J. Ind. Geophys. Union, 29(1) (2025), 56-63

Kinematics of the Capricorn microplate and its surrounding regions as inferred from the analyses of GPS data

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ABSTRACT

The Capricorn microplate, located between the Indian and Australian Plates, is a prominent tectonic block introduced between the two plates, primarily to explain the inconsistency observed in the Indian oceanic plate motions and the prevailing intraplate seismicity. We evaluated the kinematics of this microplate, relative to adjacently located other tectonic plates using GPS data to understand the underlying plate tectonic processes and associated deformation/strain patterns. The lengths of baseline are computed from the DGAR GPS site, placed at the northern fringe of the Capricorn Plate, and adjacently positioned other GPS sites in different geotectonic blocks. The estimated baseline lengths indicate a relative convergent tectonics between Capricorn microplate and southern tip of India with a rate of 1 mm/yr. In comparison, a much higher rate of convergence (about 18 mm/yr) is seen between the Capricorn microplate and the Sunda Plates. Such a high rate of convergence, if persists, would considerably shrink the wide diffusive boundary that currently exists between the Capricorn microplate and the Sunda blocks. Similarly, the baseline length changes between Capricorn microplate and Australia, indicate a shortening at a rate of about 10 mm/yr, which is in good agreement with earlier findings with a diffusive convergent boundary inferred between Capricorn microplate and Australia. A complex rate of change in baseline length is also noticed between this plate and the two different sites inside the African Plate. The DGAR-ZAMB station pair shows divergence between the two plates at a rate of 9 mm/yr, while the DGAR-SUTH (southern margin of Africa) pair shows convergence at a rate of ~4 mm/yr. The observed divergence between the Capricorn and Rovuma microplates, can be explained by the presence of Comores hotspot in the Somalian Plate, which is centered between north Madagascar and Rovuma microplate. This feature causes deformation due to magmatic extrusion led internal rifting (or spreading) below the Comores Islands and its surrounding regions. Consequently, a broad deformation zone is being formed east to the Rovuma microplate due to internal rifting of the Somalian Plate that includes the northern part of Madagascar and northernmost part of the Lwandle Plate.

Key word: Capricorn microplate kinematics, Madagascar, Indian Ocean, GPS, intraplate seismicity, Deformation zone

INTRODUCTION

During the process of plate-tectonics, movement of rigid lithosphere over the ductile asthenosphere may undergo convergence, divergence and/or strike-slip motion. The relative motion between the major tectonic plates, associated with the underlying plate tectonic processes, is the mechanism for the generation of different geological features as well as land forms (mountains and basins, ocean ridges and trenches). Thus, it acts as the primary driving force for natural disasters like earthquakes and volcanic activities (Wilson and Burke, 1972; Chapple and Forsyth, 1979; Sinton and Detrich., 1992). Interestingly, several studies have indicated the presence of microplates within the major tectonic plates that act as a separate entity and show different kinematics than the major lithospheric plates over which they are located (Bird and Naar, 1994; Koehn et al., 2008). Therefore, it is necessary to study the nature and amount of relative motion between different lithospheric plates for better understanding of the various active tectonic processes and associated deformation.

The Global Positioning System (GPS) technology is one of the effective methodologies to study the deformation and movement occurring at any point on the surface of the earth by evaluating the kinematics of the lithospheric plates (Dixon et al., 1991; Larson and Agnew, 1991; Bevis et al., 1995; Bouin and Vigny, 2000; Sella et al., 2002; Vigny et al., 2005; DeMets et al., 2010; Akilan et al., 2016). The Indian Ocean being the third largest among the oceans, has several neighborhood continental regions, which are associated with diverse plate tectonic processes that govern the geodynamic events occurring in the eastern hemisphere (Schlich, 1982). This region is characterized by many geotectonic features, for example, prominent ridges and triple junctions where three plate boundaries meet. The Indian and Australian Plates have long been referred to as one Indo-Australian Plate. The trio of Indo-Australia, Antarctica and Somalia Plates, meets at the Rodrigues triple junction in the Indian Ocean (Royer and Gorden, 1997). The plate motions in the Indian Ocean do not define the rigidity of the Indo-Australian Plate, suggesting major deformation zones that divide the plate into different blocks (Minster and Jordan, 1978; Stein and Gorden, 1984; Royer and Change, 1991; Royer and Gorden, 1997; Conder and Forsyth, 2001). The distribution of strong earthquakes and the currently available GPS data indicate the presence of three active plates in the region: Indian, Australian and Capricorn microplate, which are moving relative to each other independently and have large regions of diffused boundaries.

