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Mesozoic to Neogene Tectonism and Evolution of Murray Ridge

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ABSTRACT

This paper is chiefly focused on Mesozoic to Neogene tectonism and evolution of marginal basins of Indian Craton in the east of Murray Ridge including Offshore Indus Basin of Pakistan, evolution of the Murray Ridge and its effect on sedimentation in the Offshore Indus Basin and movement of the Indo-Pakistani Craton in a NE, with a significant shift in the strike of the Murray Ridge in the NE. The Mesozoic to Neogene tectonism has been found important in the evolution process of the marginal basins of Indian Craton in the east of Murray Ridge. The major marginal basins in the east of Murray Ridge, with their synonymous regional structural history includes Offshore Indus and Lower Indus basins of Pakistan and Kach, Cambay, Narmada, Saurashtra and Bombay basins of India. The widespread presence of Deccan volcanics as penetrated in most of the Onshore Lower Indus Basin and the near-shore wells of the Offshore Indus Basin at the base of Tertiary witness the Late Cretaceous rifting event of the Indo-Pakistani Craton from Medagascar (Baloch, S.M. 2000/Un-published). The evolution of Murray Ridge and change in the strike of this ridge in the NE has been interpreted as an effect of Mesozoic to Neogene tectonic events of the Indo-Pakistani Craton.

INTRODUCTION

The various Mesozoic to Neogene rifting and drifting events of the Indo-Pakistani Craton with Eurasia have resulted in evolution of the marginal basins of Indian Craton in the east of Murray Ridge. Configurations of the basement involved normal faults interpreted on seismic sections have proved existence of extensional tectonic regime for the marginal basins in the east of Murray Ridge. The concepts of earlier workers on the regional structural evolution have been compared with the present study, which reveal that no effect of any compressional tectonism was found in the marginal basins evolved in the East of Murray Ridge. All the interpreted Mesozoic, Tertiary and younger successions were found as representing a similar extensional regime with major normal and rollover structural features and their upward extension in the younger strata (Baloch, S.M. 2000/Un-published). The rifting and drifting phases have been found as playing a significant role in the evolution of marginal basins of Indo-Pakistani-Craton, and the prominent Murray Ridge. The compressional structural configuration has been witnessed in the west of Murray Ridge in Pakistan Offshore, where there is a inter-plate thrusting between the Arabian and Eurasian plates.

MESOZOIC AND PALEOGENE TECTONISM AND EVOLUTION OF MARGINAL BASINS OF INDIAN CRATON IN THE EAST OF MURRAY RIDGE INCLUDING OFFSHORE INDUS BASIN OF PAKISTAN

The rifting concept of the Indian Craton from Madagascar, and its northward movement gives a good insight on evolution of the northwestern marginal basins of the Indo-Pakistani Craton evolved in the east of Murray Ridge as well as the structural geometry of these basins. These structural events are associated with at least four phases of Indo-Pakistani Craton movement (Figures 1-4) after its separation from Madagascar since the Late Cretaceous (Figure 1) to its Early Miocene Orogenic / Intra-Cratonic structural evolution event (Figure 4) (Hay et al., 1999). The various drifting events of the Indo-Pakistani Craton from its 1st to 4th phase of movement (Figures 1-4) have resulted in shifting the position of this major plate in a NE direction from 0°-30° to 30°-60° and onward between 60°-90° East. These stages have been compared with various subsidence and thermal cooling events of the Offshore Indus Basin of Pakistan, as discussed by Baloch and Qurik 2001, under the caption "Computed Tectonic Subsidence and Hydrocarbon Generation of the Offshore Indus Basin of Pakistan" in Pakistan Journal of Hydrocarbon Research vol.12, 2001.

A mid-oceanic ridge produced as an effect of rifting of the Indian Plate and eventually thinning of the lithosphere of this plate is named as Murray Ridge. The offshore Pakistan represents two different regional tectonic events on both sides of the Murray Ridge. The west of Murray Ridge represents a compressional tectonism with thrusting structural configurations resulted as a major effect of inter-plate thrusting between Arabian and Eurasian plates in the west of Murray Ridge, whereas, the basins evolved in the east of Murray Ridge are governed under an extensional regime of tectonism, characterized by normal and rollover structural patterns (Baloch, S.M 2000/Un-published). These normal faults bound the extensional marginal basins including the Lower Indus and Offshore Indus Basins of Pakistan (Baloch, S.M. 2000/Un-published) and the Kach, Cambay, Narmada, Saurashtra and Bombay basins of India (Biswas, 1987). Similar normal fault-bound marginal basins with an extensional origin have been recognized along the Namibian Continental Margin and the East Argentinean Margin (Miller et al., 1992 and Light et al., 1993).

