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On the hunt for suture zones in South India

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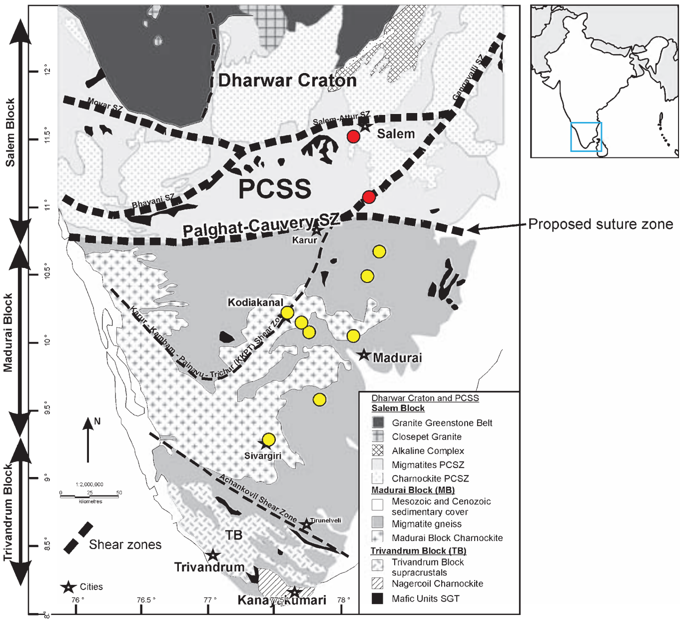


Fig. 1. *Geological map of the Southern Granulite Terrane of India (SGT). The filled circles show locations of the metasedimentary samples analysed in my study. Red circles are metasediments north of the proposed suture zone (Palghat-Cauvery SZ) and the yellow circles are metasediments south of the proposed suture zone.*

Each year, the Australian Society of Exploration Geophysicists (ASEG) is kind enough to award travel scholarships to postgraduate students that wish to attend conferences, thus giving them the opportunity to present their research. This year I was lucky enough to have been awarded the $1500 travel scholarship in order to attend the International Geological Congress (IGC) in Brisbane.

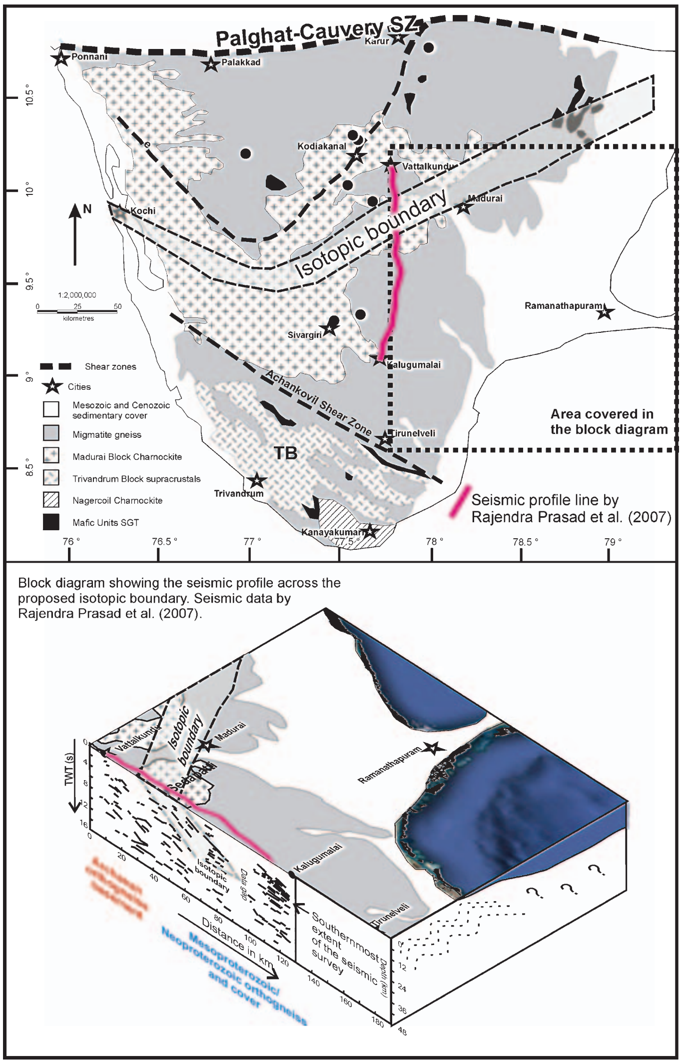
In 2008, when I decided to do a Doctorate of Philosophy (PhD), I never dreamed geology could be so exciting. My interests have always been focussed on tectonic reconstructions in high-grade Precambrian terranes, so when I saw the postgraduate project offered by Associate Professor Alan Collins (The University of Adelaide) titled: '*The tectonic evolution of Southern India*', I couldn't resist.

