Continental Shelf Research 83 (2014) 108–115

Contents lists available at ScienceDirect

Continental Shelf Research

journal homepage: www.elsevier.com/locate/csr

Research papers

Seabed mapping to support geological storage of carbon dioxide in offshore Australia

Andrew D. Heap*, Scott L. Nichol, Brendan P. Brooke

Geoscience Australia, GPO Box 378, Canberra, ACT 2601, Australia

ARTICLE INFO

Article history:
Received 3 June 2013
Received in revised form
3 February 2014
Accepted 9 February 2014
Available online 22 February 2014

Keywords:
Marine habitats
Geological sequestration
Clean energy
Surrogates

ABSTRACT

The geological storage of carbon dioxide (CO_2) has the potential to provide future clean energy solutions. Geoscience Australia has demonstrated how its national seabed mapping programme can be successfully applied in assessing containment integrity in offshore basins. These assessments include targeted seabed research that aims to reduce uncertainty around the risks of CO_2 storage by developing an integrated understanding of the physical relationships between the deeper basin structures, the shallow (< 100 m) sub-surface and seabed environments. This paper presents an overview of the science strategy developed to undertake this work in the Australian context, with reference to case studies.

1. Introduction

Australia must balance the needs of an increasing demand for energy with meeting its internationally agreed greenhouse gas emission reduction targets (Australian Government, 2012). The targets set by the Australian Government are a 5 per cent reduction in CO_2 emissions below 2000 levels by 2020 and an 80 per cent reduction by 2050. This is in accordance with the International Energy Association's (IEA) target of 450 ppm carbon dioxide (CO_2), which is modelled to limit the world to a 2 °C warming scenario.

In 2012 the Australian Government released its Energy White Paper which then set out the strategic policy framework to ensure all Australians have access to reliable, affordable and diverse sources of energy, while maintaining clean energy outcomes for the nation (Australian Government, 2012). Embodied in this framework were policies that promote the adoption and development of renewable energy sources and carbon capture and storage (CCS). In practical terms, these are the only options available for materially reducing greenhouse gas emissions in countries that rely predominantly on fossil fuels to meet their energy demands (Tester et al., 2005). Australia is one such country, deriving > 90% of its energy from significant CO_2-emitting sources (Geoscience Australia and ABARE (2010)), and in 2012 emitted a total of 552 Mt CO_2-equivalent in greenhouse gases (Australian Government, 2013). Australia is also one of the world's largest exporters of coal and holds almost 10% of the world's known reserves. Under the scenario of increasing domestic and world energy demands and continued use of fossil fuels, Australia's future greenhouse gas emissions will continue to increase, hence the need to find suitable CO_2 storage sites to achieve its emissions reduction targets.

Geological storage of CO_2 is recognised as a viable strategy to reduce greenhouse gas emissions on a global scale (Cook, 2012). The principal geological storage options include: (i) depleted oil and gas reservoirs; (ii) deep unused saline water-saturated formations; (iii) application in enhanced oil or coal bed methane recovery; (iv) deeply buried coal seams, and possibly; (v) igneous formations. Storage of CO_2 in saline formations, depleted oil and gas fields and its use for enhanced oil recovery and storage, are already proven storage options (International Energy Agency (IEA), 2008). However, it is clear that sedimentary basins offer the greatest storage potential (Holloway, 2001). The logistics and methodology of CO_2 storage and containment in sedimentary basins are also well understood, based on geological and engineering studies of depleted oil and gas reservoirs and saline formations (e.g., Johnson et al., 2004; Hawkes et al., 2005; Gozalpour et al., 2005; van der Meer, 2005; Birkholzer et al., 2009; Gaus, 2010; Juanes et al., 2010) and data from current CCS projects, including at Sleipner and Snohvit (Norway), Weyburn (Canada), Labarge (USA), In Salah (Algeria), and Otway (Australia) (Michael et al., 2010).

In 2008, the Australian Government in conjunction with industry commissioned a scientific programme to drive prioritisation of, and access to, a national geological storage capacity to accelerate development of CCS. This included a national assessment of Australia's sedimentary basins for their CO_2 storage potential, with an estimated total potential capacity for Australia's offshore basins of 253 gigatonnes (at the P50 level; i.e., at least a 50% probability that the storage capacity is greater than this

* Corresponding author.
E-mail address: andrew.heap@ga.gov.au (A.D. Heap).

http://dx.doi.org/10.1016/j.csr.2014.02.008

amount) (Carbon Storage Taskforce, 2009). Following this assessment, sedimentary basins (onshore and offshore) deemed suitable for CO_2 storage and which are in close proximity to major current and projected CO_2 emission sources were identified for further study to improve knowledge of their reservoir capacity and seal integrity. In the offshore, these studies included an assessment of the potential for leakage of CO_2 into the marine environment. The primary approach adopted has been seabed mapping integrated with the analysis of the storage potential of the underlying basin.

This paper presents an overview of the science strategy developed in Australia to apply seabed mapping techniques to address the national challenge of geological CO_2 storage. The seabed mapping science strategy comprises mapping geomorphic features and habitats and characterising their spatial and temporal processes to enable the development of conceptual models of seabed-basin connectivity and benthic ecosystems. We demonstrate the applicability of this strategy for providing relevant scientific information that supports the expansion of clean energy in Australia through offshore geological storage of CO_2. The strategy provides a robust framework for detailed case studies that: (i) use seabed mapping to assess the risk of containment loss through connectivity of the seabed with sub-surface CO_2 reservoirs (Nicholas et al., in this issue), and; (ii) assess a project's environmental significance through a review of the potential ecological impacts associated with the construction of CO_2 storage infrastructure (Carroll et al., in this issue). The strategy represents an innovative and novel application of seabed mapping beyond its well established application in marine environmental management (e.g. marine protected area design and monitoring; Harris et al., 2008).

