DIGGING DEEP: PROPERTY RIGHTS IN SUBTERRANEAN SPACE AND THE CHALLENGE OF CARBON CAPTURE AND STORAGE

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Abstract A burgeoning international interest in Carbon Capture and Storage (CCS) as a means of mitigating the effects of climate change has raised a number of novel legal issues, one of which concerns ownership of the underground sites in which captured carbon dioxide can be stored. This paper considers the extent of a surface landowner's rights above and below land and explores the treatment of underground space within the context of CCS in relation to differing jurisdictions. Particular attention is paid to legal principles applied in the United Kingdom and the United States, and consideration is also given to relevant legislation in Australia and Canada.

Keywords: airspace, carbon capture and storage, mining, real property, subsurface land.

I. INTRODUCTION

It is a commonplace across jurisdictions that underground (otherwise known as 'subterranean' or 'subsurface') space is utilized and exploited in a variety of ways such as mining, storage, landfill and waste disposal. Trends in technology, alongside the socioeconomics and geopolitics of resource demands have led to increasing use, on larger scales and in new ways.[1] Potentially significant in this regard is carbon capture and storage (CCS). CCS involves the subsurface storage of carbon dioxide (CO_2) which has been captured and transported from point sources such as large power stations.[2] As such, it provides an opportunity to facilitate the continued use of coal and other

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[1] D Evans, M Stephenson and R Shaw, 'The present and future use of "land" below ground' [2009] Land Use Policy 26S S302–S316. For the first deep excavation in the UK since the 1980s, see <http://www.bbc.co.uk/news/uk-england-tyne-13914718> reporting on the drilling of a borehole in Newcastle to capture geothermal energy. Another use of subterranean space—hydraulic fracturing (fracking)—has already taken place in the Bowland Basin in Lancashire at depths greater than 6,000 feet.

[2] The Committee on Climate Change states that CCS technology is also likely to be feasible in energy-intensive industries including iron and steel, industrial CHP (combined heat and power), refining, cement and chemicals: *The Fourth Carbon Budget: Reducing Emissions through the 2020s* (Committee on Climate Change London 2010) 228.

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carbon-based energy reserves for power generation, enabling emissions reduction targets to be achieved and preventing the escalation of greenhouse gas emissions until cleaner methods of energy production can be developed and made more commercially viable.

Although not without its critics,[3] considerable support exists at international, EU and domestic levels for CCS as a means of mitigating climate change, and other ecological harms such as from ocean acidification,[4] caused by rising concentrations of atmospheric CO_2.[5] In the UK, the Climate Change Act 2008 imposes a duty on the Secretary of State to ensure that the net UK carbon account for the year 2050 is at least 80 per cent lower than the 1990 baseline,[6] and it has been stated that CCS will need to deliver almost 20 per cent of the total greenhouse gas (GHG) emissions reductions needed to achieve the 2050 target if GHG concentrations in the atmosphere are to be stabilized at an acceptable and cost-effective level.[7] Potentially, the most effective type of CCS is geological storage or geo-sequestration (GS) whereby CO_2 is injected into geologic formations.[8] Prior to any deployment, the suitability of subsurface space required to house the large quantities of CO_2 will need to be identified

[3] See Greenpeace, *False Hope: Why Carbon Capture and Storage Won't Save the Climate* (Greenpeace International, Amsterdam 2008) <http://www.greenpeace.org/usa/Global/usa/report/2008/5/false-hope-why-carbon-capture.pdf>.

[4] <http://www.parliament.uk/documents/post/postpn343.pdf>.

[5] Internationally, the first steps to mitigate the impact of climate change were taken in 1992 with the United Nations Framework Convention on Climate Change (UNFCCC). The Kyoto Protocol—an addition to the UNFCCC—expressly identified 'research on, and promotion, development and increased use . . . of carbon dioxide sequestration technologies' for promoting sustainable development, (Kyoto Protocol to the United Nations Framework Convention on Climate Change, 10 Dec 1997, UN Doc FCCC/CP/197/L.7/Add. 1, art 2, section 1(a)(iv) <http://unfccc.int/resource/docs/convkp/kpeng.pdf> while at their Hokkaido Summit in 2008, G8 leaders agreed to establish an international initiative with the support of the International Energy Agency 'to develop CCS technology roadmaps and co-operate through existing and new partnerships' <http://www.mofa.go.jp/policy/economy/summit/2008/doc/doc080714__en.html>. At European level, the European Climate Change Programme was launched in 2000 to identify and develop an EU strategy to achieve a reduction in greenhouse gas emissions to 8 per cent below 1990 levels by 2008–12, as required by the Kyoto Protocol (The European Union Commission, *Towards a European Climate Change Programme* <http://eur-lex.europa.eu/LexUriServ/site/en/com/2000/com2000_0088en01.pdf>). The 'climate and energy package' (which was agreed by the European Parliament and Council in December 2008 and became law in 2009) includes the Directive on the Geological Storage of Carbon Dioxide Directive 2009/31/EC <http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0114:0135:EN:PDF>. The Storage of Carbon Dioxide (Licensing) Regulations 2010 partially fulfil the UK's obligation to transpose the Directive into UK domestic law, stipulating, inter alia, that geological storage of CO_2 will be possible only with an appropriate permit.

[6] 'The 1990 baseline' means the aggregate amount of (a) net UK emissions of carbon dioxide for that year, and (b) net UK emissions of each of the other targeted greenhouse gases for the year that is the base year for that gas: section 1(2) of the Climate Change Act 2008.

[7] International Energy Agency, *Energy Technology Perspectives, Executive Summary* (IEA Paris 2010).

[8] Carbon capture and *storage* is said to be something of a misnomer given that, 'storage assumes that materials will be retrieved, whilst disposal aims to store and isolate materials for longer periods, perhaps for many tens of thousands of years in the case of carbon dioxide and nuclear waste': Evans, Stephenson and Shaw (n 1) S303.

and tested so as to make GS environmentally effective and economically viable. Although CCS has not yet been successfully deployed anywhere on a large commercial scale, the EU has a regime in place principally regulating safety and certain liability aspects of the storage process.[9] Transposition in Member States was subject to a deadline of 25 June 2011, and appropriate national instruments are also required to address the prior stages of capture (at emitting installations) and transportation (between installation and chosen storage site).[10] The central focus of this article is the new challenges for current legal regimes for property rights posed by the location of such GS space.[11] Particular attention is paid to legal principles applied in the common law jurisdictions of the United Kingdom and the United States, and consideration is also given to relevant legislation in Australia and Canada.