The Southern Granulite Terrane of India (SGT) is located at the apex of the Indian subcontinent. This terrane is dominated by granulite facies rocks and is separated from the largely greenschist to amphibolite facies Archaean (Dharwar Craton) rocks to the north by a series of anastomosing crustal scale shear zones (Drury *et al*., 1984) here termed the Palghat-Cauvery Shear System (PCSS; Figure 1). These shear zones represent a zone of reworking of the SGT during the latest Neoproterozoic (500–550 Ma) that is associated with the final stages of the Gondwana amalgamation (Collins *et al*., 2007; Clark *et al*., 2009; Santosh *et al*., 2009; Plavsa *et al*., 2012). In particular, the southernmost Palghat Cauvery Shear Zone (PCSZ) is thought to represent the suture zone that resulted in the closure of the Mozambique Ocean between the Indian and East African (Congo/Tanzania/Bangweulu) cratons around 500 million years ago (Collins and Pisarevsky, 2005; Sato *et al*., 2011; Santosh *et al*., 2012).

Geophysical surveys (including seismic, MT and gravity data) show a southward deepening of the Moho across the PCSS and provide further evidence of crustal thickening in this domain (Mishra and Vijaya Kumar, 2005; Singh *et al*., 2006; Naganjaneyulu and Santosh, 2010). However, ambiguity still exists on the exact location of this suture zone as isotopic data show similarities in the ages of igneous rocks (~2.5–2.7 Ga) on either side the proposed suture zone (Harris *et al*., 1994; Bhaskar Rao *et al*., 2003; Ghosh *et al*., 2004; Plavsa *et al*., 2012). Furthermore, geochemical and structural data (and lack thereof) only add to the ambiguity associated with the exact location of the suture zone and its continuation into the neighbouring continental blocks in Gondwana reconstructions.

Working in high-grade terranes is not exactly a walk in the park as many geologists found out over the years. Isotopic systems tend to get reset due to high temperatures and pressures (of up to 1000°C and 12 kbars in SGT, Braun and Appel, 2006; Shimpo *et al*., 2006; Tsunogae *et al*., 2008; Clark *et al*., 2009), structural geology becomes very complex due to its highly ductile nature and not one, but a number of deformational events overprinting each other (Ghosh *et al*., 2004; Cenki and Kriegsman, 2005). However, the resilience of one mineral under such extreme conditions can still provide some insight into the nature of the original protolith and that mineral is zircon.

To find this enigmatic suture zone, or to prove/disprove its existence, I have decided to carry out detrital provenance studies of zircons from metasediments on either side of the proposed suture zone using U-Pb geochronology and Hf isotope studies of detrital zircons. The isotopic analyses were carried out using Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICPMS) and multi collector (MC) LA-ICPMS for U-Pb and Hf isotopic studies, respectively. The U-Pb and Hf isotope duo works extremely well as not only is the age of the detritus in metasediments determined, but also Hf isotopes provide information on whether that age represents crust derived from the mantle (juvenile) or reworking of older crustal material (evolved).



Rajendra Prasad, B., Kesava Rao, G., Mall, D.M., Koteswara Rao, P., Raju, S., Reddy, M.S., Rao, G.S.P., Sridher, V., Prasad, A.S.S.S.R.S., 2007. Tectonic implications of seismic reflectivity pattern observed over the Precambrian Southern Granulite Terrain, India. Precambrian Research 153, 1-10.