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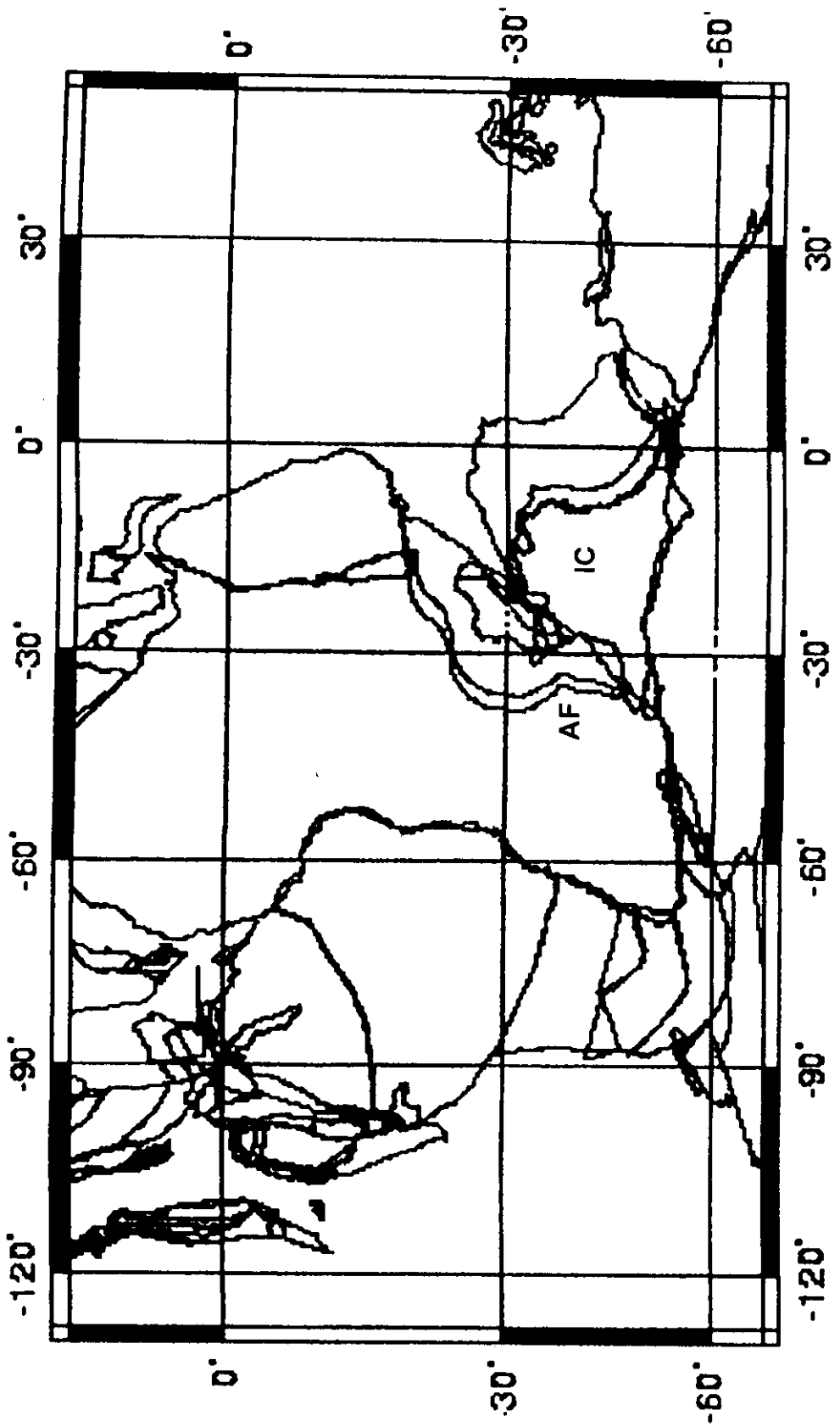


Figure 1- Pre-rift position of Indian-Pakistani Craton (modified after Hay et al., 1999).