The Capricorn microplate located between the Indian and Australian Plates, was basically proposed by Royer and

Gorden (1997) to explain the observed high intraplate seismicity and also to explain the inconsistency found in the plate kinematic models defined using spreading rates, transform fault azimuths, and earthquake slip vectors (Conder and Forsyth, 2001). Nevertheless, plate geometries and kinematics of the Indian Ocean are not tightly constrained in the context of global tectonics. In the present study, the relative motion of the Capricorn microplate within the Indian Ocean is derived using GPS data to understand the plate tectonic processes and deformation/strain pattern surrounding this region.

GEOLOGIC EVOLUTION OF INDIAN OCEAN

The Indian Ocean was created consequent to Gondwana supercontinent breakup that gave rise to the continental segments like Africa, India, Australia, and Antarctica (Reeves and de Wit, 2000; Conder and Forsyth., 2001; Chatterji et al., 2013). The Indian Ocean presently carries two hotspot tracks, Rajmahal–Kerguelen track in the eastern part of the Indian Plate and the Deccan–Reunion and Marian plume in the western part (Chatterji et al., 2013). These hotspot trails are seen in the form of two linear underwater ridges, the Ninety East Ridge and the Chagos–Laccadive Ridge lying on either sides of the Indian Plate. Apart from these, 90 Ma Marion plume, which led to the breakup of Madagascar from the Indian subcontinent was also located close to the west coast of India (Curray and Munasinghe, 1991; Agrawal et al., 1992). The series of islands and seamounts was formed because of the fast northward movement of India during the Cretaceous-Tertiary period over the Kerguelen and Reunion mantle plumes (Duncan and Pyle, 1988; Chatterji et al., 2013). The Ninety East Ridge resulted from the interaction of the Kerguelen plume within the Indian Plate, while the Chagos–Laccadive Ridge resulted from the interaction of the Reunion plume with the Indian Plate. In addition to the general seismicity seen along the ridge axes, notable seismic events occur at the Chagos Bank that lies in the extensional regime between the Indian and Capricorn microplate and located close to the east of Central Indian Ridge axis (Tinnon and Holt., 1995; Radha Krishna et al., 1998; Henstock and Minshull, 2004; Royer et al., 2015). The seismicity in the Chagos Bank is limited to a region of 100 km in north-south extent, which coincides with a deep trough cutting east-west across the bank (Henstock and Minshull., 2004; Royer et al., 2015 and references therein). The Diego-Garcia Island in the Chagos part of the Chagos–Laccadive Ridge, is located to the south of the Chagos bank and characterized by seismic swarm activity. Diego Garcia Island represents the northern edge of the Capricorn microplate.

