Estimation of the CO$_2$ storage capacity of the structural traps in the southern Jeju Basin, offshore southern Korea, northern East China Sea

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ABSTRACT: We analyzed 2-D seismic and well-log data from the southern Jeju Basin, offshore southern Korea, northern East China Sea to estimate the CO$_2$ storage capacity of the structural traps in the area. Sand intervals with >10-m gross thickness were identified from the gamma-ray logs and their porosity was estimated from the neutron logs corrected for the shale effect. A total of 14 structural closures was delineated from the depth-converted maps of the sand intervals. Seismic inversion and multi-attribute transform were performed to predict the reservoir quality (i.e., porosity) of the closures away from the well control. The total storage capacity of the closures was estimated from the deterministic, volumetric method, based on the published storage efficiency parameters. The estimated CO$_2$ storage capacity for the 14 closures is about 302 Mt, comparable to the CO$_2$ emission (ca. 530 Mt) of Korea in 2009.

Key words: CO$_2$ storage capacity, Jeju Basin, structural traps

1. INTRODUCTION

Geological sequestration of CO$_2$ involves pumping the CO$_2$ into the subsurface formations to store it in the pore space of the rock in the same way that hydrocarbons are trapped in oil and gas reservoirs. At depths below about 800–1000 m, CO$_2$ becomes supercritical and has a liquid-like density which increases the efficiency of CO$_2$ storage in deep formations. Depleted oil and gas reservoirs, coal formations, and saline formations can be used for storage of CO$_2$ (IPCC, 2005). CO$_2$ can also be injected into active oil fields to improve production rates and increase productive lifetime of the field. This CO$_2$-driven enhanced oil recovery (EOR) has become one of the earliest methods of CO$_2$ storage because of the economic benefits to offset the production cost. In the long term, the large capacity and advantageous locations of deep saline formations will increasingly make them the preferred storage site as the amount of CO$_2$ to be sequestered increases (White et al., 2003).

The Donghae-1 field in the southern Ulleung Basin margin, East Sea (Japan Sea) is the only producing field in Korea. The Donghae-1 field is producing mostly gas and thus CO$_2$-driven EOR cannot be used. It is also planned to be used for the national strategic petroleum storage after depletion. Therefore, the most likely option for the geological sequestration of CO$_2$ in Korea is storage in deep saline formations. The onshore geological sequestration of CO$_2$ may be ruled out in Korea because the onshore basins are shallow and the distribution of good reservoir-quality rocks is very limited. On the other hand, offshore basins of Korea (the Ulleung, Gunsan, and Jeju basins) contain thick and young clastic sediments (Lee et al., 2001; Lee et al., 2006; Shinn et al., 2010). The Gunsan and Jeju basins contain over 5000-m thick, Late Cretaceous and Tertiary, dominantly nonmarine sediments. The Ulleung Basin is the youngest and contains over 11 kilometers of Late Oligocene and younger, dominantly marine sediments. In this study, we analyzed 2-D seismic and well-log data from the southern part of the Jeju Basin off southern Korea, northern East China Sea (Fig. 1) to map the structural traps and estimate their CO$_2$ storage capacity. Inversion and multi-attribute transform were applied to the data to predict the reservoir quality of the traps away from the well control. Kingdom Suite® (version 8.6) and Hampson-Russell® (version 4.4.1) were used for seismic and well-log data analysis and inversion and multi-attribute transform, respectively.

2. GEOLOGICAL SETTING

The Jeju Basin is located in the northern East China Sea shelf basin (Fig. 1). It is separated from other subbasins (the Socotra and Domi basins) to the south and north by the Hupijiao Rise and faulted basement blocks and bounded to east by the Taiwan-Sinzi belt (Lee et al., 2006; Gungor et al., 2012). Initial rifting in the Late Cretaceous created grabens and half grabens in the northern part of the proto-East China Sea shelf (Lee et al., 2006). The rifting was termi-
nated by regional uplift and folding in the Late Eocene-
Early Oligocene. This regional deformation was extensive
near the Hupijiao Rise and in the Jeju Basin. Rifting resumed
in the Early Oligocene but was interrupted in the Early
Miocene by uplift in the Domi Basin and areas adjacent to
the Hupijiao Rise. This uplift, although relatively minor,
marks the transition to the postrift phase in the northern
East China Sea shelf basin. The early part of the postrift
phase (Early Miocene-Late Miocene) is characterized by
eastward and southeastward tilting and regional subsidence.