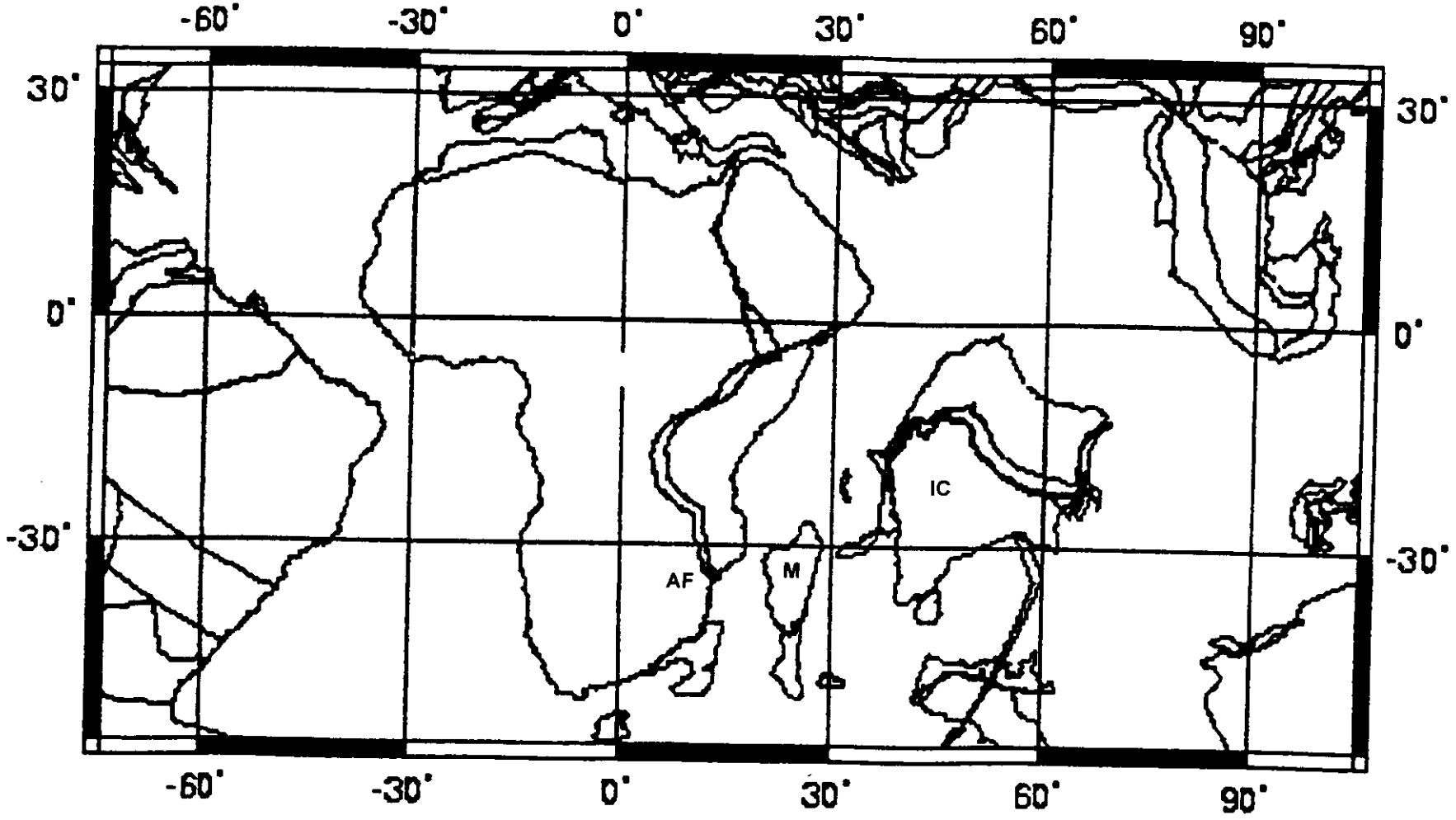