Regional tectonics and plate boundary features

The Indian Ocean consists of several seismic and aseismic mid-ocean ridges, transform faults, subduction zones and diffused deformation zones (**Figure 1**). Morphologically, it is dominated by four active mid-ocean ridges that include the north-west oriented Carlsberg Ridge (CR), north-south oriented Central Indian Ridge (CIR), Southwest Indian Ridge (SWIR) and Southeast Indian Ridge (SEIR) (McKenzie and Sclater, 1973; Chatterjee et al., 2013). These ridge structures have very different spreading rates and they converge at the Rodriguez Triple Junction (RTJ) in the mid-ocean region. They also mark the boundaries between three major tectonic plates; the Central Indian Ridge and Carlsberg Ridge form the tectonic division between the Somalia (or Africa) and Indo-Australia Plates, the Southeast Indian Ridge separates the Antarctica and Indian–Australia Plates, and the Southwest Indian Ridge demarcates Somalia/Africa from Antarctica Plate (Chatterjee et al., 2013). In comparison, The SWIR, characterized by its slow spreading rate (< 2 cm/year), joins with the Mid-Atlantic Ridge (MAR) system in the west. The SEIR , which has the fastest spreading rate of 7 cm/year, joins with the East Pacific Rise in the Pacific Ocean (Chatterjee et al., 2013). The CIR to the north of Rodriguez Triple Junction runs to the north with a sequence of spreading centers and fractures zones in an echelon fashion, while it turns towards the northwest direction as CR. The CIR and CR systems form the boundary between the Somalia/Africa and Indo-Australian Plates. The Java-Sumatra trench system in the eastern side and the Makran trench in the northwest side are the other two major tectonic features of the Indian Ocean (Bouysse et al., 2004).

As mentioned earlier, the Indian Ocean lithosphere is shared between different major tectonic plates. The Indian and Australian plates were earlier considered as a single unit. But, the global plate motion data and the intraplate seismicity exhibited by the assumed India-Australia single plate, redefined the plate boundary geometry in the Indian ocean and suggested a wide diffused east-west trending boundary, from the CIR to the Java trench, separating the Indian and Australian plates as the two distinct plates (Weissel et al., 1980; Gorden et al., 1990; Royer and Gorden, 1997; Gorden et al., 1998; Conder and Forsyth, 2001; DeMets et al., 2010). A larger misfit in plate motion models along the SEIR exists, than that along other plate boundaries. Royer and Gordon (1997) supported the presence of an additional diffused plate boundary within the Australian plate, to explain misfit along the SEIR, which was introduced as ‘Capricorn’ microplate between India and Australia.

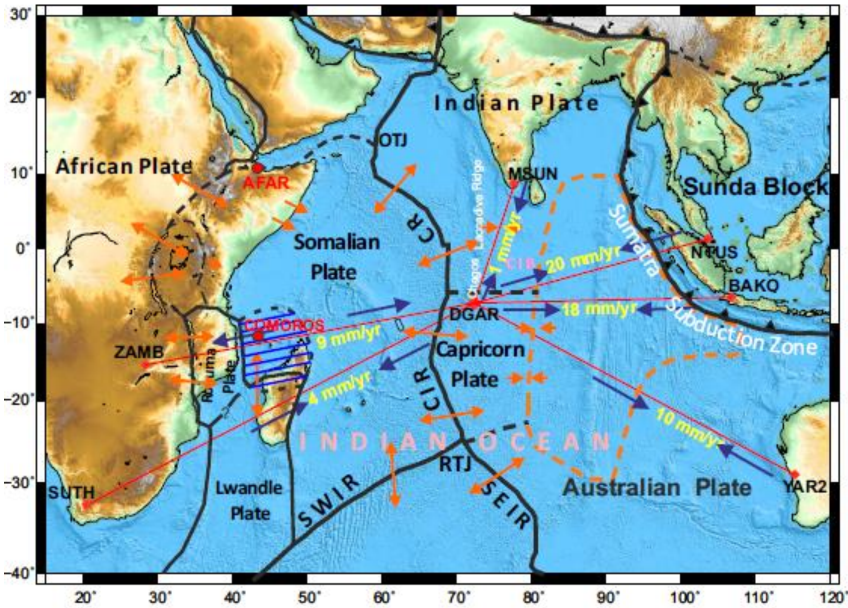

Figure 1. Major tectonic plates and plate boundaries in and around the Indian Plate. Orange broken line marks the diffused plate boundary inferred between the Indian and Australian Plates. Location of the GPS sites (red diamond symbol) and the baseline lengths analyzed, along with their annual rates of change are given. A broad deformation zone that is being formed east of Rovuma in the Somalian Plate, is also shown (Blue lines). SWIR-South West Indian Ridge; SEIR-South East Indian Ridge; CIR-Central Indian ridge; RTJ-Rodrigues Triple Junction; OTJ-Owen Triple Junction.