Securing access to subterranean space on a scale which is large enough to accommodate CCS projects may impact upon multiple actors, including both natural and corporate persons, holding estates and interests in and around the storage site. A particularly significant issue therefore is the ownership of the underground areas in which CO_2 can be sequestered. Questions arise in such circumstances as to whether title to the subsurface is vested in the surface owner or—if mineral rights have been severed and transferred to a third party—in the mineral owner. Should subterranean space below a certain depth be regarded as *res omnium communis* (the property of everyone) or *res nullius* (the property of no-one)—both concepts allowing, initially at least, for full exploitation of subterranean space—or should it belong to the state (or the Crown) as custodian of a resource which can be used for the common good? Is it enough that the state (or the Crown) assumes a right to store sequestered CO_2 regardless of who owns the subterranean space over which the right is exercised?

The first section of this article will give a snapshot of what CCS involves and establish the significance of property questions in the CCS context. The following section will consider the extent of a surface owner's rights in land, referring to the *cuius est solum* doctrine and outlining the main authorities concerning airspace in order to establish whether they shed any useful light on the issue of how rights to subterranean space should be viewed. The next

[9] While the directive assumes that CCS may be deployed both under terra firma and under the seabed, for the present the UK is focusing on the latter hoping to exploit its geophysical circumstances in light of decades of gas and oil exploration and extraction.

[10] Directive 2009/31/EC, art 39 (see n 5).

[11] The issues raised by the storage of captured CO_2 have much in common with those associated with the underground storage of natural gas, particularly in relation to the nature of, and title to, the storage space. See e.g. *Central Kentucky Natural Gas v Smallwood* 252 S.W.2d 866 (Ky Ct. App 1952) in which the main question was whether rent payable for a natural gas storage space should be paid to the surface owner or the mineral owner. However, unlike captured CO_2, natural gas is generally stored for only short periods of time and, because it is a valuable commodity, the ownership of the gas itself is significant (where, for example, it has migrated into neighbouring land: see e.g. RE Hardwicke, 'The Rule of Capture and Its Implications As Applied to Oil and Gas' (1935) 13 TexLRev 391).

section will consider the extent of rights over subterranean space, focusing on the decision of the UK Supreme Court in *Star Energy Onshore Ltd*. v *Bocardo SA*.[12] The final part will explore the treatment of underground space within the context of CCS in relation to differing jurisdictions and will offer conclusions concerning the most favourable arrangements for allocation of subterranean space in pursuit of CCS objectives.

II. CARBON CAPTURE AND STORAGE

The burning of fossil fuel—primarily through the use of road transport and of coal- and gas-fired power stations—releases large volumes of CO_2 into the atmosphere. Every year, the UK emits more than 500 millions of tonnes of CO_2,[13] with each individual in the UK being responsible for about 10 tonnes.[14] The build-up from human activities of CO_2 in the atmosphere is widely believed to be a major cause of global warming.[15] Another effect is ocean acidification which will have severe consequences for marine wildlife and ecosystems.[16] Given the current reliance on fossil fuels, one way of helping to address these problems may be through CCS which the EU has described as an essential 'bridging technology towards a low-carbon future'.[17]

CO_2 can be stored in three main ways for the purposes of CCS: in deep geological formations (geological storage: GS), in deep ocean water (ocean storage), and in the form of mineral carbonates (mineral storage). GS—currently considered to have greatest potential and be the least environmentally objectionable method of CCS—involves the capture of CO_2 emitted from power plants or other industrial installations at point source and its conversion into a 'supercritical' CO_2.[18] This is transported (sometimes for several hundreds of miles) by pipeline or by tanker over roads and/or sea

[12] [2011] 1 AC 380.

[13] UK Carbon Storage and Capture Community <http://www.co2storage.org.uk/ccs-importance.html>.

[14] <http://www.guardian.co.uk/environment/datablog/2009/sep/02/carbon-emissions-per-person-capita>.

[15] According to the Intergovernmental Panel on Climate Change (IPCC) 'warming of the climate system is unequivocal, as is now evident from observations in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level': IPCC, *Fourth Assessment Report: Climate Change 2007: Synthesis Report* (IPCC Geneva 2007), 1.1. It states that, 'most of the observed increase in global average temperatures since the mid-20th century is *very likely* due to the observed increase in anthropogenic GHG concentrations' (ibid, 2.4).

[16] The Royal Society, *Ocean Acidification Due to Increasing Atmospheric Carbon Dioxide* (2005) <http://royalsociety.org/uploadedFiles/Royal_Society_Content/policy/publications/2005/9634.pdf>.

[17] Preamble to Directive 2009/31/EC, art 39 (n 5).

[18] 'Fluids in a supercritical state . . . typically exhibit gaslike viscosity, reducing resistance to flow relative to a liquid, and liquidlike density, reducing the volume required to store a given mass of fluid' (O Popova et al, 'Comparative Analysis of Carbon Dioxide Storage Resource Assessment Methodologies' (2012) 19(3) Environmental Geosciences 105, 109.

to a storage site and then injected into porous sedimentary rock, thereby displacing salt water, oil or gas already present in microscopic pores within the rock. Potential GS storage sites (which are at depths generally exceeding 700 metres)[19] include old oil and gas fields, saline aquifers (saline water-filled basalt volcanic rocks), and unworkable coal seams.[20] To some extent, GS builds upon existing technology, CO_2 having been injected underground for many years for purposes such as enhanced oil recovery (EOR).[21] However, injection of CO_2 specifically for GS involves potentially much larger volumes of CO_2 and larger-scale projects than in the past, alongside more complex technical issues.[22]

The UK's onshore capacity for CCS is limited. With one exception,[23] its oil and gas fields are too small, its major aquifers are widely used for potable water extraction onshore, and its onshore coal seams have low permeability.[24] Its largest capacity for storage is offshore, with depleted oil and gas fields and saline water-bearing reservoir rocks in the North Sea offering the best prospects. Ownership of the sites where currently proposed storage will take place is not an issue insofar as the right to store gas (including CO_2) in the offshore area is vested in the Crown.[25] The EU Directive does not mandate actual deployment of CCS in any form and a decision has been made not to allow onshore storage in the UK at present. Not surprisingly therefore, no domestic statutory regime currently exists to provide for this. However, as technology develops and the need to contain greenhouse gases—and to

[19] International Energy Agency, *Energy Technology Perspectives* (OECD/IEA 2008) 268.