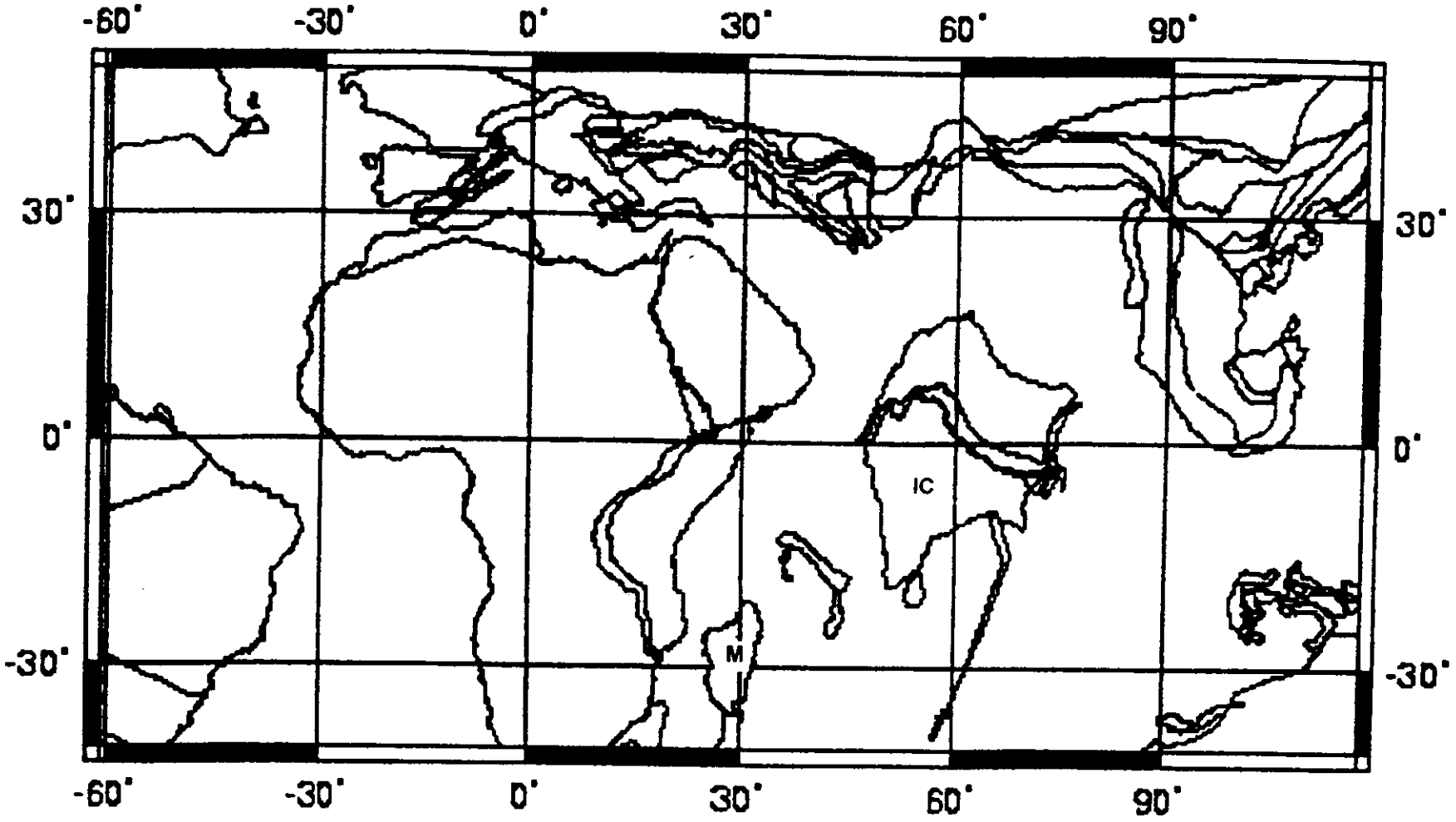