2. The Australian marine environment

The Australian marine jurisdiction covers 14.6 million km^2, spanning approximately 60° of latitude from the tropics to the Antarctic and incorporating parts of the Indian, Southern and Pacific Oceans (Heap and Harris, 2008). This vast area ranges in water depth from <200 m on the continental shelf to >7000 m in deep ocean trenches (Fig. 1). It comprises a diverse range of geomorphic features including submerged plateaus, seamount chains, submarine canyons and expansive plains (Heap and Harris, 2008).

Since the Neogene ($\sim$23 Ma), the western, southern and eastern margins of the Australian continent have evolved in a passive tectonic setting. The northern margin is currently affected by collision with the southern part of the Eurasian and Pacific Plates (Hillis and Muller, 2003). This relatively stable tectonic setting and the divergent sedimentary basins that comprise the Australian continent and its margins provide suitable sites for geological storage of CO_2 (Bachu, 2003).

The collision of the Australian continent to the north around 40 Ma has created the unique situation whereby the continent is bounded on both its eastern and western margins by warm water, poleward-flowing boundary currents; the East Australian and Leeuwin currents, respectively (Brooke et al., 2012). As a result, Australian waters are generally nutrient poor (oligotrophic) (Koslow et al., 2008; Condie and Harris, 2006). This unique tectonic and oceanographic setting is expressed in relatively low productivity of the oceans and a marine biota that may not be as

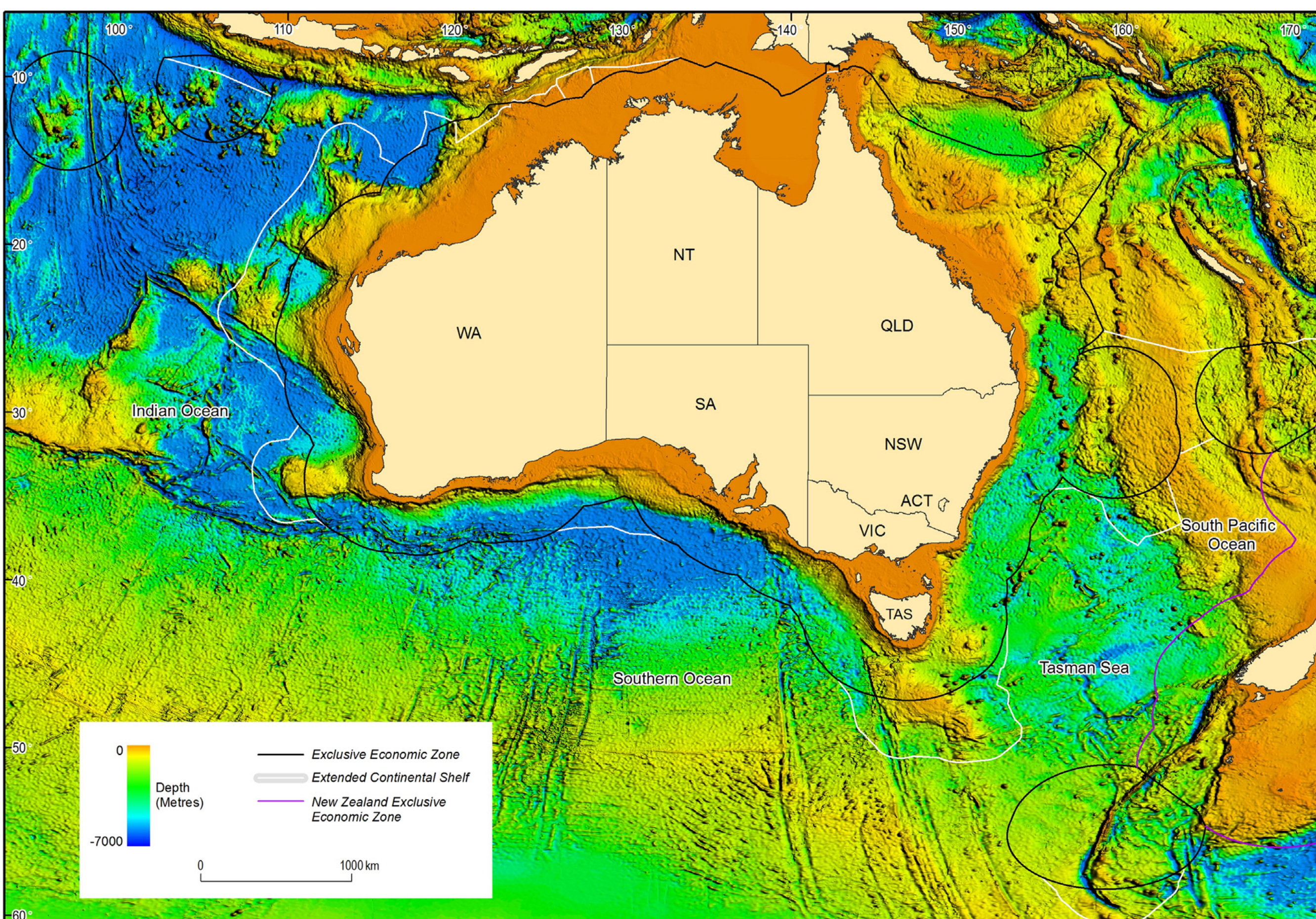

Fig. 1. Map of Australia showing bathymetry across Australia's maritime jurisdiction, not including the Australian Antarctic Territory. (NT – Northern Territory, QLD – Queensland, NSW – New South Wales, ACT – Australian Capital Territory, VIC – Victoria, TAS – Tasmania, SA – South Australia, WA – Western Australia).