[20] S Holloway, 'Carbon Capture and Geological Storage' (2007) 365(1853) PhilTransRSocA 1095, 1095.

[21] In EOR, CO_2 is injected into a depleting oilfield to reduce the viscosity of the oil. As it sweeps through the reservoir, it releases oil additional to that recoverable by ordinary production methods. The first commercial CO_2 EOR project was initiated in 1972 in Texas: TJ Russial, *CCS: Legal and Regulatory Framework – 10 Year Progress Report* (United States Carbon Sequestration Council 2010) 4. During the early 1980s, EOR projects using CO_2 were undertaken in the UK at the Egmanton and Bothamsall oilfields in the East Midlands but the results were disappointing and the research was ended because of 'prohibitive costs': Evans et al (n 1) S310.

[22] Simulations have shown that the areal extent of a plume of CO_2 injected from a 1 GW coal-fired power plant over 30 years into a 100 m-thick zone will be approximately 100 km^2 and may grow after injection ceases: K Pruess et al, 'Numerical Modeling of Aquifer Disposal of CO_2' (Society of Petroleum Engineers, 2001) SPE Paper no 66537 quoted in J Rutqvist and C-F Tsang, 'A Study of Caprock Hydromechanical Changes Associated with CO_2 Injection into a Brine Formation' (2002) 42 Environmental Geology 296–305.

[23] The largest onshore oilfield in the UK is the Wytch Farm field, which underlies Poole Harbour, on the south coast of England: S Holloway, CJ Vincent and KL Kirk, *Industrial Carbon Dioxide Emissions and Carbon Dioxide Storage Potential in the UK*. British Geological Survey Commercial Report, CR/06/185N (2005) iv, 13 <http://nora.nerc.ac.uk/4837/1/CR06185N.pdf>.

[24] ibid.

[25] Section 1 of the Energy Act 2008. Under the UN Convention of the Law of the Sea (UNCLOS) 1982, territorial waters may extend 12 nautical miles from its baselines. The Crown Estate owns the majority of the seabed around the UK out to the 12-nautical-mile limit. The 2008 Act asserts the right of the Crown under art 56(1) of UNCLOS to a Gas Importation and Storage Zone (GISZ) for the storage of natural gas and CO_2. The area of the GISZ is designated by the Gas Importation and Storage Zone (Designation of Area) Order 2009 (SI 2009/223).

achieve binding emissions reduction targets—becomes more pressing, that decision may need to be revisited and appropriate statutory provision put in place. It is within this context, therefore, that comparisons with the law of other jurisdictions in which onshore storage will be prevalent may contribute to the development of coherent perspectives under the law of England and Wales.[26]

In such circumstances, the issue of who owns the pore space, i.e. the voids within the rock where the CO_2 will be stored, may be critical. This will ultimately include issues of potential liability, for instance from long-term CO_2 leakage. But in the context of this article, ownership questions crucially determine, first, who may grant storage rights and, secondly, who may be entitled to compensation in the event of expropriation.[27] To this end, the next section considers the fundamental property question as to how far the rights of the surface landowner extend beneath his land by virtue of his or her estate.

III. *CUIUS EST SOLUM, EIUS EST USQUE AD COELUM ET AD INFEROS*

One answer to the question of an estate owner's rights under his or her land lies in the well-known maxim, '*cuius est solum, eius est usque ad coelum et ad inferos*' ('he who owns the soil owns also up to the heavens and down to the centre of the earth'). The origins of the maxim are unclear but in England it is recorded as having been used as early as 1285 in a contract for the sale of a house in Norwich,[28] and it first appeared in the law reports in *Bury v Pope*.[29] Not surprisingly, given its longevity, it has since become the subject of numerous statutory and common law qualifications which restrict the surface owner's rights. Indeed, in *Bernstein of Leigh (Baron) v Skyviews and General Ltd*,[30] Griffiths J dismissed it as a 'fanciful notion leading to the absurdity of a trespass at common law being committed by a satellite every time it passes over a suburban garden', and in *Commissioner for Railways v Valuer-General*, it was said that 'so sweeping, unscientific and unpractical a doctrine is unlikely to appeal to the common law mind'.[31] However, it cannot be written off completely: while in *Bocardo SA v Star Energy Onshore Ltd*,[32] Aikens LJ (in the Court of Appeal) said that maxim was not part of English law, Lord Hope (in the Supreme Court) took the view that it 'still has value in English law as encapsulating, in simple language, a proposition of law which has commanded general acceptance'.[33]

[26] These will involve landlocked countries and those with only limited access to continental shelf marine environments.

[27] BN Grave, 'Carbon Capture and Storage in South Dakota: The Need for a Clear Designation of Pore Space Ownership' (2010) 55 SDLRev 72, 88.

[28] (1931) 47 LQR 14; DE Smith (1982) 6 Trent Law Journal 33, 38. For a history and analysis of the maxim's application in Scots Law see F Lyall, 'The Maxim *cuius est solum* in Scots Law' [1978] JR 147.

[29] (1586) I Cro Eliz 118.

[30] [1978] QB 479, 487.

[31] [1974] AC 328, 351–2.

[32] [2010] Ch 100, para 59.

[33] [2011] 1 AC 380, para 26.

Historically, most of the cases concerning the *cuius est solum* doctrine (which is embedded throughout the Common Law world) have arisen in the context of airspace; relatively few have concerned the ownership of subsoil. The discussion now turns therefore to the main authorities concerning airspace in order to establish whether they provide any useful insights as to how rights to subterranean space may be viewed.