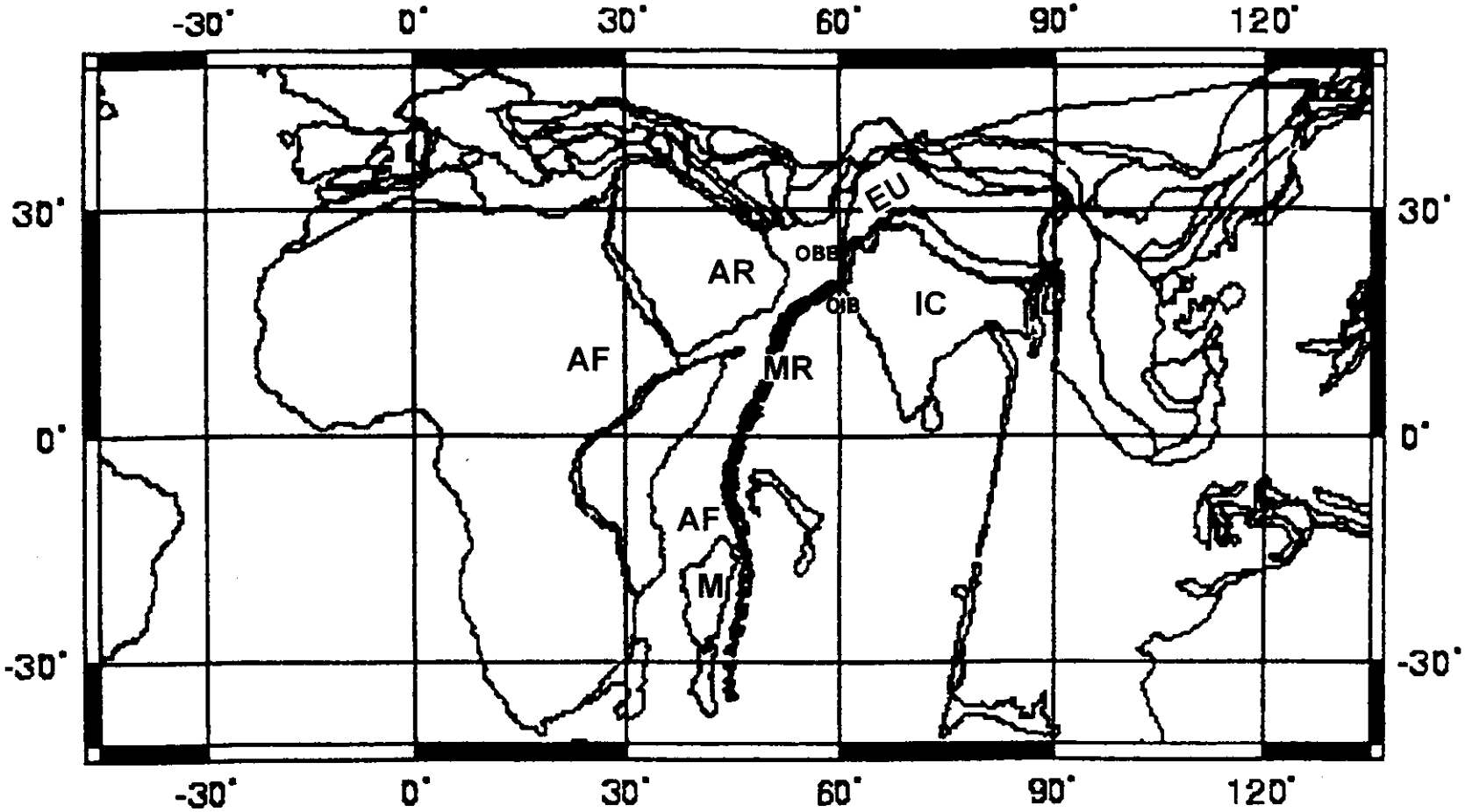
Figure 2- Late Cretaceous rifting position of Indo-Pakistani Craton (modified after Hay et al., 1999).



