet of Morocco: fluid inclusion and isotope (S, O, Sr) evidence for regional fluid mixing related to Central Atlantic rifting. Economic Geology, 95(3), pp.587-606.

Van Kranendonk, M.J. and Pirajno, F., 2004. Geochemistry of metabasalts and hydrothermal alteration zones associated with c. 3.45 Ga chert and barite deposits: implications for the geological setting of the Warrawoona Group, Pilbara Craton, Australia. Geochemistry: Exploration, Environment, Analysis, 4(3), pp.253-278.

Veevers, J.J., 2009. Palinspastic (pre-rift and-drift) fit of India and conjugate Antarctica and geological connections across the suture. Gondwana Research, 16(1), pp.90-108.

Viete, D.R. and Lister, G.S., 2017. On the significance of short-duration regional metamorphism. Journal of the Geological Society, 174(3), pp.377-392.

Vijaya Kumar, K., Ernst, W.G., Leelanandam, C., Wooden, J.L., Grove, N.J., 2010. First Paleoproterozoic ophiolite from Gondwana: geochronologic-geochemical documentation of ancient oceanic crust from Kandra, SE India. Tectonophysics, 487, 22–32.

Vijaya Kumar, K., Leelanandam, C. and Ernst, W.G., 2011. Formation and fragmentation of the Palaeoproterozoic supercontinent Columbia: evidence from the Eastern Ghats Granulite Belt, southeast India. International Geology Review, 53(11-12), pp.1297-1311.

Vincent, E.A. and Phillips, R., 1954. Iron-Titanium oxide minerals in layered gabbros of the Skaergaard intrusion, East Greenland: Part I. Chemistry and ore-microscopy. Geochimica et Cosmochimica Acta, 6(1), pp.1-26.

Wang, Y., Liu, D., Chung, S.L., Tong, L., Ren, L., 2008. SHRIMP zircon age constraints from the Larsemann Hills region, Prydz Bay, for a late Mesoproterozoic to early Neoproterozoic tectono-thermal event in East Antarctica. Am. J. Sci. 308, 573–617.

Watson, E.B. and Brenan, J.M., 1987. Fluids in the lithosphere, 1. Experimentally-determined wetting characteristics of CO2H2O fluids and their implications for fluid transport, host-rock physical properties, and fluid inclusion formation. Earth and Planetary Science Letters, 85(4), pp.497-515.

Watson, E.B., Wark, D.A., Thomas, J.B., 2006. Crystallization thermometers for zircon and rutile. Contrib. Mineral. Petrol. 151, 413–433.

Wendlandt, R.F., 1981. Influence of CO_2 on melting of model granulite facies assemblages: a model for the genesis of charnockites. American Mineralogist, 66(11-12), pp.1164-1174.

Whalen, J.B., Currie, K.L. and Chappell, B.W., 1987. A-type granites: geochemical characteristics, discrimination and petrogenesis. Contributions to mineralogy and petrology, 95, pp.407-419.

White, R.W., Clarke, G.L., 1993. Timing of Proterozoic deformation and magmatism in a tectonically reworked orogen, Rayner Complex, Colbeck Archipelago, east Antarctica. Precambr. Res. 63, 1–26.

Wiedenbeck, M.A.P.C., Alle, P., Corfu, F.Y., Griffin, W.L., Meier, M., Oberli, F.V., Quadt, A.V., Roddick, J.C. and Spiegel, W., 1995. Three natural zircon standards for U-Th-Pb, Lu-Hf, trace element and REE analyses. Geostandards newsletter, 19(1), pp.1-23.

Wolf, M.B. and Wyllie, P.J., 1994. Dehydration-melting of amphibolite at 10 kbar: the effects of temperature and time. Contributions to Mineralogy and Petrology, 115(4), pp.369-383.

Yardley, B.W., 2005. 100th Anniversary Special Paper: metal concentrations in crustal fluids and their relationship to ore formation. Economic Geology, 100(4), pp.613-632.

Yardley, B.W., 2009. The role of water in the evolution of the continental crust. Journal of the Geological Society, 166(4), pp.585-600.

Yardley, B.W.D. and Graham, J.T., 2002. The origins of salinity in metamorphic fluids. Geofluids, 2(4), pp.249-256.

