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Tectonic Evolution of Structures in Southern Sindh Monocline, Indus Basin, Pakistan Formed in Multi-Extensional Tectonic Episodes of Indian Plate

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Summary

There are number of structures and structural styles found in extensional tectonic settings of the world but the evolution of these structuresis still needful and a big challenge as well. Evolution of structures in extensional settings have been studied by Yuan Li et al., (2016)and many other reserachers on different extensional basins of the world. Sindh Monocline lies on the western corner of Indian Plate and the tectonic history of Indian plate has been well described by Chatterjee et al., (2013) while tectonic history of Sindh Monocline has been studied by Zaigham, and Mallick, (2000), Chatterjee et al., (2013) (Fig.1). The aim of this study is the evolution of structures in the subsurface of Southern Sindh Monocline, Pakistan using the seismic data interpretation and faltenning of horizons approach. Jamaluddin et al., (2015) and others have also testified such approach. Southern Sindh Monocline is charaterized and experienced by different tectonic episodes of Indian plate while rifting from Gondwanaland, rifting from other plates at different geological times and to its collision with the Asia. Basic structures with in study area are classified into nine types whilethe structural styles have been classified into six types as horst and grabens,dominos,crotch,synthetic and antithetic,negative and flashlight structural style. The structures with in the study area revealed evidence for three major structural episodes which can be characterized as Episode 1: Structures associated with rifting of Indian plate from Gondwanaland during Late Jurassic to Early Cretaceous, Episode 2: Modification and reactivation of previous structures while Madagascar rifted from Indian Plate during the Middle Cretaceous and during Episode 3: Inversion and reactivation of structures occurred when Indian Plate collided with Asia during Early Eocene (Fig. 2).

Theory / Method / Workflow

Seismic data, well log(s) have been used for the study of tectonic evolution of structures, structural styles. Kinematics of Indian plate has been studies by using GPlate software used for the reconstrcution of tectonic plates.

Results, Observations, Conclusions

Structural styles evolved in various tectonic settings are extremely important and most prolific for the accumulation of hydrocarbons. Variety of structures, structural styles and hydrocarbon structural traps are broadly associated with the unified mechanism of their formation in different plate tectonic settings. World's major hydrocarbon fields and major portion of hydrocarbon potential is located in extensional basins. The area selected for the study is also characterized by extensional structures and because of that many hydrocarbon fields have already been discovered from Southern Sindh Monocline. As Sindh Monocline is producing 30% of country's oil and 12% of country's gas production is from Sindh Monocline. There are number of structures and structural styles found in extensional basins of the world

but Some structures hold better prospects than others and the identification of these structures using seismic data is a big challenge as well.

On the basis of overall results the conclusions of the study can be made as: Study area is largely characterized by normal faults. Basic structures of study area has been classified into nine types as Large normal faults Small normal faults, Spoon shape normal faults, Master normal faults, Rider normal faults, Folding, Flexure, Vertical faults and Listric shovel. Structural styles have been classified into six types as Horst and grabens, Dominos, Crotch, Synthetic and antithetic faults, Negative and Flashlight structural styles. New type of structural style i.e. “Flashlight structural style”, is reported first time from extensional basin during current study. The structures with in the study area revealed evidence for three major structural episodes first one associated with the rifting during Late Jurassic to Early Cretaceous, modification and reactivation of earlier structures during the Middle Cretaceous and inversion and reactivation during Early Eocene. Present day trap was also formed in third episode. Large normal faults have more chance of success as compared with other structural styles. The migration of hydrocarbons from source rock (Sembar Fm) to reservoir rock (Lower Goru Sands) probably have been greatly facilitated by faults and juxtaposed lithology.

Novel/Additive Information

In the global outlook, study area is located at the intersection of Indian, plate and Eurasian plates (Fig. 3). The Indian plate in the Jurassic-Early Cretaceous underway drifting in the northeastern direction forming an island continent that floated northwards into the Tethyan Ocean and collision with the Asiaoccurred in Paleocene-Early Eocene age. This collision is characterized by face-face collision, abduction and thrusting is the main cause of the Himalayan Orogen. The Southern Indus Basin was experiencedby extensional tectonics and generation of normal faulting followed by volcanic activity hasbeen observed in the southern Sindh during Early-Middle Cretaceous. These two focal tectonic episodes have greatly affected on the structures and structural stylesand revised the tectonics of the study area (Malick et al., 1988). Better understanding of the tectonic evolution will ultimately provide strategies for the new oil and gas discoveries in the study area (Fig.3)