A. Airspace

Before the middle of the twentieth century, most of the cases in which the courts in England and Wales used the *cuius est solum* maxim concerned items attached to the adjoining land such as overhanging buildings, branches, signs or telegraph wires. It was not necessary therefore for judges 'to cast [their] eyes towards the heavens', for they were simply concerned with the rights of the owner in the airspace immediately adjacent to the surface of the land.[34] In *Pickering v Rudd*,[35] a board attached to the wall of a neighbouring house which projected just a few inches over the plaintiff's garden was held *not* to amount to a trespass on the basis that there was no contact with the surface of the land, but later decisions regarding similar 'permanent' incursions into airspace have been unanimous in holding that a trespass has occurred despite a lack of contact. So, for example, in *Wandsworth Board of Works v United Telephone Co Ltd*,[36] the Court of Appeal held that the owner of land was entitled to cut a wire placed over his land; while in *Gifford v Dent*,[37] Romer J held that it was a trespass to erect a sign that projected in excess of a metre over the plaintiff's forecourt and ordered it to be removed.[38] Temporary but unauthorized intrusions at a higher level, such as booms of cranes being used for construction work on neighbouring land, have also been held to be a trespass even though the claimants had no immediate use for the airspace through which they passed.[39]

In *Pickering v Rudd*, referred to above, Lord Ellenborough floated the suggestion, *obiter*, that no trespass would be committed were an aeronaut in a balloon to pass over land without coming into contact with the surface.[40]

[34] *Bernstein of Leigh (Baron) v Skyviews and General Ltd* [1978] QB 479, 485 (Griffiths J).
[35] (1815) 171 E.R. 70; 4 Camp 219.
[36] (1884) 13 QBD 904.
[37] [1926] WN 336.
[38] See too e.g. *Kelsen v Imperial Tobacco Co (of Great Britain and Ireland) Ltd* [1957] 2 QB 334; *Laiqat v Majid* [2005] EWHC 1305; *Didow v Alberta Power Ltd* (1988) 45 CCLT 231.
[39] *Anchor Brewhouse Developments Ltd v Berkeley House (Docklands Developments) Ltd* [1992] Ch 225; *Woollerton and Wilson Ltd v Richard Costain Ltd* [1970] 1 WLR 41; *Graham v KD Morris & Sons Pty Ltd* [1974] Qd R 1; *Bendal Pty Ltd v Mirvac Project Pty Ltd* (1991) 23 NSWLR 464; *Lewvest Ltd v Scotia Towers Ltd* (1982) 126 DLR (3d) 239.
[40] *Pickering v Rudd* (1815) 4 Camp 219, 220–1; 171 ER 70, 72. In *Kenyon v Hart* (1865) 6 B & S249; 122 ER 1188 Blackburn J stated (at 1190) that he understood and agreed with Lord Ellenborough's doubt concerning whether the passage of an aeronaut in a balloon constituted trespass, though he could not understand the legal reason for it. The answer may be found in the Tasmanian case of *Davies v Bennison* (1927) 4 TLR 8, where Nicholls CJ pointed out that 'if the

Subsequently, notwithstanding the rapid development of the aviation industry during the twentieth century, it was not until the late 1970s that the courts of England and Wales were called upon to consider the position of overflying aircraft. In *Bernstein of Leigh (Baron) v Skyviews & General Ltd*,[41] the defendant company, which ran an aerial photography business, flew over Lord Bernstein's land and took a photograph of his country house which they then offered to sell to him. His claim in damages alleged that by entering the airspace above his property in order to take photographs the defendants were guilty of trespass. The report does not indicate the precise height at which the aircraft intruded, except that it was 'many hundreds of feet above the ground'.[42]

Faced with determining what level of interference was and was not acceptable, the court concluded that by flying over land for the purpose of taking a photograph the defendants' aircraft did not infringe any rights in the claimant's airspace and thus did not commit any trespass. Griffiths J rejected the proposition that a landowner's rights must extend to an unlimited height, stating that the problem was to balance the rights of an owner to enjoy the use of his land against the rights of the general public to take advantage of 'all that science now offers in the use of airspace'. In 'our present society', he said:

> The balance is . . . best struck . . . by restricting the rights of an owner in the airspace above his land to such height as is necessary for the ordinary use and enjoyment of his land and the structures upon it and declaring that above that height he has no greater rights in the airspace than any other member of the public.[43]

The same approach was put in a more nuanced way by Hodson J in *LJP Investments Pty Ltd v Howard Chia Investments (No 2)*:[44]

> the relevant test is not whether the incursion actually interferes with the occupier's actual use of land at the time, but rather whether it is of a nature and at a height which *may* interfere with any ordinary uses of the land which the occupier *may* see fit to undertake.

In the United States, the Supreme Court had considered the issue of overflying aircraft some 30 years earlier. In *United States v Causby*,[45] frequent and regular flights of military aircraft over land at low altitudes significantly interfered with the owners' use and enjoyment of the land and destroyed their use of the property as a commercial chicken farm. Declaring that the *cuius est solum* doctrine 'has no place in the modern world', Mr Justice Douglas explained that

hovering aeroplane is perfected, the logical outcome of Lord Ellenborough's dictum would be that a man might hover as long as he pleased at a yard, or foot, or an inch, above his neighbour's soil, and not be a trespasser, yet if he should touch it for one second he would be'.

[41] [1978] QB 479. [42] ibid, 488. [43] [1978] QB 479, 488.
[44] (1989) 24 NSWLR 490, 495–6. [45] (1946) 328 US 256.

'the air is a public highway' and that 'private claims to the airspace would clog these highways, seriously interfere with their control and development in the public interest, and transfer into private ownership that to which only the public has a just claim'.[46] The Court noted that an airplane is 'part of the modern environment of life'. . . and the airspace (apart from that immediately above the land) is part of the 'public domain'.[47] In reaching its decision, the Court referred to the Air Commerce Act 1926 which provided that the US had 'complete and exclusive national sovereignty in the air space' over the US and granted any of its citizens 'a public right of freedom of transit in air commerce through [its] navigable airspace'.[48]

Nevertheless, the Court found that the farmers could recover just compensation for a taking by the federal government of an easement of flight over the farm. It recognized that even though the airspace is a 'public highway', a landowner must have 'exclusive control of the immediate reaches of the enveloping atmosphere' if he or she is to have 'full enjoyment' of the land; otherwise 'buildings could not be erected, trees could not be planted, and even fences could not be run'.[49] Thus, a landowner owns 'at least as much space above the ground' as he or she 'can occupy or use in connection with the land'. The fact that the landowner does not occupy it in a physical sense by erecting buildings etc is immaterial; the intrusion by airplanes—even if they do not touch the surface—'is as much an appropriation of the use of land as a more conventional entry upon it'.[50] Although this approach echoes the 'ordinary use of the land' approach in *Bernstein* referred to above, the crucial difference between the two cases lies in the statutes which featured in them, the Supreme Court in *Causby* construing the Air Commerce Act 1926 as designating the upper airspace as a 'public highway'.