Young, D.N., Black, L.P., 1991. U-Pb zircon dating of Proterozoic igneous charnockites from the Mawson Coast, East Antarctica. Antarc. Sci. 3, 205–216.

Young, D.N., Ellis, D.J., 1991. The intrusive Mawson charnockites: Evidence for a compressional plate margins of the Proterozoic mobile belt of East Antarctica. In Int. Symp. Antarc. Earth Sci. 5, 25–31.

Young, D.N., Zhao, J.X., Ellis, D.J. and McCulloch, M.T., 1997. Geochemical and Sr□ Nd isotopic mapping of source provinces for the Mawson charnockites, east Antarctica: implications for Proterozoic tectonics and Gondwana reconstruction. Precambrian Research, 86(1-2), pp.1-19.

Yund, R.A. and Kullerud, G., 1966. Thermal stability of assemblages in the Cu—Fe—S system. Journal of Petrology, 7(3), pp.454-488.

Zhang, H., Ling, M.X., Liu, Y.L., Tu, X.L., Wang, F.Y., Li, C.Y., Liang, H.Y., Yang, X.Y., Arndt, N.T. and Sun, W.D., 2013. High oxygen fugacity and slab melting linked to Cu mineralization: evidence from Dexing porphyry copper deposits, southeastern China. The Journal of Geology, 121(3), pp.289-305.

Zhao, G. and Zhai, M., 2013. Lithotectonic elements of Precambrian basement in the North China Craton: review and tectonic implications. Gondwana Research, 23(4), pp.1207-1240.

Zhao, G., Sun, M., Wilde, S.A. and Li, S., 2003. Assembly, accretion and breakup of the Paleo-Mesoproterozoic Columbia Supercontinent: records in the North China Craton. Gondwana Research, 6(3), pp.417-434.

Zhao, G., Sun, M., Wilde, S.A. and Li, S., 2004. A Paleo-Mesoproterozoic supercontinent: assembly, growth and breakup. Earth-Science Reviews, 67(1-2), pp.91-123.

Zhao, J.X., Ellis, D.J., Kilpatrick, J.A. and McCulloch, M.T., 1997. Geochemical and Sr Nd isotopic study of charnockites and related rocks in the northern Prince Charles Mountains, East Antarctica: implications for charnockite petrogenesis and proterozoic crustal evolution. Precambrian Research, 81(1-2), pp.37-66.

Zheng, Y., Chen, R., Xu, Z. and Zhang, S., 2016. The transport of water in subduction zones. Science China Earth Sciences, 59, pp.651-682.

Precambrian Research 387 (2023) 106994

Contents lists available at ScienceDirect

Precambrian Research

journal homepage: www.elsevier.com/locate/precamres

Petrological, geochemical and geochronological evolution of massif type charnockite from the Eastern Ghats Province, India: Implications on the regional tectonics of the Rayner-Eastern Ghats orogeny

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ARTICLE INFO

Keywords:
Charnockite
Arc magmatism
Metamorphism
U-Pb zircon age
Eastern Ghats Province

ABSTRACT

Massif type charnockite was emplaced in the lower crust of the Eastern Ghats Province and is now exposed over a large geographic area. The rock shows clear evidence of magmatic emplacement in lower crustal metasedimentary rocks, which occur as enclaves within the charnockite. Textural data suggest the magma underwent subsolidus cooling and subsequently metamorphosed to granulite facies (up to ~ 910 °C, 9 kbar). Geochemical data show that the charnockite magma had variable chemistry which was acquired by differentiation and possible crustal contamination. The rock shows both high- and low-SiO_2 types, with weakly peraluminous to metaluminous characters. Trace and REE fractionation trends suggest the magma had calcic to calc-alkaline affinities and was emplaced in a continental arc type collisional setting. Theoretical modelling suggests that such a magma could be generated by melting of a hydrated basaltic slab under CO_2-rich fluid. U-Pb analysis on oscillatory zoned zircon domains from eight samples yields crystallization ages for the magma. While the majority of the samples show crystallization ages within ca. 980–940 Ma (978 ± 16 Ma, 968 ± 22 Ma, 951 ± 9 Ma, 954 ± 8 Ma, 951 ± 13 Ma and 939 ± 27 Ma), two samples yield crystallization ages of 1002 ± 13 Ma and 1020 ± 16 Ma. This implies two-phase emplacement of the charnockite magma which can be correlated with the tectonometamorphic evolution of the province. While the earlier pulse of charnockite magmatism is broadly synchronous with the first cycle (M_1) of metamorphism, the later pulse followed when the lower crust was still hot. The two pulses of charnockite magmatism are broadly synchronous with those of the Mawson charnockite of the Rayner Province, East Antarctica. It is argued that the charnockite magmatism in the combined Rayner-Eastern Ghats Province was extensive and resulted from arc-continent accretion and collision between the India and East Antarctica during ca. 1030–900 Ma.

