CHAPTER

8

POTENTIAL CARBON STORAGE AND ENHANCED OIL RECOVERY

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8.1 INTRODUCTION

The causes, impacts, mitigation strategies, and the hundreds of initiatives that are addressing the issue have all been extensively disputed in relation to climate change worldwide. To mitigate the effects of global warming, emissions of anthropogenic greenhouse gases (GHGs), primarily carbon dioxide (CO_2), must be reduced, as per the 1997 Kyoto Protocol treaty, which is an extension of the 1992 United Nations Framework Convention on Climate Change (UNFCCC).

Furthermore, the 2015 Paris Agreement, also known as the *Accord de Paris*, was carried out. Its components include financing, adaptation, and greenhouse gas emission mitigation will start in 2020. The fact that the oil and gas industry is one of the main sources of CO_2 emissions, it is necessary that those of us with virtue reduce CO_2 emissions to some degree to slow down the effects of climate change (Adu et al., 2019). There are several ways to reduce the quantity of CO_2 in the atmosphere such as CO_2 sequestration being the most well-known (Nunes, 2023).

The term CO_2 sequestration refers to the process of CO_2 capture and storage (CCS). There are basically three different kinds of the CO_2 sequestration process which are terrestrial, geologic, and mineralization.

The process of permanently storing the collected CO_2 gaseous in underground formations including oil reservoirs, basins, basalt formations and aqueous saline deposits is known as geologic sequestration (Kelemen et al., 2019). Many geological media that are suitable for storing CO_2 are found in sedimentary basins such as coal beds and deep saline aquifers. Nonetheless, a screening procedure needs to be carried out to assure the lifespan and safety of the prospective CO_2 storage to achieve net zero 2050.

Moreover, enhanced oil recovery (EOR) is referred to as the tertiary process of oil recovery operations, the first two being which are primary recovery (natural depletion), and secondary recovery (waterflooding, gas injections). When the primary and secondary recovery become economically not feasible, EOR will be carried out. On the reverse spectrum, CO_2 gas is pumped into the reservoir during the carbon dioxide-enhanced oil recovery (CO_2–EOR), process to store and remove any remaining depleted oil. According to Trigos and Cubillos (2023), around 500,000-barrel oil per day (BOPD) of oil recovery from 140 projects had been acquired by CO_2–EOR targets and this number is continually rising. Thus, how about Malaysia oilfield? Malaysia is now regarded as one of the oil-production in the world, with sedimentary basins providing most of the country's oil supply.

8.2 MALAY BASIN

Malaysia petroleum basins consist of six main sedimentary basins namely Penyu, Malay, Sarawak, Sabah, Northeast Sabah, and Southeast Sabah Basin with sedimentary thickness more than 4 km. Currently, only Malay, Sabah and Sarawak Basin are only producing oil and gas. The Malay Basin located in offshore of Peninsular Malaysia has been reported to be reaching the completion of its current exploration phase and prospecting for oil in the basin started in the late 1960s (Madon, 2021).

By 2003, more than 150 petroleum fields had been identified, and about 50 of these were already in production. These fields occur in water depths of less than 200m, between latitudes 4°–8°N and longitudes 104°–107°E.

The basin is a NW–SE–trending elongated structure covering approximately 80,000 km² and containing up to 14 km of sedimentary fill (Zhang & Lau, 2022). It lies at the southeastern termination of the Three Pagodas Fault, a major strike-slip fault system extending into Thailand. The Malay Basin is classified as a Tertiary oil and gas province, dominated by continental clastics and lacustrine shales, and is structurally characterized by multiple half-grabens.

The southeastern half of the basin produces most of the oil, between 370,000 and 400,000 BOPD and gas is extracted from fields in the basin's middle and northern region (Madon et al., 2006). The basement of this basin is composed of approximately 12 km of Cretaceous-era alluvial, fluvial, and estuarine sedimentary deposits.

Table 8.1 Malay Basin seismostratigraphic groups (Source: Lunt, 2021)

Age	Group	Description
Quaternary-late miocene	A & B	Gentle subsidence less tectonic activity happens. Open-marine environment. Consist of marine slit and clay deposited during marine transgression in near shore to shallow marine.
Early-middle miocene	D & E	Deposited by progradational stacking of fluvial or estuarine channel and terminated with a localised erosional unconformity.
	F & H	Marine to deltaic sediment with fluvial or estuarine channel deposited during sea-level rises.
	I & J	Progradational to aggradational fluvial to tidally dominated estuarine sand.
Pre-miocene	M, K, & L	Subsidence controlling faulting. Fill extensional sub-basin comprise braided channel, coastal plain, lacustrine delta and lake.

The stratigraphic development of Malay Basin is related to its structural evolution had occurred in three phases from pre-miocene, early-middle miocene, and late miocene to quaternary. The stratigraphic in Malay Basin was divided into seismostratigraphic 'group' namely after Esso Production (EPMI) in 1980. The description of the group is tabulated in Table 8.1.