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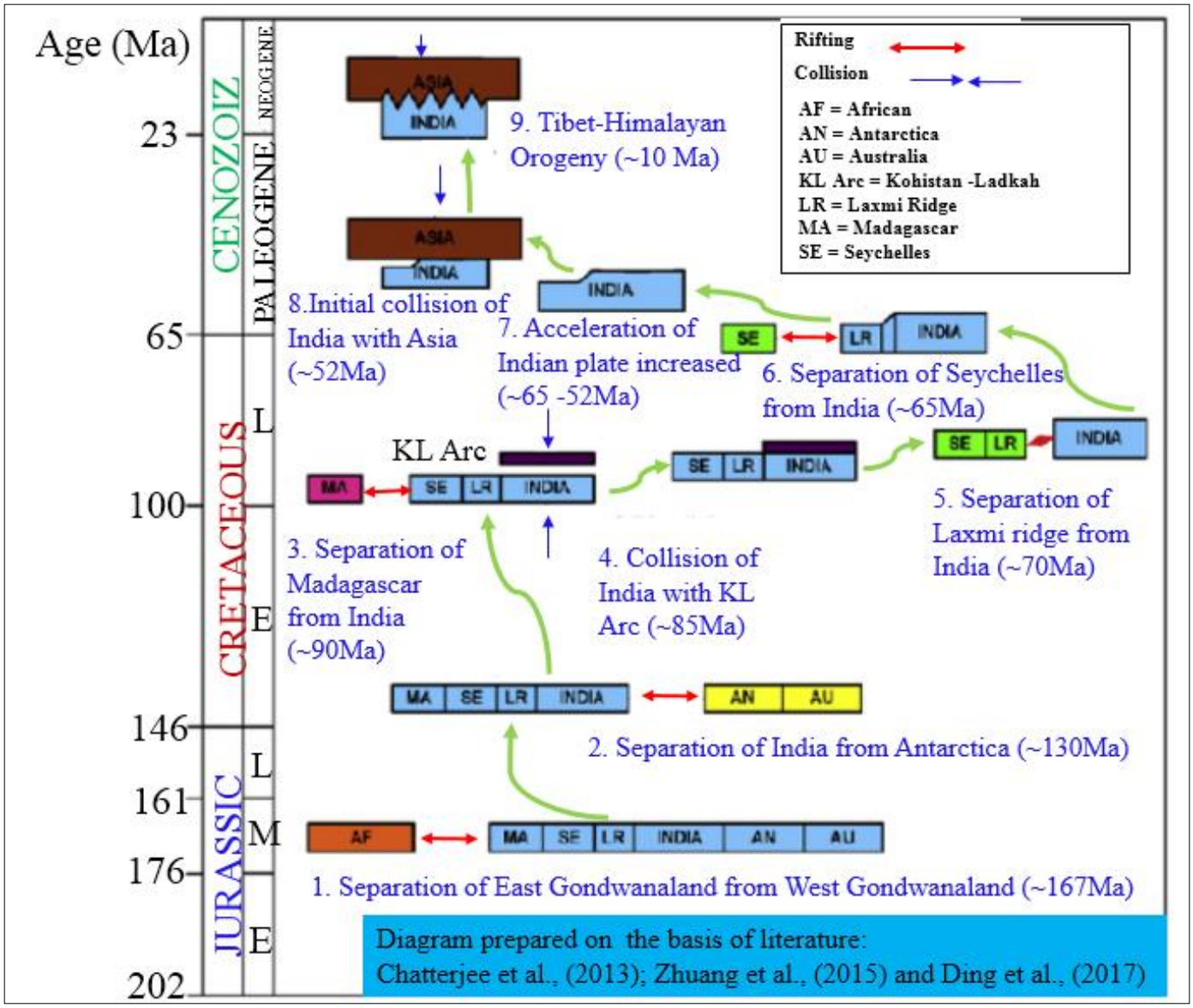