1. Introduction

Charnockite constitutes an integral part of regional granulite terranes and igneous complexes and play crucial roles in formation and evolution of the Proterozoic crust (Duchesne and Wilmart, 1997). This rock has been variably classified by different names, but Frost and Frost (2008) brought all the orthopyroxene-bearing felsic rocks under the umbrella of charnockite. Magmatic charnockites are reported to be produced from differentiated magma generated from crustal (Duchesne et al., 1989; Hughes et al, 2004) or mantle (Emslie et al., 1994) sources having crystallization temperature > 900 °C (Kilpatrick and Ellis, 1992; Percival and Mortensen, 2002; Mendes and De Campos, 2012). The H_2O-undersaturated charnockite magma shows broadly A-type granitic characters and such a magma can be formed in both divergent (Meshram et al., 2021), or convergent (Feio et al., 2012) tectonic settings. In most cases, these rocks represent crystallized arc magmas with minor crustal components (Yang and Santosh, 2015). These are volumetrically significant compared to those formed by metamorphic (Newton et al., 1980) or anatectic (Bose et al., 2020) processes. Kilpatrick and Ellis (1992) coined the term C-type magma for this rock, but such exclusivity of the magma has been questioned when charnockite was found to occur in close proximity to S-type granites, indicating a genetic linkage

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https://doi.org/10.1016/j.precamres.2023.106994
Received 12 August 2022; Received in revised form 1 February 2023; Accepted 2 February 2023
Available online 10 February 2023

Precambrian Research 355 (2021) 106080

Contents lists available at ScienceDirect

Precambrian Research

journal homepage: www.elsevier.com/locate/precamres

Zircon and monazite geochronology from the Rengali-Eastern Ghats Province: Implications for the tectonic evolution of the eastern Indian terrane

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ARTICLE INFO

Keywords:
Singhbhum craton
Eastern Ghats Province
Rengali Province
Zircon
Monazite

ABSTRACT

The tectonic evolution of the Rengali Province and its eventual juxtaposition to the Eastern Ghats Province has important bearings on the geological evolution of the Eastern Indian terrane. New zircon and monazite age data from the Rengali Province and the northern-northwestern part of the Eastern Ghats are presented in this study to trace this evolutionary history. Monazite U-Th-total Pb data from the paragneissic rocks of the eastern Rengali Province show a metamorphic age of 2775 ± 18 Ma while an older age of 2943 ± 35 Ma from the same rock probably suggests an older metamorphic/magmatic event. Zircon U-Pb (LA-ICPMS) data from the northern part of the Eastern Ghats show 1230 ± 21 Ma and 1220 ± 9 Ma ages that we interpret as a major phase of high-grade metamorphism of the basement. Paragneissic rocks from the northwestern margin of the Eastern Ghats yields monazite ages of 966 ± 21 Ma and 555 ± 12 Ma respectively from the core and rim parts of monazite grains. Similar ages of 966 ± 25 Ma and 540 ± 12 Ma are reported from paragneissic rock occurring at the contact of Rengali Province and the Eastern Ghats. This younger (~555–540 Ma) age likely correlates to the amphibolite facies reworking of the granulitic lower crust which coincides with the emplacement of nepheline syenite at 556 ± 28 Ma (zircon U-Pb data) and the contact metamorphism of the ultramafic granofels at 553 ± 18 Ma (monazite data). Nepheline monzosyenite veins intruded the gneissic nepheline syenite at 506 ± 9 Ma (zircon U-Pb data). Emplacement of the monzosyenite veins within the felsic gneiss country at the northwestern margin of the Eastern Ghats at 490 ± 3 Ma (zircon U-Pb data) marks the last thermal imprint in response to large-scale shear-induced deformation at the northern/northwestern contacts of the Eastern Ghats. We infer that the Neoarchean (ca. 2943–2775 Ma) events possibly resulted from the ensuing convergent tectonics driven by lithospheric peeling (peel-back convergent tectonics). The Eastern Ghats and its Antarctic counterpart juxtaposed with the Rengali Province during ca. 1000–900 Ma and become a part of the Eastern Indian terrane. The Ediacaran-Cambrian (ca. 556–490 Ma) events imply the reactivation of the deep crustal Tonian-age shear systems in a transpressional tectonic setting.

