PERTEMUAN PERSATUAN
Meetings of the Society

Ceramah Teknik (Technical Talk)

Anomalous pressure: Key to unlocking unconventional hydrocarbon resources

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Laporan (Report)

On 15th July, 1996 at the Department of Geology, University of Malaya, the society was presented a talk on *"Anomalous pressure: Key to unlocking unconventional hydrocarbon resources"* by Professor Ronald C. Surdam. His trip to Malaysia is part of the *AAPG Foundation's Roy M. Huffington Distinguished Lecturer* tour organised by the American Association of Petroleum Geologists. Petronas Petroleum Research and Scientific Services was his host in Malaysia.

Professor Surdam has been Professor of Geology at the University of Wyoming since 1973, and is director of the Institute for Energy Research (IER) at the University. He formed the IER, a multidisciplinary organization devoted to energy research at the University, in 1993, to foster research on fossil energy resource assessment and the development of new approaches to hydrocarbon exploration and exploitation in Wyoming.

This talk is based on his work as well as those of his students and co-worker at the Institute of Energy Research. His main contention is that unconventional hydrocarbon accumulations, in particular deep gas, will be that next focus for exploration by the industry. He showed that the understanding of these accumulations is based upon advances in different fields of geological disciplines. His talk was illustrated with examples from the Laramide Basin and the Powder River Basin.

Professor Surdam's early work was on the sedimentology and geochemistry of lacustrine deposits, which led to the recognition of lacustrine deposits as tremendous sources for hydrocarbons and an understanding of their origin and distribution in sedimentary basins throughout the world. Subsequent work on lake deposits led him to examine the relationships between the hydrocarbon source rocks in the lakes, the mobile hydrocarbons, and the associated sand deposits. He and his students discovered organically based mechanisms for the dissolution of minerals in hydrocarbon reservoirs, identified the agents of the reactions, and delineated their implications for hydrocarbon exploration. Prof. Surdam and his co-workers continue to investigate the interaction between the organic and inorganic components of sedimentary deposits, most recently the reduction-oxidation reactions associated with the emplacement of hydrocarbons into water-bearing sandstones. A current research interest is the origins and characteristics of pressure variations in sedimentary basins, useful in hydrocarbon exploration as an indicator of oil and gas generation and entrapment.

Prof. Surdam's group at the IER has clearly demonstrated that the traditional theories on the origin of high pressure in sedimentary basins do not explain overpressure in most basins,

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and has proposed alternative mechanisms which are more generally operative. In so doing, they also explained the relationships between sedimentary deposits, diagenetic reactions, thermal maturation and hydrocarbon expulsion, migration and accumulation at great depths.

Some 80 members turned up for this very interesting and informative talk. More interestingly, it was also memorable as the first part had to be delivered with electric supply from a small generator due to power failure. Even in this unfavourable situation, Prof. Surdam was able to deliver his talk with enthusiasm, finesse and clarity.

Abstrak (Abstract)

Anomalously pressured, compartmentalized gas accumulations represent a huge and largely untapped gas resource. At present, these unconventional gas accumulations tend to defy exploitation by conventional exploration and production technologies. Based on work in Rocky Mountain Laramide basins (e.g., Western Canada (Alberta), Powder River, Bighorn, Wind River, Greater Green River, Denver, and San Juan basins), a new paradigm has been created for gas exploration in basins characterized by anomalously pressured, compartmentalized gas accumulations. This paradigm is defined as: "The determination and, if possible, three-dimensional evaluation of the pressure boundary between normal and anomalous pressure regimes, and the detection and delineation of porosity/permeability 'sweet spots' (i.e., areas of enhanced storage capacity and deliverability) below this boundary are the two most important elements in exploring for basin-center, or deep-basin gas accumulations" (Surdam, 1995). The evaluation of the regional pressure boundary and detection of underlying storage sweet spots are paramount when designing any new exploration strategies to exploit anomalously pressured gas accumulations and constitute a new way to search for and exploit such deposits. Certainly, there are other critical aspects, but these two elements are absolutely essential; they are as important to finding the gas-saturated, anomalously pressured section of a basin as structural closure and stratigraphic pinch-outs are to finding conventional hydrocarbons in the water-saturated, normally pressured section.

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The new paradigm is a product of a dynamic, process-oriented conceptual model for the formation and destruction of anomalously pressured, compartmentallzed gas accumulations. Another product of the process-oriented conceptual model is an innovative exploitation technology and the diagnostic tools necessary to (1) expedite the discovery of additional gas reserves, (2) substantially increase the rate of such discovery, and (3) eliminate much of the exploration risk presently associated with developing unconventional accumulations. This technology and resultant strategy eliminate many of the problems presently plaguing operators in anomalously pressured basins. Specifically, this strategy gives the explorationists the ability to:

- determine the position of the pressure boundary;
- evaluate the 3-D aspects of the pressure boundary surface, with special emphasis on areas characterized by positive relief;
- establish which depositional facies have the greatest potential for enhanced storage and deliverability below the pressure boundary (sweet spots);
- document the potential determinative elements that control sweet spot development in the targeted lithofacies (e.g. fractures, early migration of liquid hydrocarbons, overpressuring, chlorite rims, and/or dissolution of early carbonate cement);
- detect porosity/permeability sweet spots using 2-D and 3-D models of well log and/or seismic data.

The new technology, exploration paradigm, and diagnostic tools provide the keys to unlocking anomalously pressured, compartmentalized gas accumulations. Armed with new knowledge and diagnostic tools explorationists, with substantially less risk, will be able to more efficiently and effectively convert unconventional gas resources to conventional energy reserves.

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