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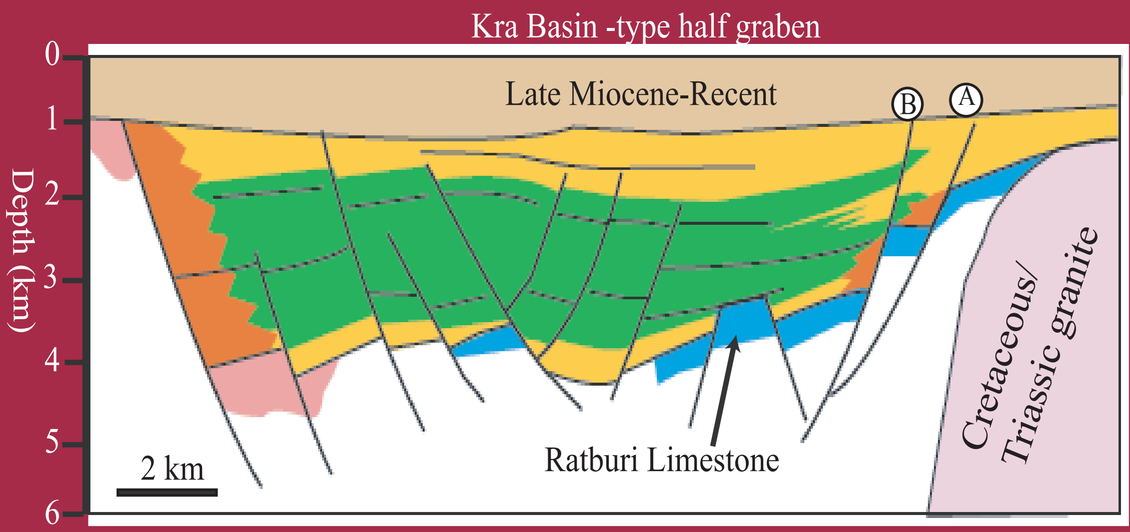

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Cover: A schematic model of the Kra Basin (page 3)

Editorial office:
Department of Geology, Faculty of Science, Chulalongkorn University, Phrayathai Road., Bangkok 10330, THAILAND.
Telephone: 66-2-218-5445, 218-5442-3 Fax: 66-2-218-5464
Website: http://www.geo.sc.chula.ac.th/geonew/Page/BESTjournal.php Editor Email: monkeng@hotmail.com

Preface

The Bulletin of Earth Sciences of Thailand (BEST) has established itself as an international academic journal of the Geology Department, Chulalongkorn University (CU) since the year 2008. This Number 2 issue of Volume 3 is devoted specifically to the publications contributed by the International Petroleum Geoscience M.Sc. Program of the Geology Department, Faculty of Science, CU for the academic year 2009/2010. Certainly this Bulletin has attained more and more international recognition, not to mention the citation of publications in previous volumes, as can be seen from the contributions of 17 research papers by international students of the M.Sc. program. This program is an intensive one year curriculum that has been taught in the Geology Department of CU in the academic year 2009/2010 for the first year. These scientific papers were extracted from the students' independent studies which are compulsory for each individual student in the program. Because of the confidentiality reason of a number of contributions, the requirement of the Chulalongkorn Graduate School as well as time constraints of the program, only short scientific articles were able to release publicly and publish in this Bulletin.

Lastly, on behalf of the Department of Geology, CU, I would like to acknowledge the Department of Mineral Fuels, Ministry of Energy, Chevron Thailand Exploration and Production, Ltd, and the PTT Exploration and Production Public Co., Ltd., for providing full support for the Petroleum Geoscience Program and the publication cost of this issue. Sincere appreciation also goes to guest editors; Professors Joseph J. Lambiase, Ph.D., John K. Warren, Ph.D., and Philip Rowell, Ph.D., the full-time expat staff, for their contributions in editing all those papers. Deeply thanks also go to Associate Professor Montri Choowong, Ph.D., the current editor-in-chief, and the editorial board members of the BEST who complete this issue in a very short time. The administrative works contributed by Ms. Suphannee Vachirathienchai, Ms. Anamika Junsom and Mr. Thossaphol Ditsomboon are also acknowledged.

Associate Professor Visut Pisutha-Arnond, Ph.D.
Head of the Geology Department
August 2010

Fracture Characterization in Contrasting Platform Carbonate Facies, Muak Lek and Chumphae Area, Central – Northeast Thailand

Rachmat Utomo*

Petroleum Geoscience Program, Department of Geology, Faculty of Science,
Chulalongkorn University, Bangkok 10330, Thailand