Thus the original Indo-Australian plate is now considered to be made of three smaller plates: the Indian, Australian, and central `Capricorn' microplate (Figure 1) (Conder and Forsyth, 2001). The boundary between the Capricorn microplate and the Australian Plate extends from the SEIR to the southwest of Java Trench. The primary objective of the present study is to estimate inter-continental scale relative plate motion, which can be inferred by calculating the change in baseline length between the GPS sites in different plates.

GPS DATA ANALYSIS

We analyzed the GPS data from the IGS site located within the Capricorn microplate, namely Diego Garcia (DGAR), and six other sites surrounding the Capricorn plate (Figure 1). All the six sites, namely M. S. University (MSUN), Bakosurtanal (BAKO), Yaragadee (YAR2), Zambia (ZAMB), Suther Land (SUTH), and Singapore (NTUS), are located within the major tectonic plates neighboring the Capricorn microplate. The location details of the GPS sites are given in Table 1. The stations BAKO and NTUS are located in the Sunda Plate, the station YAR2 in the Australian Plate, while the stations ZAMB and SUTH are located in the African Plate. All the above sites fall within the rigid plate.

In the present study, we utilize the GPS data recorded from January 2014 to March 2017. The selection of the data time frame is made in such a way that no large earthquakes occur near Diego Garcia during the period, in order to avoid co-seismic and post-seismic deformations in the crust induced by large earthquakes (Paul et al., 2001; Earnest et al., 2005; Jade et al., 2005; Akilan et al., 2014). This data selection will also avoid any bias in the plate motion evaluation due to earthquake induced deformation effects. For example, the 2004 Sumatra earthquake displaced the Diego Garcia by more than 5 mm (Vigny et al., 2005).

The data processing was carried out using the Bernese 5.0 scientific software (Dach et al., 2007) and baseline lengths between different pairs of station were computed and analyzed using the weekly solutions as widely adopted (Larson and Agnew, 1991). For estimating the change in baseline length between the GPS sites, the rate of change of baseline length per year is derived from the baseline length time series, and strain per year, $\left[\frac{dx}{x}\right]$ (where dx is the change in baseline length/year and the x is the length of the baseline length), is estimated for different arms of baseline lengths formed by the station Diego Garcia. The station DGAR is the fixed station for the entire period of data processing. During the processing, the satellite clock error, receiver clock error, ionosphere error, and the troposphere errors were removed. The precise orbital files were used during the processing. The estimated baseline lengths between different GPS sites, with respect to Diego Garcia, and strain rates are given in Table 2 and Figure 1. As can be seen from Table 2, the R.M.S. error for all the estimations are less than 3 mm.

Table 1. Details of the GPS stations

Station name	Latitude (Deg.)	Longitude (Deg.)	Tectonic plate	Station details
M.S. University (MSUN)	8.76	77.65	Indian plate	NGRI permanent station
Bakosurtanal (BAKO)	-6.49	106.85	Eurasian plate	IGS station
Yarragadee (YAR2)	17.42	78.55	Australian plate	IGS station
Zambia (ZAMB)	-15.43	28.31	African plate	IGS station
Suther Land (SUTH)	-32.38	20.81	African plate	IGS station
Singapore (NTUS)	1.35	103.68	Eurasian plate	IGS station
Diego Garcia (DGAR)	-7.27	72.37	Capricorn plate	IGS station

Table 2. The baseline length between the stations, the corresponding rate per year and the strain rate

Pair of GPS stations	Baseline length between the stations (m)	Rate (mm/yr)	Error (mm)	Strain rate
DGAR-BAKO	3754380.299	-18	2	-4.7944×10^{-9}
DGAR-MSUN	1860354.464	-1	1	-5.37532×10^{-10}
DGAR-NTUS	3557623.589	-20	2	-5.62173×10^{-9}
DGAR-SUTH	5781513.409	-4	3	-6.9186×10^{-10}
DGAR-YAR2	4969198.225	-10	2	-2.0124×10^{-9}
DGAR-ZAMB	4765990.320	9	3	1.88838×10^{-9}