Fig. 2. *Seismic reflection survey showing a series of south dipping reflectors interpreted to represent basement/cover relationship between the Archaean basement and largely Mesoproterozoic/Neoproterozoic metasediments to the south. Figure as published in Plavsa* et al. *(2012).*

Numerous arduous hours sitting on the laser (LAICPMS) shooting zircons well into the night in the basement of Adelaide Microscopy (The University of Adelaide) as well as days spent on the Waite Campus (CSIRO) mass spectrometers analysing Hf isotopes in zircons were absolutely worth it after data was processed. The results show that metasediments north of the proposed suture zone (PCSZ) are dominated by Archaean detritus with largely juvenile signatures most likely derived from the basement rocks they were deposited on, while metasediments south of the PCSZ have ages varying between 0.6–3.1 Ga and Hf isotopic evolution that shows detritus derived from juvenile Neoproterozoic and reworked Archaean terranes, most akin to the rocks of the East African (Congo/Tanzania/Bangweulu) cratons. Furthermore, the metasediments south of the PCSZ show a basement/cover relationship as determined from geochronological, isotopic and seismic data showing a series of south dipping reflectors (Figure 2; Rajendra Prasad *et al.*, 2007). The disparity of the detrital provenance data from these metasediments confirm that until the latest Neoproterozoic, the basement rocks of the metasediments north of the PCSZ were proximal to the Dharwar (Indian) Craton, while those to the south were proximal to the East African Craton.

While making breakthrough research is exciting, what is even more so is presenting it. Thanks to the ASEG I have had the opportunity to present my research at the IGC held in Brisbane in August earlier this year. With over 6000 delegates attending the congress, it was amazing to see the diversity of topics and scientific research that is currently taking place all over the world. I sincerely hope that my small contribution has helped in unravelling part of the mystery that is our planet.

References

Bhaskar Rao, Y. J., Janardhan, A. S., Vijaya Kumar, T., Narayana, B. L., Dayal, A. M., Taylor, P. N., and Chetty, T. R. K. 2003, Sm–Nd model ages and Rb–Sr isotope systematics of charnockites and gneisses across the Cauvery Shear Zone, southern India: implications for the Archaean-Neoproterozoic boundary in the southern granulite terrain. Tectonics of Southern Granulite Terrain (M.Ranmakrishnan, ed.): *Geological Society of India Memoirs*, **50**, 297–317.

Braun, I., and Appel, P. 2006, U-Th-total Pb dating of monazite from orthogneisses and their ultra-high temperature metapelitic enclaves: implications for the multistage tectonic evolution of the Madurai Block, southern India. *European Journal of Mineralogy* **18**, 415–427. doi:10.1127/0935-1221/2006/0018-0415

Cenki, B., and Kriegsman, L. M. 2005, Tectonics of the Neoproterozoic Southern Granulite Terrain, South India. *Precambrian Research* **138**, 37–56. doi:10.1016/j.precamres.2005.03.007

Clark, C., Collins, A. S., Santosh, M., Taylor, R., and Wade, B. P. 2009, The P-T-t architecture of a Gondwanan suture: REE, U-Pb and Ti-in-zircon thermometric constraints from the Palghat Cauvery shear system, South India. *Precambrian Research* **174**, 129–144. doi:10.1016/j.precamres.2009.07.003

Collins, A. S., and Pisarevsky, S. A. 2005, Amalgamating eastern Gondwana: the evolution of the Circum-Indian Orogens. *Earth-Science Reviews* **71**, 229–270. doi:10.1016/j.earscirev.2005.02.004

Collins, A. S., Clark, C., Sajeev, K., Santosh, M., Kelsey, D. E., and Hand, M. 2007, Passage through India: the Mozambique Ocean suture, high-pressure granulites and the Palghat-Cauvery shear zone system. *Terra Nova* **19**, 141–147. doi:10.1111/j.1365-3121.2007.00729.x