It can be seen, therefore, that whilst differently resolved, both *Bernstein* and *Causby* allow for a distinction to be drawn between what has been described as the lower and higher strata of airspace.[51] Stating that the courts are 'notoriously unwilling' to quantify the extent of the airspace which falls within the control of the landowner, Gray and Gray suggest that in England and Wales the lower stratum is unlikely to extend beyond the minimum permissible distance for normal overflying by any aircraft.[52] As for the upper stratum, lying beyond 'any reasonable possibility of purposeful exploitation by the landowner below', this can be depicted as 'an unpropertised commons, owned by no state or individual, but available for use by all'.[53] This accords with a labelling as *res omnium communis* which, i*n classical Roman law,* was generally regarded as referring to objects which, by their nature, are incapable of individual ownership, being so abundant that no managed system of allocation

[46] ibid, 261. [47] ibid, 266. [48] ibid, 272. [49] ibid, 264.
[50] ibid, 264. [51] K Gray and SF Gray, *Elements of Land Law* (OUP 2009) 1.2.32.
[52] Rules of the Air Regulations 2007, Sch 1, section 3(5).
[53] Gray and Gray (n 51) 1.2.38.

is required.[54] Examples commonly cited as falling within this category include air, the sea and sunlight. In *Lacroix v The Queen*,[55] a landowner claimed compensation from the Crown on the basis that it had appropriated his airspace by establishing a flight path over his land to and from an airport. Fournier, J took the view however that air and space fall in the category of *res omnium communis*. The Crown was not liable therefore because it could not expropriate something which was not susceptible of ownership. As was said by Morse J in *Re The Queen in Right of Manitoba v Air Canada*, 'air or airspace is incapable of delineation or demarcation' and no scientific method has been devised 'to define [it], to contain it within boundaries and to delineate it sufficiently for proper identification so that ownership can be firmly established if questioned'.[56]

Lest it be thought that the concept of *res omnium communis* signifies public ownership of property, Cassese notes that it is not a 'community-oriented' concept which obliges states that use and exploit areas in the best interests of mankind; instead it 'means that every state is authorized to use a certain good for its own purposes and its own interest'.[57] Further, although the majority of unpropertized resources commence from a default position of freedom from any form of regulation, some of them are subject to 'some form of regulatory regime directed towards the public interest' (e.g. air traffic routes or pollution controls) and 'some degree of public administration . . . may even in some cases be considered as creating a "public property" vested in the state'.[58] Thus, in England and Wales, the Civil Aviation Act 1982 provides that it is not a trespass for aircraft to fly at a reasonable height having regard to wind, weather and all the circumstances prevailing at the time.[59] But it does not go so far as the Air Commerce Act 1926 (which played such a prominent part in the *Causby* ruling) in conferring upon the public 'right of freedom of transit . . . through the navigable airspace'. Indeed, as Howell points out, it is implicit in *Bernstein* that 'there is not a "free for all" in the airspace above "the notional height at which the owner's usable rights stop"'. For instance, 'the use to which it can be put is limited to that of passage and the landowner may maintain an action for nuisance to restrain greater use'.[60] Even as regards passage, rights are limited. It is possible, for example, that trespass could occur in the case of aeromagnetic surveys, in which 'every square inch of the land is overflown by

[54] In the modern, environmental era, more attuned to the risks posed by the externalization of harms, threats to the 'unowned' environment are now of mainstream concern. See the classic exposition by G Hardin, 'Tragedy of the Commons' (1968) 162 Science 1243–8.

[55] [1954] Ex CR 69.

[56] [1978] 86 DLR (3d) 631 (2 WWR 694).

[57] A Cassese, *International Law* (OUP 2005) 5.1.

[58] K Gray, 'Property in Thin Air' (1991) 50 CLJ 252, n 103.

[59] Section 76(1). Similar legislation exists in many other jurisdictions, e.g. section 30 of the Victoria Wrongs Act 1958.

[60] J Howell, 'Subterranean Land Law: Rights below the Surface of Land' (2002) 53 NILQ 268, 270.

aircraft traversing the land in a grid formation' to secure detailed information about minerals below the surface of the land.[61]

B. The Extent of Rights to the Subsurface

The fact that—unlike airspace—deep subterranean space is capable of delineation or demarcation, that it can be defined, mapped and contained within boundaries,[62] militates against its categorization as *res omnium communis*. Arguably, a more appropriate classification is as *res nullius*: 'free territory, not as every or any man's land, but rather as a sort of "no man's land"',[63] which belongs to no-one until reduced to individual possession by appropriation. Indeed, subsurface space has been described as the 'lost continent' of urban space—the *terra nullius* of the era of progress.[64] In Roman law, the main class of objects which fell into the category of terra nullius was ferae naturae, i.e. wild animals and fish. A wild creature belonged to everybody and nobody until such time as a person killed or captured it at which point it became the private property of the killer/captor (even if he was a trespasser) rather than the person on whose land it was found.[65] From this developed the notion of *terra nullius* which (although it was gradually extended 'to justify acquisition of inhabited territories by occupation if the land was uncultivated or its indigenous inhabitants were not "civilized" or not organized in a society that was united permanently for political action')[66] was initially applied to the acquisition of 'new' uninhabited territory. Further support for the classification of subterranean space as *res nullius* lies in the fact that although it is extensive, it is also finite. Airspace can be used and reused but pore space in which CO_2 has been sequestered cannot be used for anything else. In an article published over 20 years ago, Bradbrook suggested that if the *cuius est solum* doctrine were to operate to a limited depth only (as suggested by the then limited authority), the area beyond that depth would constitute a *res nullius* and would vest in the ownership of the first person to reduce it into possession.[67]

[61] SM Morgan, 'The Law Relating to the Use of Remote Sensing Techniques in Mineral Exploration' (1982) 56 ALJ 30.