55 Ma Reconstruction

Key
IC = India-Pakistan Craton
M = Madagascar

Figure 3- Early Eocene drifting position of Indian-Pakistani Craton (modified after Hay et al., 1999).



20 Ma Reconstruction

Key

AF = Africa	IC = India-Pakistan Craton
M = Madagascar	EU = Eurasia
AR = Arabia	MR = Murray Ridge
OBB = Offshore Balochistan Basin	
OIB = Offshore Indus Basin	

Figure 4- Early Miocene drifting position of Indian-Pakistani Craton (modified after Hay et al., 1999).

Northward in Pakistan Offshore the Murray Ridge extends to unite the Ornach-Nal-Chaman Fault (ONC) in the onshore, displaying a strike-slip boundary between the major tectonic plates of India and Eurasia (Figure 5). In onshore the major sedimentary region in the east of ONC fault is the Indus Basin and in its west is the Balochistan Region, with various basins, differentiated on the bases of various geological sedimentary succession. In Offshore Pakistan the Murray Ridge plays a boundary between the Offshore Indus and Offshore Balochistan basins.

NEOGENE INTRA-CRATONIC TECTONISM OF INDIAN CRATON AND ITS EFFECTS ON THE OFFSHORE INDUS BASIN OF PAKISTAN

The Neogene intra-cratonic phase of tectonism of Indian Craton is associated with the orogenic event of the Himalayan Mountain Range in the northeast (Powell, 1979). In the Offshore Indus Basin the Miocene is characterized by widespread siliciclastic deposits sourced by the River Indus from the Himalayas to the NE (Kolla and Coumes, 1987). The extensional normal faults identified in the Miocene and younger strata of the Offshore Indus Basin of Pakistan have been associated with the latest phase of tectonism of the marginal basins in the east of Murray Ridge (Baloch, S.M. 2000/Un-published).

EVOLUTION OF MURRAY RIDGE AND ITS EFFECT ON SEDIMENTATION IN THE OFFSHORE INDUS BASIN

The evolution of the Murray Ridge is associated with rifting of the Indian Craton from Madagascar. Rifting occurred due to convective upwelling of asthenosphere causing extension of the crest and volcanism. The widespread Deccan Volcanics, which mark the base of Tertiary in the marginal basins of Pakistan and India, record this tectonic event (Baloch, S.M. 2000/Un-published). During rifting the lithosphere thinned due to extension and eventually the asthenosphere broke down to produce a mid oceanic ridge. Thus a new basin with oceanic crust was formed which is bordered by areas of stretched continental lithosphere and passive margin basins in the east of Murray Ridge. Offshore Pakistan rifting produced a new oceanic basin called the Offshore Balochistan Basin, which is bordered by the passive margin of the continental Offshore Indus Basin, located in the east of Murray Ridge (Figure 5&6). Due to thermal cooling, the thinned crust tends to subside and produces accommodation space for sediments to accumulate as in the case of the Offshore Indus Basin.

The predominantly Paleogene carbonates in the Offshore Indus Basin suggest that siliciclastics were not being sourced from the Himalayas at this time (Baloch, S.M., 2000 / Unpublished). It would, therefore, appear that a major tectonic event occurred in the Early Miocene, possibly the creation of the Himalayas themselves, which caused an influx of siliciclastic material and carbonate deposition to switch off.

EXPLANATION FOR CHANGE IN STRIKE OF THE MURRAY RIDGE AT ITS NORTH-EAST

The Murray Ridge runs sub-parallel to the apparent drift direction of the Indian Craton from Africa (Figures 5 & 6). This implies that there was some sinistral strike-slip movement along the ridge as the craton was moved northward towards Eurasia during the Tertiary (Figures 1, 2, 3 & 4). Change in the strike direction of the Murray Ridge in its northeast is associated with a change in the locus of seafloor spreading and shift in the drifting position of the Indian Craton. Collision of the Arabian Plate in the west with Eurasia in the Early Miocene caused enhancement in shifting the northern part of the Murray Ridge to the east while its 4th stage (Figure-4).

An evidence given by the earlier workers for the initial Late Cretaceous-Early Paleocene drifting of the Indian Craton and its collision with Eurasia is the widespread extrusion of ophiolites in the Bela and Muslimbagh areas onshore (Gansser, 1979) from south to north, along the Ornach-Nal-Chaman fault (Figure 5). These ophiolites, which become younger between Paleocene-Eocene ages were traced by earlier workers further north in the Chitral and Kabul areas (Auden, 1974) indicate variation in movement of Indo-Pakistani Craton during different geological periods.

The prominent Balochistan fold belt in the onshore including the Sulaiman and Kirthar Ranges (Figures 5 & 6) is believed to have been initiated during the Late Paleocene-Eocene collision phase of the Indian Craton with Eurasian Plate (Auden, 1974). This fold belt extends NE to the Salt Range (Figure 6). This mega structural pattern also helps enhancement in shifting the strike direction of Murray Ridge in addition to various drifting phases of Indo-Pakistani Craton.

SUMMARY

- Comparison of the present study with the earlier work revealed that various tectonic stages of Indo-Pakistani Craton have caused NE movement of this plate with significant change in the position of Indian Plate with reference to the regional co-ordinates through various geological time.
- The rifting occurred due to convective upwelling of the asthenosphere causing extension of crust and volcanism.
- The evolution of Murray Ridge is associated with Mesozoic-Neogene tectonic events of the Indian Plate.
- Rifting process in Pakistan Offshore eventually caused break through to produce the Murray Ridge with a basin of oceanic crust in the west called Offshore Balochistan and a marginal basin in the east known as the Offshore Indus Basin of Pakistan.
- The Murray Ridge which is displaying a boundary between the Offshore Indus Basin in the east and the Offshore Balochistan Basin in the west is extending northward in the onshore area to unite the Ornach-Nal-Chaman boundary fault between the Indian and Eurasia plates.