RESULTS

The rate of change in baseline length between two measurement sites (changes in the distance between the pair of stations per year) shows the relative motion between the two sites (Figure 2). While a negative baseline rate indicates convergence between the two studied points used to compute the baseline, a positive value indicates divergence. The accuracy of baseline lengths estimated using GPS is higher below the threshold baseline length of 6000 km (Dach et al., 2007). The baseline lengths estimated between DGAR and the other stations (BAKO, MSUN, NTUS, SUTH, YAR2 and ZAMB) range from 1860354.464 m to 5781513.409 m (Table 2; Figure 1). The changes in baseline length generally suggest the deformation at the plate boundary, but it can also be due to deformation occurring within the plate (intra-plate). The strain rate between the pair of stations, provides an overall indication about the seismicity within the region bounded by the two points on earth. Higher strain rate implies that earthquake occurrence is more likely in the region between the two points, while less strain rate suggests, least seismic activity. The strain rates observed for the different pairs of stations considered in this study vary between -6.9186×10^{-10} and 1.88838×10^{-9} (Table 2). The study provides significant inferences about the observed baseline lengths and strain rates for each station pair and their implications to understand the plate tectonic process operating between the plates in the studied region.

The computed rate of change of baseline length between the DGAR station in the Capricorn microplate and the BAKO station in the Sunda Plate, is -18 mm/yr, which suggests that the two stations are in convergent motion and approaching each other at a rate of 18 mm/yr. Previous study has estimated a NNE resultant velocity of 30.61 mm/yr (north velocity of 30.28 mm/yr and east velcoty of 4.50 mm/yr) for DGAR station with respect to Kerguelen isaland in the Antarctica plate and relative to ITRF 00 (Ravikumar et al., 2008). The major plate boundary existing between the plates, represented by the above two stations, is the wide diffused plate boundary zone that acts as the common divider of the Capricorn-India-Australia-Sunda Plate system (DeMets and Royer, 2003). The east-west orientation of the DGAR-BAKO baseline suggests that the observed deformation can be attributed to the ongoing subduction of the India-Australia-Capricorn microplate system beneath the Sunda block. The deformation caused by the subduction process is producing strain at a yearly rate of -4.7944×10^{-9}, which might be accommodated in the deforming zone and thus could provide necessary conditions for seismogenesis. Similarly, the rate of change of baseline length for the DGAR-NTUS pair, shows a comparable value of -20 mm/year with a corresponding strain rate of -5.62173×10^{-9}. Kreemer et al. (2003) however, estimated higher strain that accumulated in the Sumatra subduction zone resulting in significant seismic hazards in the region. The occurrence of diffuse deformation between DGAR and NTUS, may have contribution from the ongoing subducation occurring along the Sumatra trench, in addition to the diffuse deformation within the Indian Ocean. The present study cannot clearly throw light on to the effect of these two different geological processes on the deformation between DGAR and NTUS.