1. Introduction

The geological history of the Earth since its inception is etched in the rock records of cratons which are the only repositories of products of the early Earth processes (Condie and Pease, 2008; Cawood et al., 2013; Hawkesworth et al., 2017). Geological records suggest that cratonic cores formed mostly during the early-to-mid Archean eon (references as above) and subsequently modified by multiple cycles of magmatism, metamorphism, sedimentation, and deformation along their margins (Friend and Nutman, 2005; Windley and Gerde, 2009; Goscombe et al., 2019). These processes eventually led to the growth of cratons that we see in their present configuration. Tectonics played a pivotal role in this evolutionary process in terms of crust-mantle coupling and decoupling. Although the debate on how and when the tectonic styles of the Earth

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https://doi.org/10.1016/j.precamres.2020.106080
Received 31 May 2020; Received in revised form 21 December 2020; Accepted 21 December 2020
Available online 21 January 2021

Polar Science 26 (2020) 100588

Contents lists available at ScienceDirect

Polar Science

journal homepage: http://www.elsevier.com/locate/polar

Petrogenetic re-examination of spinel + quartz assemblage in the Larsemann Hills, East Antarctica

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ARTICLE INFO

Keywords:
Larsemann hills
Spinel + quartz
Monazite
Metastable contact

ABSTRACT

We present textural evidence of spinel (low-Zn) and quartz from two samples of quartzofeldspathic rocks from the Larsemann Hills, East Antarctica. The present occurrence is unusual for the fact that the direct grain contact is preserved unlike most other occurrences where these two phases are separated by reaction products during retrograde and/or prograde metamorphic stages. Textural features further indicate that Ti-biotite was part of the prograde assemblage that underwent partial melting to produce spinel. The maximum temperature estimated from the rock is 870 °C. Monazite grains are abundant in the rock and these are mostly homogeneous in terms of U, Th and Pb distribution. In situ U–Th-total Pb EPMA data of these monazite yield a group age of 527 ± 8 Ma. Textural and geochronological data match with the second (M_2) stage of metamorphism of the Larsemann Hills region as evident from the existing geological record. Although spinel and quartz was considered to be a part of peak M_2 assemblage in earlier studies, preservation of their grain contact is enigmatic. We consider the grain contact metastable and its preservation possibly resulted from significant overstepping of cooling reaction due to fast reaction kinetics.

1. Introduction

The occurrence of hercynitic spinel and quartz is a diagnostic feature of high temperature (>800 °C) mid-crustal metamorphism (Waters, 1991). This association is reported from many regional and contact metamorphic zones where temperature exceeded 900 °C (Vielzeuf, 1983; Dasgupta and Ehl, 1993; Mouri et al., 1996; Ouzegane and Boumaza, 1996; Sandiford et al., 1987 among others). Decades later, it was understood that this assemblage could be treated as "suggestive" but not "diagnostic" feature of ultrahigh temperature (UHT) metamorphism (Harley, 2008; Kelsey, 2008; Kelsey and Hand, 2015). This is due to the fact that non-FMAS components like Zn, Cr, Ni, Ti, V, Fe^{+3} can significantly expand the stability field of the assemblage to lower temperature (Harley, 1986; Waters, 1991; Dasgupta et al., 1995; Guiraud et al., 1996). Spinel and quartz can also occur metastably as Fe–Al spinel may exsolve out of a complex Fe–Al–Ti–Fe^{3+} spinel solid solution (Sandiford et al., 1987; Waters, 1991; Dasgupta et al., 1995). Despite these limitations, low-Zn and low-Fe^{+3} spinel in stable coexistence with quartz have been reported from several regional UHT terranes (Kawakami and Motoyoshi, 2004; Morimoto et al., 2004; Ouzegane and Boumaza, 1996). In all other cases, spinel is separated by a corona comprising of various combinations of cordierite, sillimanite, sapphirine, orthopyroxene and garnet (Clarke et al., 1989; Perchuk et al., 1989; Stüwe and Powell, 1989; Waters, 1991; Dasgupta et al., 1995; Bose et al., 2000; Morimoto et al., 2004; Sajeev et al., 2006; Tsunogae and Santosh, 2006; Ganguly et al., 2017).