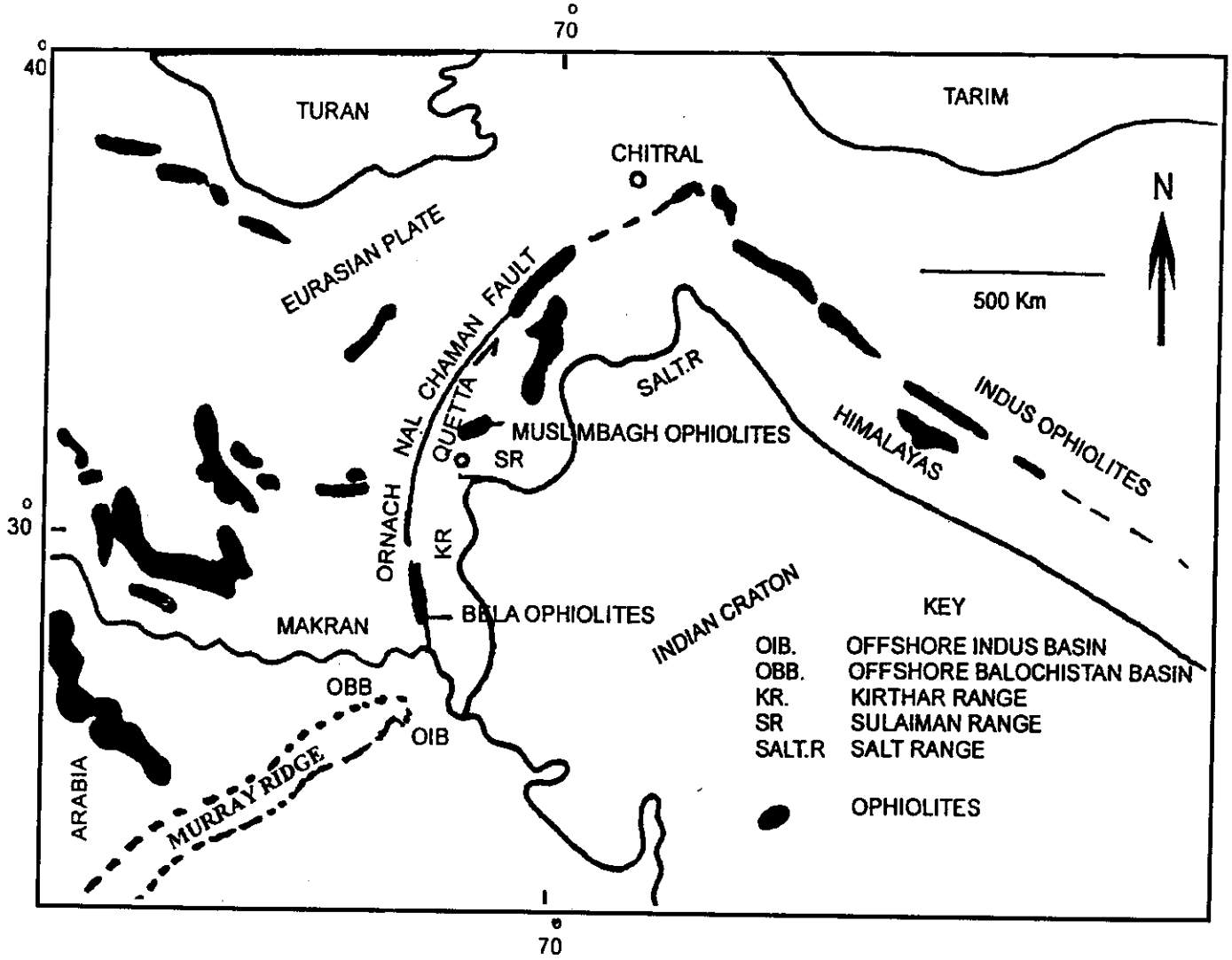


Figure 5- Map showing ophiolites, related to Mesozoic – Neogene events of tectonism between Indian, Eurasian and Arabian plates.