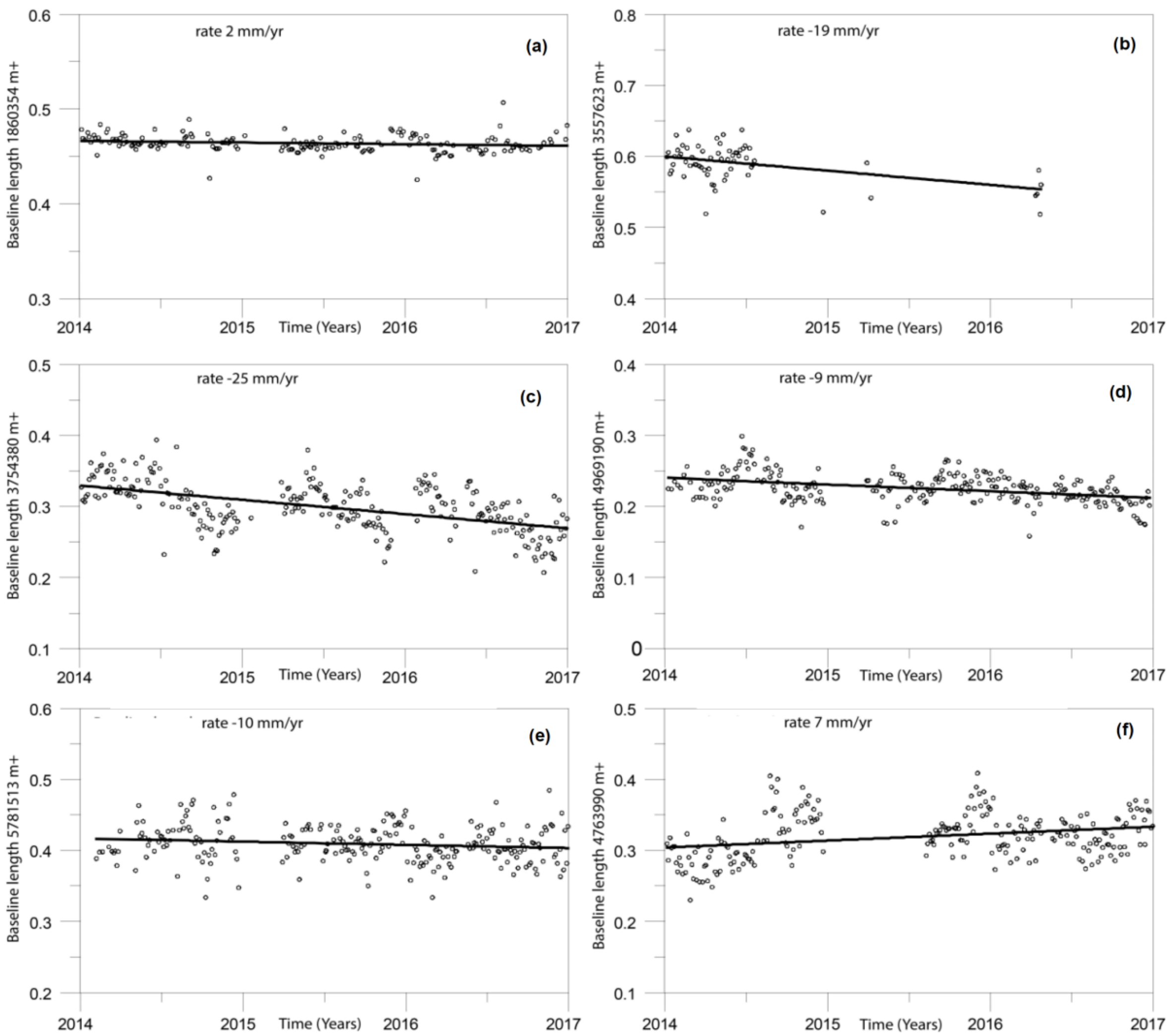

Figure 2. Changes in baseline length between the station pairs, **(a)** DGAR and MSUN, **(b)** DGAR and NTUS, **(c)** DGAR and BAKO, **(d)** DGAR and YAR2, **(e)** DGAR and SUTH and **(f)** DGAR and ZAMB. Their rate of change is shown against each block.

The relative motion between the Capricorn and Indian Plates are inferred from changes in baseline length occurring between the DGAR and MSUN stations, representing the Indian plate. The DGAR-MSUN pair gives a marginal decreasing trend of the baseline length at a rate of 1 mm/yr, which suggests a convergent motion between the Indian plate and Capricorn microplate. The corresponding estimated strain rate is -5.37532 x 10^{-10}. Similarly, the change in baseline length computed for the DGAR-YAR2 pair is -10 mm/yr, which indicates a shortening of baseline length between the Capricorn microplate and the Australia Plate at a rate of 10 mm/yr. The results of this study show a convergence between the Capricorn oceanic lithospheric block and the Australian lithospheric plate, which is in agreement with the findings of Royer and Gordon (1997) that proposed a diffused convergent boundary between the Capricorn microplate and the Australian Plate. Kreemer et al. (2003) have inferred a convergence at the rate of ~11 mm/yr between India and Australia. This study gives the relative motion (convergence) between the Capricorn and Australian Plates at a rate of 10 mm/yr. The estimated strain generated due to this convergence is -2.0124 x 10^{-9}, which could be accommodated along the diffused plate boundary between the Capricorn and Australia Plates.

