1999 AAPG Distinguished Lecture — 4-D analysis of extensional fault systems in rift basins

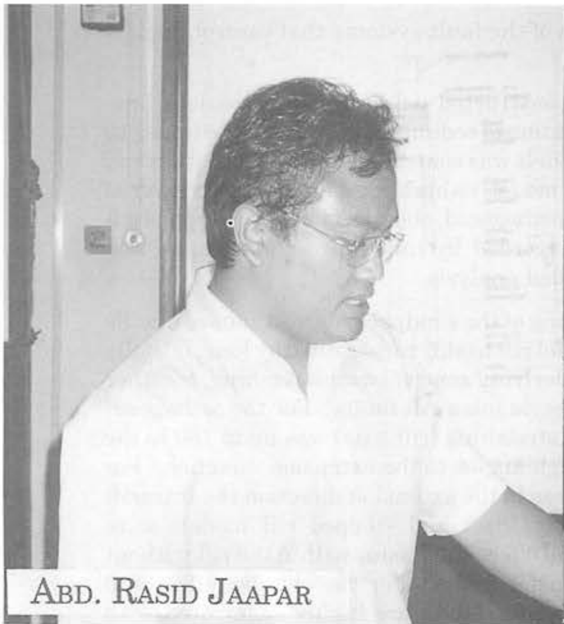
KEN MCCLAY

Laporan (Report)

Ken McClay, Acro Professor of Structural Geology, Royal Holloway, University of London, U.K., gave the above lecture on 17th June 1999, at the Geology Department, University of Malaya.

Abstrak (Abstract)

The 4-D evolution of extensional fault systems in sedimentary basins, and in particular rift systems, has been investigated using scaled sandbox analogue models. Sandbox models have proved to be a powerful and graphic tool in developing an understanding of the 4-D geometric and kinematic evolution of extensional fault systems. The model results have been compared with natural examples of fault systems at both outcrop and seismic scales. Many rift basins and passive margins contain major hydrocarbon accumulations and an under-



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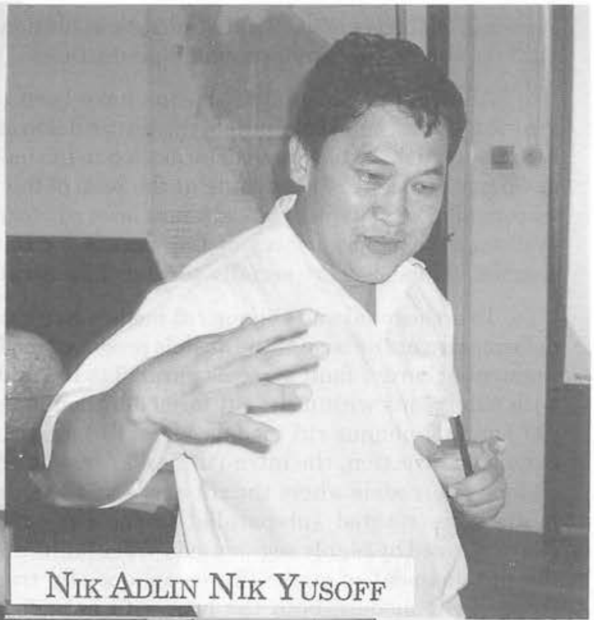


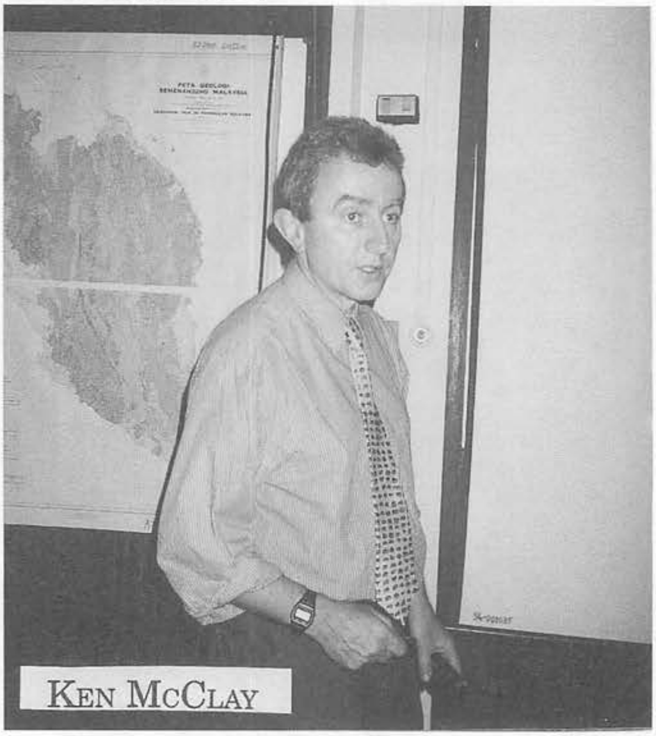
NIK ADLIN NIK YUSOFF

standing of the geometric and kinematic evolution of the fault systems that control them is vital for successful exploration and production.

Analogue models of rift basins have been constructed using dry, cohesionless fine-grained, quartz sand to simulate the brittle deformation of sedimentary rocks in the upper 10 km of the crust. Extensional deformation in the models was controlled by the orientation and geometry of a zone of stretching at the base of the model, either a rubber sheet or a layer of viscous silicone polymer. Models have been run for orthogonal, oblique, offset and stepped rift systems. The top surfaces of the models were recorded by time-lapse photography and completed models were serially sectioned for detailed analysis.

In orthogonal and oblique rift models stretching of the sandpack above a zone of ductile deformation at the base of the models produced model rift basins constrained by long, initially segmented border fault systems parallel to the underlying zone of basal stretching, together with sub-basins within the rift formed by domino-style intra-rift faults. For the orthogonal (90") and for oblique rift models where the zone of stretching (rift axis) was up to 150 to the extension direction, the intra-rift faults were at high angles to the extension direction. For oblique rift models where the rift axis was 450 or less to the extension direction the intrarift faults were rotated sub-parallel to the rift axis. Offset and stepped rift models were characterized by highly segmented border faults and offset sub-basins within the rift without the development of strike-slip or oblique-slip transfer faults. For the oblique, offset and stepped rift models, both the intra-rift and rift border faults are highly segmented with individual offsets of like-dipping, dominostyle, extensional faults forming characteristic relay ramp structures. Offset, oppositely dipping extensional faults from interlocking fault arrays-transfer zones. Along-strike displacement transfer within the rift between segmented and offset sub-basins is accommodated by "soft-linked" accommodation zones characterized by interlocking arrays of conjugate extensional fault systems. The results of these analogue model studies have permitted the construction of 4-D evolutionary extensional fault models that can be applied to natural fault systems in sedimentary basins.

The results of the analogue models are compared and contrasted with natural examples of extensional fault systems from the Gulf of Suez and Red Sea, Egypt, from the Gulf of Aden, Yemen, from the North Sea, Indonesia and Australia. These natural extensional fault systems show geometries, segmentation and offset structures that are extremely similar to those developed in the analogue models.



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