

The 2010 George Brown Lecture

Earth's energy "Golden Zone": a synthesis from mineralogical research

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ABSTRACT: The impact of diagenetic processes on petroleum entrapment and recovery efficiency has focused the vast majority of the world's conventional oil and gas resources into relatively narrow thermal intervals, which we call Earth's energy "Golden Zone". Two key mineralogical research breakthroughs, mainly from the North Sea, underpinned this discovery. The first is the fundamental particle theory of clay mineralogy, which showed the importance of dissolution/precipitation mechanisms in the formation of diagenetic illitic clays with increasing depth and temperature. The second is the surface area precipitation-rate-controlled models for the formation of diagenetic cements, primarily quartz, in reservoirs. Understanding the impacts of these geological processes on permeability evolution, porosity loss, overpressure development, and fluid migration in the subsurface, lead to the realization that exploration and production risks are exponential functions of reservoir temperature. Global compilations of oil/gas reserves relative to reservoir temperature, including the US Gulf Coast, have verified the "Golden Zone" concept, as well as stimulated further research to determine in greater detail the geological/mineralogical controls on petroleum migration and entrapment efficiency within the Earth's sedimentary basins.

KEYWORDS: global energy resources, petroleum geology, hydrocarbon migration, clay mineral diagenesis, fundamental particles, quartz cementation, porosity, permeability, basin analysis, North Sea, US Gulf Coast, oil and gas reserves, exploration risks, temperature, overpressure.

Energy in the form of large oil and gas accumulations in sedimentary basins has been the most important natural resource used by our society over the last century. This energy forms a key basis for our high-yield agricultural production, the infrastructure that provides our water, housing, transportation, medical care, educational and other

services, as well as our impressive research establishments. Civilization as we know it today would not be possible without this energy. In this George Brown Lecture, we will review advances in mineralogical research, some of which began here at the Macaulay Institute in the early 1980s, in the area of clay mineralogy and sedimentary diagenesis. These diagenetic processes, which occur with increasing depth and temperature in sedimentary basins, have played a major role in the formation of our valuable oil and gas energy accumulations. The petroleum industry refers to them as conventional oil and gas resources, which stand at ~2 trillion

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