The kinematics of the Capricorn microplate with respect to the African plate to its west, can be understood from changes in baseline length computed for the DGAR-ZAMB and DGAR-SUTH station pairs (Figure 1). Both the stations ZAMB and SUTH, represent the African Plate. It is found that the baseline change between DGAR and ZAMB occurs at a rate of 9 mm/yr, but that between DGAR and SUTH

(SUTH is in the southern margin of the African plate) is -4 mm/yr. Several tectonic blocks are present between DGAR and ZAMB stations. However, it is not possible to assess the deformation effects at each tectonic segments separately.

DISCUSSION

The plate boundary between the Capricorn microplate and the African plate is defined by the CIR, which is an active spreading ridge in the Indian Ocean (Fisher et al., 1971; Eagles and Hoang, 2014). The dynamics of the plates is well reflected in the rate of change in baseline lengths, as obtained in the present study. Long baselines should be evaluated cautiously as the vertical component of the deformation begins to influence the baseline length between the GPS station pairs having large station spacing. In our study, the stations are not located over geodynamically active zones with significatnt vertical deformation. Hence, the influence of vertical deformation is negligible in the baseleine lengths presented in this study. Divergent kinematics, as seen by the GPS baseline rate estimates, correlates well with the ongoing east-west divergence between the African and Somalian Plates, along the East African rift system (Horner-Johnson et al., 2007). The strain calculated for the DGAR-ZAMB pair baseline is positive, i.e. 1.88838×10^{-9}, suggesting no strain accumulation at the boundary between the African and Indian Plates, which also correlates with the low seismicity along the CIR, as compared to the SWIR and SEIR. On the other hand, the DGAR-SUTH pair shows a convergence motion between the plates at a rate of -4 mm/yr. The above contradicting observation seen between the two baseline arms, i.e., DGAR-ZAMB and DGAR-SUTH, having stations within same plates (i.e., DGAR in Capricorn microplate, and ZAMB and SUTH in African Plate), illustrate a complex plate dynamics in the region. The Lwandle-Somalia Plate boundary is now inferred to be a diffused plate boundary zone that gives rise to the east-west convergence (e.g., Horner-Johnson et al., 2007). Thus, our GPS observation along the DGAR-SUTH arm, clearly identifies the convergent plate kinematics occurring between the African Plate and the southern segment of the Somalia Plate. Therefore, we infer that the convergence along the diffused Lwandle-Somalia Plate boundary, dominates over the divergence along the CIR.

Cause of divergence between DGAR and ZAMB

As mentioned earlier, baseline lengths estimated between DGAR and ZAMB, show a divergence between the two plates. The estimated rate of divergence is 9 mm/yr. Earlier, Royer and Gorden (1997) too indicated that the Indian Plate, west of the Capricon micro-plate is diverging in contrast to the convergence of the Indian Plate with respect to the Australian Plate, located east of the Capricon microplate. It appears that the Somalian plate is undergoing deformation due to internal spreading below the Comores Islands and its surrounding regions due to the presence of Comores hotspot underneath. This hotspot is located at around 12°S and 43°E in the Somalian Plate (Courtillot et al., 2003), which is considered as an active volcanic region and thus undergoing rifting and spreading, as found between DGAR and ZAMB. This spreading is possibly percolating down to south across the northern part of Madagascar, which may well be fragmenting and deforming (Hartnady, 2002; Stamps et al., 2008; Kusky et al., 2010). Northern part of Madagascar and the Comores Island is deforming inconsistently with rigid plate motion (Stamps et al., 2021). Northern Madagascar moves rigidly with the Somalian Plate and southern Madagascar moves with the Lwandle microplate (Saria et al., 2014).