[62] See text accompanying n 56.

[63] *Thrasher v City of Atlanta* 173 SE 817, 826 (1934).

[64] CA 119/01, *Akunas v State of Israel*, 57(1) PD 817 (per Aharon Barak) quoted in H Sandberg, 'Three-dimensional Partition and Registration of Subsurface Space' (2003) 37 Israel Law Review 119.

[65] cf the common law under which 'the trespasser having no right at all to kill the game . . . can give himself no property in it by his wrongful act; and that as game killed or reduced into possession is the subject of property, and must belong to somebody, there can be no other owner of it . . . but the person on whose ground it is taken or killed': *Blades v Higgs* (1865) 11 ER 1474; 11 HLC 621.

[66] U Secher, 'The Doctrine of Tenure in Australia Post-*Mabo*: Replacing the "Feudal Fiction" with the "Mere Radical Title Fiction"— Part 1' (2006) 13 APLJ 107.

[67] AJ Bradbrook, 'The Relevance of the *Cujus Est Solum* Doctrine to the Surface Landowner's Claims to Natural Resources Located above and beneath the Land' (1989) 11 Adelaide Law Review 462.

He concluded that as a practical matter the effective result would be the same whether the *cuius est solum* doctrine were to operate or, alternatively, the resource was *res nullius*: either way, access to the resource could only be obtained by the surface landowner or by developers allowed entry onto the land with the landowner's consent, thus making 'exclusive control over access to the resource . . . effectively, if not legally, the equivalent of ownership'.[68]

Because valuable resources are located underground, rights over subterranean space have been subjected to greater and more specific limitations than those in airspace. Under the law of England and Wales, the Crown is entitled to all mines of gold and silver (whether situated on public or private land). Further, as a result of statutory provision, coal vests in the Coal Authority,[69] and all rights in petroleum (including mineral oil and natural gas) vest in the Crown.[70] Otherwise, however, as made clear by Cozens Hardy MR in *Mitchell v Mosley*,[71] 'the grant of the land includes the surface and all that is supra – houses, trees and the like . . . and everything that is infra – mines, earth and clay, etc'.[72] It follows that a person entitled to possession of the surface of the land may bring an action in tort in the event of subterranean invasions of his or her land. Where roots of trees on adjoining land encroach, he or she may abate the nuisance by cutting through them or obtain an injunction or seek damages to cover reasonable remedial expenditure.[73] Intrusion of concrete foundations by 20 inches into neighbouring land has been held to constitute a trespass,[74] as has the placing of rock anchors which projected beneath the plaintiff's land,[75] and unauthorized tunnelling for the purpose of exploiting a coal-seam.[76]

As demonstrated by the above examples, the issue has almost usually arisen in situations where the defendant has been engaged in building, mining or engineering operations under land which the claimant occupies and the subsurface has been very clearly within the claimant's effective control.[77] Only rarely have cases concerned the invasion of the subsurface at such a depth that the claimant's actual or potential user is in question. An example can be found in the US case of *Edwards v Sims*,[78] involving a dispute over the Great Onyx Cave in Kentucky which the defendant had developed into a tourist attraction. The entrance to the cave was on the defendant's land but the cave itself ran 350

[68] ibid, 473–4. As illustrated by *Bocardo* (discussed below) access to subterranean space does not necessarily require access to the surface of the land immediately above, but failure to obtain the requisite consent from the relevant landowner will constitute a trespass.

[69] Section 7(3) of the Coal Industry Act 1994.

[70] Sections 1 and 2 of the Petroleum Act 1998.

[71] [1914] 1 Ch 438.

[72] ibid, 450. However, Bradbrook argues that the Crown's entitlement to certain minerals does not necessarily mean that all other mines and minerals which lie beneath the soil belong absolutely to the surface landowner (n 67) 463–4.

[73] *Delaware Mansions v Westminster City Council* [2001] UKHL 55.

[74] *Willcox v Kettell* [1937] 1 All ER 222.

[75] *Di Napoli v New Beach Apartments Pty Ltd* [2004] NSWSC 52.

[76] *Bulli Coal Mining Co v Osborne* [1899] AC 351.

[77] Morgan (n 61) 31.

[78] 232 Ky 791; 24 SW2d 619 (1929) 620.

feet below the surface of the plaintiff's land. Even though the plaintiff could not access the cave from his own land, the court barred the defendant from trespassing on that part of the cave which ran underneath the plaintiff's land, holding that 'whatever is in a direct line between the surface of the land and the center of the earth belongs to the owner of the surface'.[79] In a strong dissenting judgment, Judge Logan felt that the rights of the surface owner should be restricted to 'everything that may be taken from the earth and used for his profit or happiness' and is thereby 'subjected to his dominion'.[80] No man, he said, 'can bring up from the depths of the earth the Stygian darkness and make it serve his purposes; neither can he subject to his dominion the bottom of the ways in the caves on which visitors tread'.[81] He concluded that a cave or cavern should belong absolutely to the person who owned its entrance, and that this ownership should extend 'even to its utmost reaches if he has explored and connected these reaches with the entrance . . . [N]o-one ought to be allowed to disturb him in his dominion over that which he has conquered and subjected to his uses'.[82] Thus while the majority of the court took a wide view of the *cuius est solum* principle, Logan's dissenting judgment was effectively based on the doctrine of *res nullius*, tying rights over subterranean land to that part of it which had been actually occupied.[83]

With hindsight it can be seen as inevitable that new conflicts might arise as an incident of the march of technology. According to Sprankling, the theory that the *cuius est solum* doctrine was part of English and American Law can be traced back to 1766 when William Blackstone proclaimed it in his Commentaries on the Laws of England.[84] Sprankling explains that before then, the English approach to subsurface ownership was 'both narrow and practical', the law recognizing that a landowner had title 'only to the region immediately underneath the surface, which he could physically use for a productive purpose', e.g. to dig for gravel or clay.[85] As Howells points out 'until the advent of the mechanical digger, the greatest extent of exploitation of the area below the surface was what could be done by a man with a spade'.[86] Yet, just as the development of commercial aviation has brought about use of the

[79] cf later proceedings *Edwards v Lee's Administrator* 265 Ky 418; 96 SW 2d 1028 (1936) in which Judge Thomas expressed the view (432) that preservation of the rights of all parties concerned (including the public who should not be deprived of 'the educational and other benefits to be derived from visiting the nature-made wonder') would best be served by treating the cave 'as a unit of property throughout its entire exhibitable length, including the augmentations of prongs or branches . . . owned jointly by all of the surface owners above it, in proportion that the length of their surface ownership bears to the entire length of such exhibitable portion'.