*Author email: tomi_geologi04@yahoo.com

Abstract

A fracture characterization of Saraburi Limestone outcrops in Muak Lek and Chumphae quarries is conducted to develop a facies-based understanding of fracture distribution in exposed Permian limestones of Thailand. This is the first stage in developing an analogue understanding for fracture distributions in subsurface limestone reservoirs of Thailand and elsewhere. In the Muak Lek area, fracture density shows strong relationship with the host rock; the fine-grained lithofacies, with their thinner beds and smaller elastic moduli, show higher fracture densities and smaller apertures compared to the adjacent coarser-grained lithofacies. In contrast to Muak Lek, the Chumphae outcrop, because of apervasive diagenetic-silica cement overprint, has similar fracture densities across the various lithofacies. In summary, in outcrop analogs to fractured Permian carbonates that constitute potential reservoirs in the subsurface of central and northeastern Thailand, the fracture density and fracture aperture are responses to variations in the mechanical strength. In some diagenetic situations these relationships are resolvable in a gamma log, in others they are not. This has significant implications when a gamma log is used to cluster FMI-based fracture observations in wells in subsurface platform carbonates.

Keywords: Fracture characterization, Saraburi, Permian, mechanical strength

1. Introduction

Our understanding of the fracture characteristics of a carbonate reservoir with respect to deformation is at best semi-quantitative and tied to poorly understood relationships between deformation, facies, and diagenesis. In this paper, two contrasting types of fracture characteristics are discussed, both of which are controlled by the depositional facies and subsequent diagenetic evolution and are related to variations in fluid/cement overprints.

2. Methods

All of the datasets utilized in this research come from outcrop study in Muak Lek and Chumphae areas (Figure 1). Samples were selected for thin section and outcrop sections were studied sedimentologically in terms of fracture properties. Two spectral gamma ray profiles were measured, one at Muak Lek, the other at Chumpae. The fracture information, based on contrasts between carbonate facies, will be displayed in a series of photos that show the different fracture characteristics of each facies, it indicates the combined effects of deformation, facies, and diagenesis (Figure 2).

3. Results

3.1 Carbonate facies

In Muak Lek quarry, crinoidal rudstone occur as a clean carbonate layer and are interbedded with detrital siliceous mudstones – spicule packstones with terrigenous clay and mica flakes present. In Chumphae quarry, crinoidal rudstone with intramatrix equant rhombic dolomite spar is interbedded with biogenic siliceous wackestone-packstones lacking obvious terrigenous material.

Figure 1. The study area in two different quarries in Muak Lek and Chumphae (extracted from http://www.umsl.edu/ services/ govdocs /wofact2003/maps/th-map.gif, downloaded on 20th May 2010).

3.2 Spectral gamma ray

In Muak Lek quarry, there is a sharp contact at the top and the bottom of the crinoidal rudstone (Figure 2). It corresponds to the lower amounts of terrigenous clay in the crinoidal rudstone indicated by Th and K curves, while the uranium curve shows that uranium was a more mobile elements and more subject to any leaching processes that were driven by fluid circulation during burial diagenesis. In contrast to Muak Lek gamma ray signature, the gamma ray in Chumphae quarry does not showing any significant trend that can be used to distinguish one facies from another, and probably indicates the absence, or very limited presence of terrigenous clay materials, as a contaminant in this platform interior carbonate.

3.3 Fracture analysis

In Muak Lek quarry, in the crinoidal rudstone, the average fracture density is 8 fractures/meter. In the interbedded detrital siliceous mudstone – wackestone, the average fracture density is 30 fractures/meter. Clearly, the fracture density in the Muak Lek quarry can be tied to facies type. In contrast, in Chumphae quarry the separation of fracture characteristic among the facies is much more subtle as the densities overlay. The crinoidal rudstone facies typically has 12 to 24 fractures/meter. The biogenic siliceous wackestone-packstone B has typical fracture densities from 24 fractures/meter to 42 fractures/meter.

4. Discussions

From both quarries, there are two lithofacies associations that have distinctive fracture characteristics. The crinoidal rudstone facies consistently shows lower fracture density than the adjacent siliceous mudstone-packstone facies (Figure 2). Factors influencing the differences in fracture density between the facies are; grain size, bed thickness, and elastic modulus. With all other factors constant, decreasing the grain size increases the compressive and tensile strength, due to an increase in specific surface energy (a surface-to-volume function) as the grain diameter becomes smaller (Nelson, 2001). The other factor is bed thickness, the plot of bed thickness versus fracture density shows us that the thinner beds have higher fracture densities than the thicker ones. The other factor controlling fracture responses is the elastic modulus of the rocks as crack damage stress increases with increasing elastic modulus (Palchik & Hatzor, 2002). Experimental work by Lézin *et al*., (2009) showed that texturally fine-grained carbonate rocks such as mudstone – packstone shave a range of elastic moduli from 9 – 43 GPa, while the grainier carbonate rocks, such as a grainstone and clean rudstones, show a range of measured moduli of 60 - 70 GPa.