Formation of a new deformation zone

It is well known that a large-scale thermal anomaly exists in the Afar region and most researchers ascribe it to a deep mantle plume (Horner-Johnson et al., 2007). Intriguingly, Comores hotspot is aligned with the Afar hotspot in the Red sea region of Ethiopia. Currently, the Red sea rifting region joins with the rifting associated with the East African rift system, which is one of the world’s longest rifts that extends for thousands of kilometer from Ethiopia to Mozambique and passes through the multiple African countries. In a similar manner, the Madagascar, which is an island country in the Indian Ocean, that broke out from the Indian subcontinent at around 88 Ma back due to the outburst of the Marion plume (Agrawal et al., 1992), has again been breaking up, into smaller islands. Quite likely, the East African rift system may, in some way, be associated with the breaking up of northern Madagascar as well. This suggests that a broad deformation zone is being formed to east of Rovuma in the Somalian Plate (Figure 1) due to internal rifting of the Somalian Plate that covers the northern part of Madagascar and the northernmost part of the Lwandle Plate. (Figure 1). Stamps et al. (2021) recently indicated that the Comores Islands region, which is a diffused transitional zone, accommodates extension between the Somalian Plate and the Rovuma microplate.

The main constraint of this work lies in the reliance on a single site data (DGAR), which is situated on an island in the northern region of the proposed Capricorn microplate. Additional GNSS array with dense stations would definitely be needed to provide a better picture of the plate kinematics of the Capricorn microplate and its surrounding regions.

CONCLUSIONS

We studied the relative plate motions between the Capricorn microplate and the surrounding plates, viz., Indian, Australian, Sunda and African Plates, using the changes in baseline length values obtained from the GPS data. The relative motion between India and Diego Garcia is convergent in nature and occurs at a quite low rate of ~1 mm/yr. The rate of change in baseline length between the DGAR station in the Capricorn microplate and the BAKO station in the Sunda Plate, shows significant convergence at a rate of 18 mm/yr. The change in baseline length computed for the DGAR-YAR2 pair, indicates a shortening of baseline length between the Capricorn microplate and the Australia Plate at a rate of 10 mm/yr, which is in agreement with diffused convergent boundary inferred between Capricorn and Australia by Royer and Gordon (1997). Importantly, contrasting baseline change is obtained between DGAR and a station located in the African Plate . The DGAR-ZAMB pair shows divergence between the two plates at a rate of 9 mm/yr, while the DGAR-SUTH (station located in the southern margin of the African Plate) pair, shows a convergence motion between the plates at a rate of 4 mm/yr, which are well correlated with the complex plate kinematics in this region. Our results infer an amalgamation of the Australian continent, Sunda block and Diego Garcia from the plate tectonic kinematics. It appears that a broad deformation zone is being formed to east of the Rovuma Plate in the Somalian Plate due to regional rifting that covers the northern part of Madagascar and the northernmost part of the Lwandle Plate.

Acknowledgements

We thank Dr. Prakash Kumar, Director, CSIR-NGRI for granting permission to publish this work. The GPS data used in this study are obtained from the global data center (http://sopac.ucsd.edu/dataBrowser.shtml). This work has been carried out under the MLP 7018-28(HVS) project of CSIR-NGRI.

Author Credit Statement

A. Akilan: Conceptualised, processed the data and wrote the paper. K. K. Abdul Azeez, Sravan K Kotluri, H.V.S. Satyanarayana, S. Padhy, O.P. Pandey wrote and edited the paper.

Data Availability

All the data (except MSUN) downloaded from global data base and available from the corresponding author on reasonable request.

Compliance with Ethical standards

The authors declare no conflict of interest and adhere to copyright norms

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Received on: 24-10-2024; Revised on: 12-01-2025 ; Accepted on: 16-01-2025