In the present study, we present the petrogenetic reinterpretation of coexisting spinel and quartz in a quartzofeldspathic rocks from Larsemann Hills, East Antarctica. We discuss the possible reason(s) for the coexistence of this mineral pair and implications.

2. Geology of the Larsemann Hills

The Larsemann Hills and adjoining areas surrounding Prydz Bay have been studied by many workers (Stüwe et al., 1989; Stüwe and Powell, 1989; Fitzsimons and Harley, 1991; Fitzsimons, 1996, 1997; Carson et al., 1997; Tong and Liu, 1997; Wang et al., 2008; Grew et al., 2013; Tong et al., 2017 and references therein). The basement of the

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https://doi.org/10.1016/j.polar.2020.100588
Received 17 April 2020; Received in revised form 15 July 2020; Accepted 17 August 2020
Available online 15 September 2020

J. Earth Syst. Sci. (2019) 128:190
https://doi.org/10.1007/s12040-019-1197-3

Evolution of fluid from the ultrahigh temperature lower crust to shallower levels: Constraints from silicate–oxide–sulphide–sulphate assemblages of mafic granulites of the Eastern Ghats Belt, India

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MS received 22 May 2018; revised 24 November 2018; accepted 11 February 2019; published online 5 July 2019

Mafic granulites from key localities of the Eastern Ghats Province preserve Fe–Ti oxides, Cu–Fe sulphides and traces of sulphate minerals along with silicate phases. Two different varieties of mafic granulite exhibit slightly contrasting mineral assemblages. While the massive type of mafic granulite contains minerals assemblage orthopyroxene + clinopyroxene + plagioclase + magnetite + ilmenite + pyrite + pyrrhotite, the migmatitic variety contains garnet as an additional phase. Both oxide and sulphide minerals show contrasting textural characters. Textural analysis and construed mineral reactions imply that the variation of oxide–silicate, oxide–sulphide and sulphate relations is linked to variation of fO_2 during the pre-peak, peak and post-peak stages of metamorphism. The calculated fO_2 values range up to +4 log units relative to the QFM (quartz-fayalite-magnetite) buffer among the samples, except for one sample which shows lower values (−10 log units relative to the FMQ (fayalite-magnetite-quartz) buffer). The consistently high fO_2 condition at the lower crust could result from several factors, but the role of the externally derived fluid appears to be plausible. Hot brine solution with $CaCl_2$ species can explain the oxidation as well as local metasomatism of the mafic lower crust even though its presence is not verified from direct characterisation like fluid inclusion analysis.

Keywords. Mafic granulite; oxygen fugacity; brine solution; external fluid; Eastern Ghats Belt.

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1. Introduction

Opaque minerals like Fe–Ti oxides, Cu–Fe sulphides and graphite in granulite and amphibolite facies rocks can provide information on both temperature conditions and oxygen fugacity of the deep crust (Buddington and Lindsley 1964; Duchesne 1972; Bohlen and Essene 1977; Rollinson 1980; Frost and Chacko 1989). Assemblages like fayalite–magnetite–quartz, magnetite–haematite, orthopyroxene–magnetite–quartz (Frost *et al.* 1988; Harlov 1992, 2000a; Harlov *et al.* 1997) and pyrrhotite–pyrite–magnetite (Mohr and Newton 1983; Tracy and Robinson 1988; Cameron *et al.* 1993; Harlov *et al.* 1997; Harlov 2000b) are now reliably utilised to constrain the fluid activity during metamorphism. Compared to the oxide phases, sulphide minerals have received relatively less attention in granulite studies possibly due to the vulnerability of these minerals to retrograde reactions and also partly due to the lack of an established relationship between sulphide