Drury, S. A., Harris, N. B. W., Holt, R. W., Reeves-Smith, G. J., and Wightman, R. T. 1984, Precambrian tectonics and crustal evolution in South India. *The Journal of Geology* **92**, 3–20. doi:10.1086/628831

Ghosh, J. G., Wit, M. J. d., and Zartman, R. E. 2004, Age and tectonic evolution of Neoproterozoic ductile shear zones in the Southern Granulite Terrain of India, with implications for Gondwana studies. *Tectonics* **23**, 1–38. doi:10.1029/2002TC001444

Harris, N. B. W., Santosh, M., and Taylor, P. N. 1994, Crustal evolution in South India: constraints from Nd Isotopes. *The Journal of Geology* **102**, 139–150. doi:10.1086/629659

Mishra, D. C., and Vijaya Kumar, V. 2005, Evidence for proterozoic collision from airborne magnetic and gravity studies in Southern Granulite Terrain, India and signatures of recent tectonic activity in the Palghat Gap. *Gondwana Research* **8**, 43–54. doi:10.1016/S1342-937X(05)70261-6

Naganjaneyulu, K., and Santosh, M. 2010, The Cambrian collisional suture of Gondwana in southern India: a

geophysical appraisal. *Journal of Geodynamics* **50**, 256–267. doi:10.1016/j.jog.2009.12.001
Plavsa, D., Collins, A. S., Foden, J. F., Kropinski, L., Santosh, M., Chetty, T. R. K., and Clark, C. 2012, Delineating crustal domains in Peninsular India: age and chemistry of orthopyroxene-bearing felsic gneisses in the Madurai Block. *Precambrian Research* **198–199**, 77–93. doi:10.1016/j.precamres.2011.12.013
Rajendra Prasad, B., Kesava Rao, G., Mall, D. M., Koteswara Rao, P., Raju, S., Reddy, M. S., Rao, G. S. P., Sridher, V., and Prasad, A. S. S. S. R. S. 2007, Tectonic implications of seismic reflectivity pattern observed over the Precambrian Southern Granulite Terrain, India. *Precambrian Research* **153**, 1–10. doi:10.1016/j.precamres.2006.11.008
Santosh, M., Maruyama, S., and Sato, K. 2009, Anatomy of a Cambrian suture in Gondwana: Pacific-type orogeny in southern India? *Gondwana Research* **16**, 321–341. doi:10.1016/j.gr.2008.12.012
Santosh, M., Xiao, W. J., Tsunogae, T., Chetty, T. R. K., and Yellappa, T. 2012, The Neoproterozoic subduction complex in southern India: SIMS zircon U-Pb ages and implications for Gondwana assembly. *Precambrian Research* **192–195**, 190–208. doi:10.1016/j.precamres.2011.10.025
Sato, K., Santosh, M., Tsunogae, T., Chetty, T. R. K., and Hirata, T. 2011, Subduction–accretion–collision history along the Gondwana suture in southern India: a laser ablation ICP-MS study of zircon chronology. *Journal of Asian Earth Sciences* **40**, 162–171. doi:10.1016/j.jseaes.2010.08.008
Shimpo, M., Tsunogae, T., and Santosh, M. 2006, First report of garnet-corundum rocks from southern India: implications for prograde high-pressure (eclogite-facies?) metamorphism. *Earth and Planetary Science Letters* **242**, 111–129. doi:10.1016/j.epsl.2005.11.042
Singh, A. P., Kumar, N., and Singh, B. 2006, Nature of the crust along Kuppam-Palani geotransect (South India) from gravity studies: implications for Precambrian continental collision and delamination. *Gondwana Research* **10**, 41–47. doi:10.1016/j.gr.2005.11.013
Tsunogae, T., Santosh, M., Ohyama, H., and Sato, K. 2008, High-pressure and ultrahigh-temperature metamorphism at Komateri, northern Madurai Block, southern India. *Journal of Asian Earth Sciences* **33**, 395–413. doi:10.1016/j.jseaes.2008.02.004