[80] See also *Boehringer v Montalto* 254 NY Sup 276 (1931) in which a sewer 150 feet below the surface was held not to be an invasion of the landowner's rights because the depth at which it was placed was beyond the point at which he could conceivably make use of the property.

[81] 232 Ky 791; 24 SW2d 619 (1929) 622.

[82] ibid.

[83] This is at odds with Bradbrook's argument that the same practical effect is achieved whether *cuius est solum* or *res nullius* is applied (see text accompanying n 68).

[84] JG Sprankling, 'Owning the Center of the Earth' (2008) 55 UCLALRev 979, 986.

[85] ibid, 983.

[86] Howell (n 60) 270.

airspace at greater heights, so in the recent words of Lord Hope in *Bocardo SA v Star Energy UK Onshore Ltd*:[87]

> The advance of modern technology has led to the discovery of things below the surface, and the desire to obtain access to and remove them, that were unimaginable when the depths to which people could go were limited by what manual labour could achieve.[88]

At the same time:

> A greater understanding of geology has taught us that most of the earth's interior, due to extremes of pressure and temperature, is a complex and inhospitable structure that is beyond man's capacity to enter or make use of.[89]

A significant issue, therefore, is whether limitations as to rights in subterranean space should mirror those affecting airspace. Can—or should—a similar distinction be made between the stratum immediately beneath the surface (which is necessary for the surface owner's reasonable enjoyment of his land) and a deeper one, over which he has no greater rights than anybody else? Such a view would accord with arguments supporting use of land for purposes of CCS as being for the public good. Just as cases concerning airspace may be said to involve competition between 'individual' surface interests and the 'single and very strong' public interest element of airspace travel, so the surface owner's rights in subterranean space are confronted by 'multiple' competing rights (such as oil and gas development, subsurface groundwater use, underground injection of hazardous waste, and underground natural gas storage), all of which are arguably in the public interest.[90]

An emerging train of thought in the United States is that pore space should be seen as 'a public resource, similar to the navigable airspace'.[91] Subscribing to what may loosely be described as the 'equivalence principle', Zadick, for example, suggests that just as *Causby* extended the upward reach of ownership to provide for the exigencies of air travel, so 'contemporary technological innovation (in the way of CCS) and social interests (mitigating climate change) have conspired to make the need for widespread access to the deep pore space a necessary public good'.[92] Along similar lines, De Cesar argues that there should be no property interest in the pore space at the depths at which GS sites are likely to be located because, 'similar to an airplane flying high in the air and marring someone's view', its use will be undetectable to, and have no effect

[87] [2011] 1 AC 380. [88] ibid, para 8. [89] ibid, para 19.
[90] AB Klass and EJ Wilson, 'Climate Change, Carbon Sequestration, and Property Rights' (2010) UillLRev 363, 389.
[91] JR Zadick, 'The Public Pore Space: Enabling Carbon Capture and Sequestration by Reconceptualising Subsurface Property Rights' 36 Wm&MaryEnvtlL&PolicyRev 257, 269 (2011).
[92] ibid, 272.

upon, the landowner at the surface above.[93] He maintains that 'the subterranean deep pore space should be viewed as an open storage container in much the same way the sky is looked at as an open highway'.[94] Reisinger et al also point to *Causby*, noting that just as in 'a modern air-travel age, the outer reaches of airspace can be reserved for public use', so 'in the modern age of climate change mitigation, the deepest depths can be reserved for the public good of carbon sequestration'.[95] Further, in the same way that 'public airspace begins where reasonable surface use ends', it can be asserted that 'public CO_2 storage rights begin where economically exploitable mineral reserves and non-CO_2 storage opportunities underground end'.[96] In the US, the most recent judicial pronouncement on the issue can be found in *Coastal Oil & Gas Corp v Garza Energy Trust*[97] (a case concerning hydraulic fracturing) in which Justice Hecht, writing for the majority of the Texas Supreme Court, stated *obiter* that 'the law of trespass need no more be the same two miles below the surface than two miles above'.[98]

However, militating against a direct comparison, there are essential differences between the approach taken by the US Supreme Court in *Causby* and the situation with regard to underground CO_2 sequestration. These have been identified as follows. First, there is less likely to be legislation which designates pore space (or deep subterranean space) as being within the public domain.[99] Second, while public airspace utilized for air travel is infinite, underground space used for CO_2 sequestration is 'vast but finite' and is therefore more likely to be characterized as an 'insular property right'.[100] Third, when dealing with underground CO_2 sequestration options, the 'public highway' analogy fails as 'CO_2 will be sequestered in a specific geological formation and expected to remain there or migrate only slightly'.[101] Fourth, there is no economic incentive for landowners to find a use for the upper stratum of airspace above their land and they receive no value from the passage of commercial aircraft though it.[102] By contrast, because of the resources lying underground—including caves, valuable minerals, and reserves of coal, oil and gas—subterranean space has

[93] TR DeCesar, 'An Evaluation of Eminent Domain and a National Carbon Capture and Geologic Sequestration Program: Redefining the Space Below' (2010) 45 WakeForestLRev 261, 283.

[94] ibid, 283.

[95] W Reisinger et al, 'Reconciling King Coal and Climate Change: A Regulatory Framework for Carbon Capture and Storage' 11 (2009) Vermont Journal of Environmental Law 1, 16.

[96] ibid.

[97] 268 SW 3d 1 (Tex 2008).

[98] ibid, 11.

[99] Until recently such legislation would have been unnecessary in the same way that there was no need for legislation such as the Air Commerce Act 1926 at a time when air travel was not possible or was in its infancy.