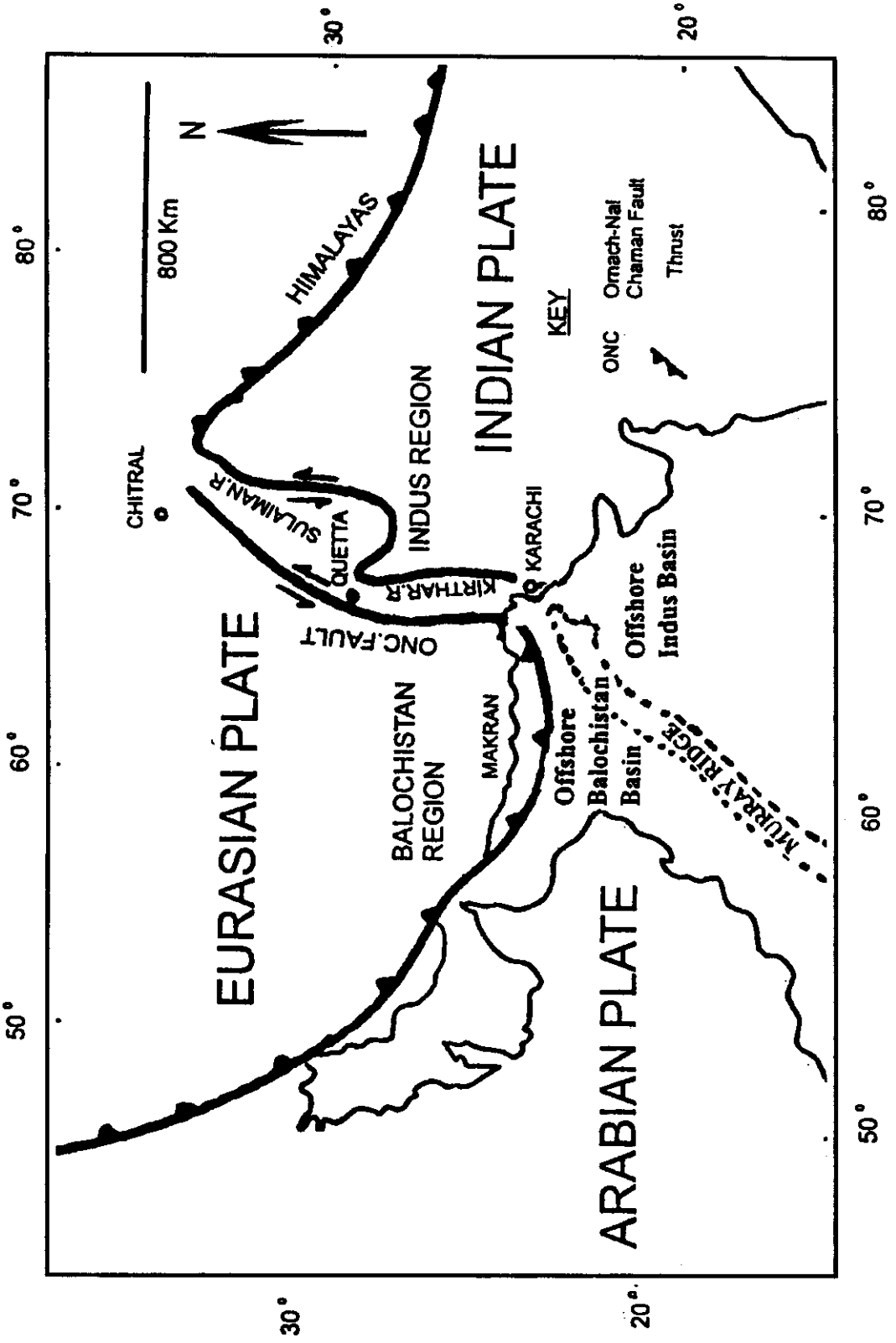


Figure 6- Map showing major plates, main onshore and offshore regions of Pakistan and prominent structural features.

- The wide spread ophiolites identified by the earlier workers and the volcanics at the base of Tertiary in the Onshore Lower Indus and near-shore wells of the Offshore Indus Basin have been found as playing a key role in witnessing the Mesozoic and Tertiary tectonic events.
- A significant NE shift in the strike of Murray Ridge with geological time with respect to the regional co-ordinates is associated with a change in the locus of seafloor spreading and shift in the drifting position of Indian Plate. However collision of Arabian Plate in the west with Eurasia in the early Miocene also helps in further movement of the strike of this ridge as witnessed during movement period of Indian Plate while its 4th stage.

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