Fig.1 Tectonic evolutionary episodes of Indian Plate

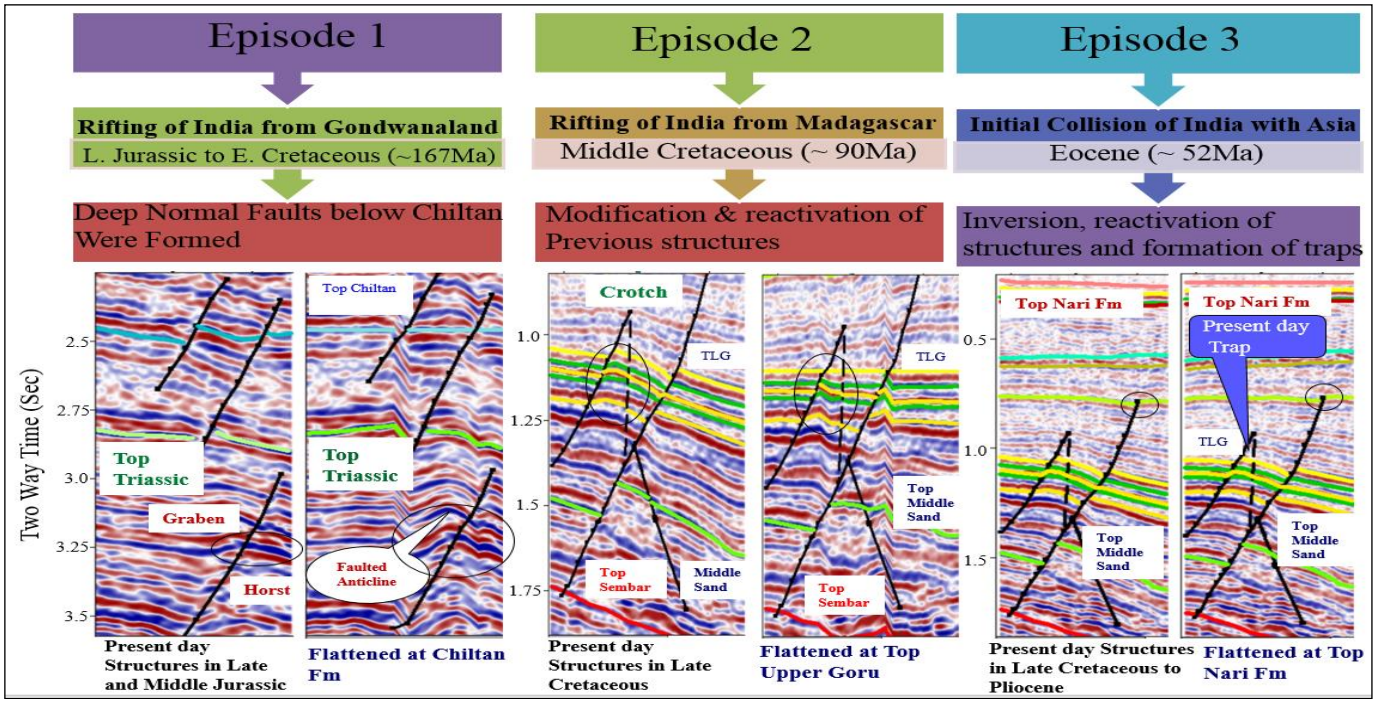

Fig. 2 Evolution of Structures in Extensional Tectonic Setting in Southern Sindh Monocline, Indus Basin, Pakistan

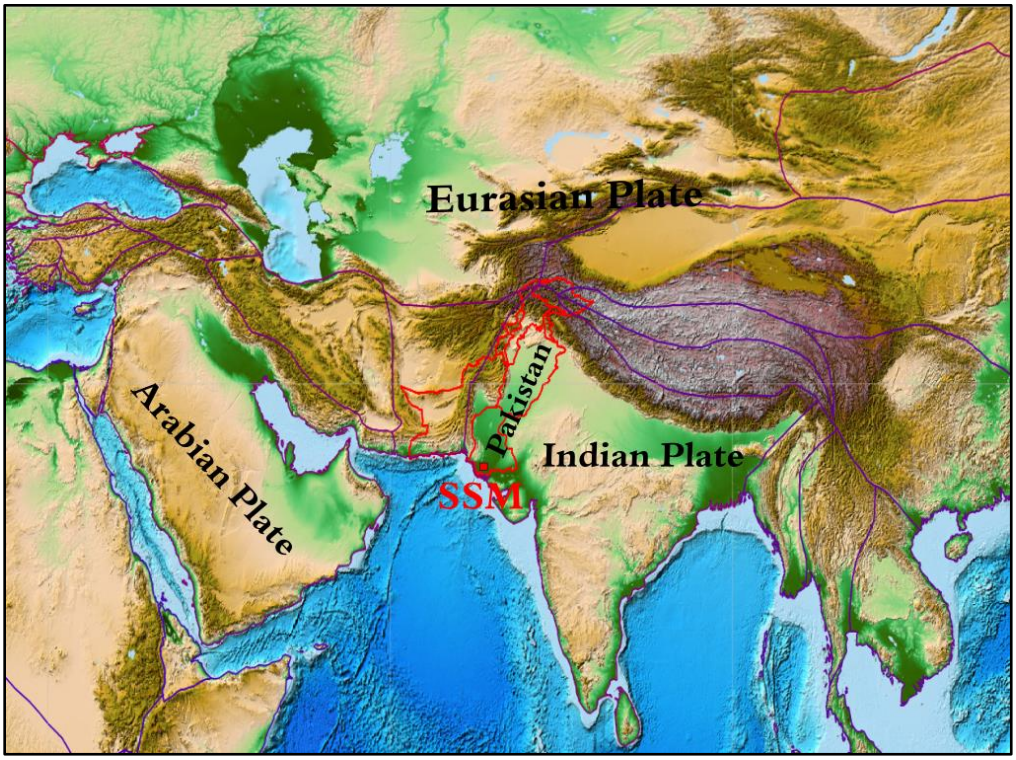

Fig.3 Map showing the location of SSM at the intersection of Indian plate, Arabian plate and Eurasian plate (Map generated using GPlates)