5. Conclusion

The studied outcrops show fracture responses that can be matched to contrasts in lithology in terms of both depositional setting and diagenetic overprint (Figure 2). The spectral gamma ray in Muak Lek area easily separates the measured section into three lithofacies units because of terrigenous materials present in the detrital siliceous

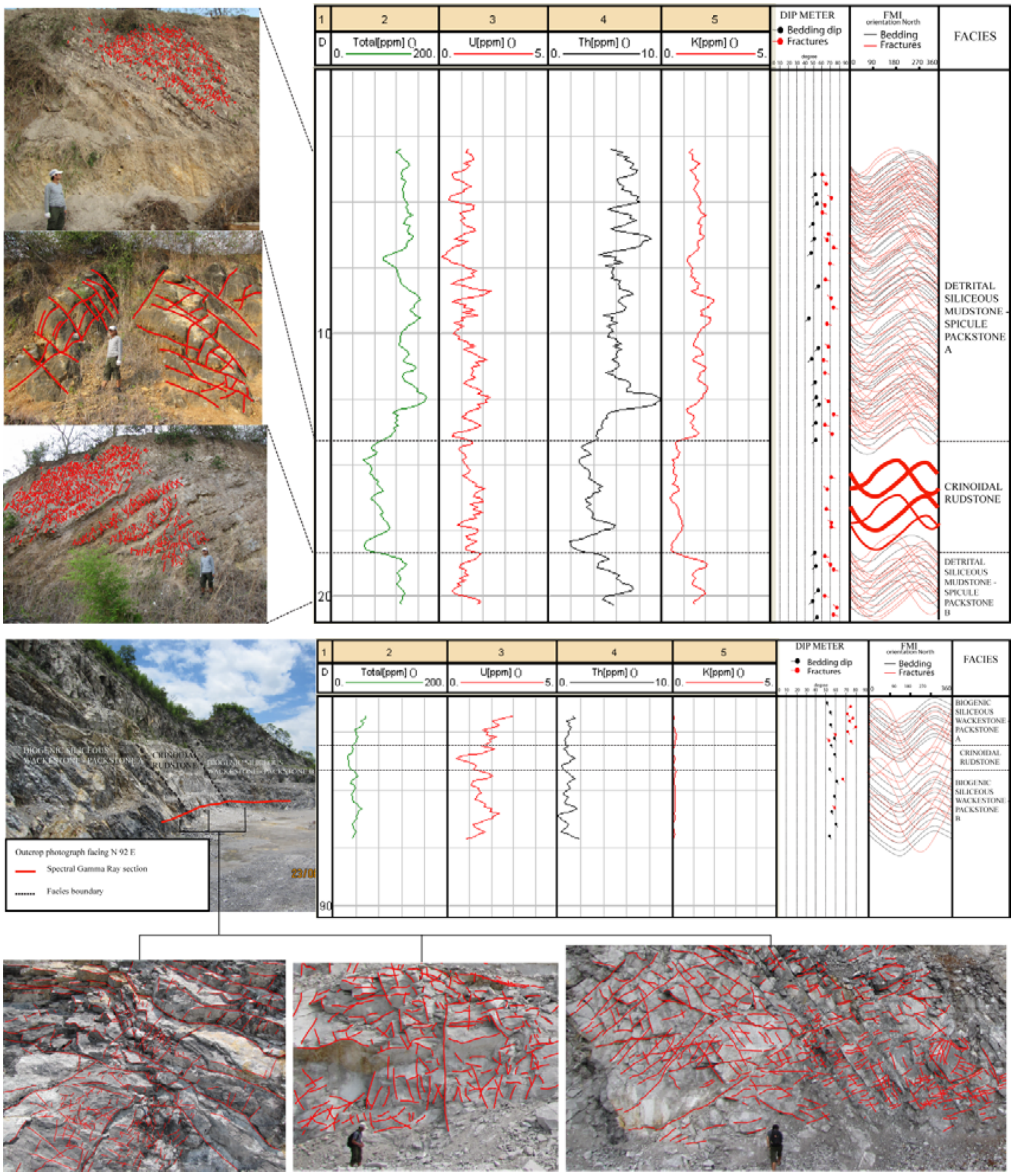

Figure 2. Fracture characteristics, in Muak Lek (upper part) and Chumphae (lower part), shown in outcrop photos with fracture highlighted, spectral gamma ray presented as pseudowells, and a corresponding reconstructed FMI & dipmeter output (using outcrop data).

mudstone – spicule packstone facies. The Chumphae outcrop contains much less detrital siliciclastic clay than Muak Lek. The high silica content on either side of the rudstone unit is biogenic so the spectral gamma ray signature merges into one lithofacies unit. On either side of a crinoidal rudstone unit, it seems terrigenous mud content in the Muak

Lek outcrop and pervasive biogenic-derived silicifications at Chumphae are the factors that controlled the mechanical strength of the rocks on either side of the rudstone. In terms of fractured reservoir characterization, fracture density is found to depend on a combination of grain size, bed thickness, and elastic modulus of the rocks. In some diagenetic situations these relationships are resolvable in a gamma log, in others they are not. This has significant implications when a gamma log is used to cluster FMI-based fracture observations in wells in subsurface platform carbonates.

6. Acknowledgements

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