[100] Reisinger et al (n 95) 16. On the other hand, the fact that subterranean space is finite could also be used to support a public domain argument: if a resource is limited, then it is preferable that it be used in the public interest.

[101] ibid.

[102] TJ Logan, 'Carbon Down Under—Lessons from Australia: Two Recommendations for Clarifying Subsurface Property Rights to Facilitate Onshore Geologic Carbon Sequestration in the United States' 11 SanDiegoIntlLJ 561, 587 (2010).

been used much more extensively and profitably than airspace.[103] As a result, unlike airspace rights, subsurface rights have been 'carved up, conveyed, used, bought, sold, and developed' by private and public bodies for hundreds of years.[104] It can be seen that the advent of CCS affords further opportunities for economic exploitation, to which legal principles and processes are required to respond. In essence, because 'large-scale deployment of GS renders the previously valueless subsurface formations an important resource, thereby greatly increasing their economic value', there may be 'a strong economic incentive to negotiate use of subsurface formations for sequestration activities'.[105]

The first modern case in England and Wales to consider how far beneath the surface a landowner's title to land extends was *Bocardo SA v Star Energy UK Onshore Ltd*.[106] The Supreme Court, declining to adopt the 'equivalence' approach, rejected a simple application of principles that had developed for airspace. In relation to substrata, therefore, the property rights of a claimant surface owner were vindicated, along with its right in principle to assert a claim in trespass for underground incursions into the subsoil and substrata. In brief, the facts were these. The Petroleum (Production) Act 1934 vested ownership of oil and gas in the Crown and gave it the right to grant licences in return for royalties.[107] Star Energy, the defendants, held a licence issued under the 1934 Act permitting them to search, bore for and get petroleum. The Act gave a licence holder the right to acquire any ancillary rights needed to extract the oil and provided for the payment of compensation to the landowner in such circumstances.[108] Part of the reservoir of petroleum to which the licence related lay beneath the surface of the claimant's land. The defendants' predecessors had drilled three diagonal pipelines from a well head outside the boundary which entered the land at a depth of at least 800 feet, the deepest terminating at about 2,800 feet below ground level. However, the drilling under Bocardo's land had been carried out without its consent, and (for many years) without its knowledge. On discovering that petroleum was being extracted from beneath its land, it brought an action against the defendants in trespass.

[103] Note SD McGrew, 'Selected Issues in Federal Condemnations for Underground Natural Gas Storage Rights: Valuation Methods, Inverse Condemnation, and Trespass' (2000) 51 CaseWResLRev 131, 178.

[104] Klass and Wilson (n 90) 388–9.

[105] Logan (n 102) 587.

[106] [2011] 1 AC 380.

[107] The 1934 Act was repealed and replaced by the Petroleum Act 1998, section 3 of which deals with the granting of licences.

[108] These provisions now appear in the Petroleum Act 1998. They empower the court to grant ancillary rights where, first, it is satisfied that the grant is expedient in the national interest and, second, it is shown that it is not reasonably practicable to obtain them by private arrangement because, inter alia, the persons with power to grant them are 'numerous or have conflicting interests' or 'unreasonably refuse to grant the right or demand terms which, having regard to the circumstances, are unreasonable'. They would appear to render unnecessary the reforms suggested in L Griggs, 'Cujus Est Solum – An Unfortunate Scrap of Latin, Doctrine in Disarray or a Brocard of Relevance? Its Applicability to the Subterranean and the United Kingdom Supreme Court Decision in *Star Energy v Bocardo*' (2011) 19 APLJ 155.

The first issue was whether Bocardo's title to the land beneath the surface extended to the depths at which the three pipelines passed through the subterranean strata. The argument advanced by Star Energy was that a limitation must necessarily be placed on the ownership of the subsurface and that the same test as applied by Griffiths J in *Bernstein of Leigh (Baron) v Skyviews & General Ltd*[109] should be used for land below the surface (ie title should be limited to as much beneath the surface as is reasonable to enjoy ownership of the surface land). Although no English authority provided direct support for this approach, the New York Supreme Court had held in *Boehringer v Montalto*[110] that a sewer laid 150 feet below the surface was not included in the surface owner's title. Title above the surface was now limited to the extent to which the owner of the soil might reasonably make use of it, and that by analogy his title was not to be extended to a depth below ground beyond which the owner might reasonably make use of it. In *Chance v BP Chemicals Inc*,[111] the Supreme Court of Ohio took the same approach to subsurface ownership rights, rejecting the appellants' assertion of absolute ownership of everything below the surface of their property. Observing that 'ownership rights in today's world are not so clear-cut as they were before the advent of airplanes and injection wells',[112] it took the view that 'just as a property owner must accept some limitations on the ownership rights extending above the surface of the property, . . . there are also limitations on property owners' subsurface rights'.[113] It concluded that some type of physical damage or interference with the use of the land must be demonstrated for the owner to recover for a trespass and that the lateral migration of hazardous waste by-products from the manufacture of industrial chemicals which had been injected deep below the surface did not meet this test.

Nevertheless, both the Court of Appeal and the Supreme Court rejected the argument that the surface owner's rights should not extend to subsurface rights. The better view, they felt, was that the owner of the surface will also be the owner of the strata beneath it, including any minerals to be found there, unless the whole or a particular part of the strata have been transferred by conveyance, at common law or by statute to someone else. By contrast with airspace, the strata below the surface of the land could not be considered as a 'public highway' to which only the public had a just claim. The test applied in *Chance v BP Chemicals Inc*,[114] that some type of physical damage or interference with the use of the land must be shown, would lead to much uncertainty. As Lord Hope pointed out:

> It overlooks the point that, at least so far as corporeal elements such as land and the strata beneath it are concerned, the question is essentially one about ownership. As a general rule anything that can be touched or worked must be taken to belong to someone.

[109] [1978] QB 479. [110] 142 Misc 560 (1931). [111] 670 NE2d 985 (Ohio 1996).
[112] ibid, 992. [113] ibid. [114] ibid, 985.

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The limit as regards subterranean property should be the depth at which pressure and temperature made the concept of ownership so absurd as to be not worth arguing about. In the instant case, however, the fact that the strata were being worked upon meant that the wells in question were far from being so deep. Accordingly, the claimant's title extended down to the strata through which the three wells and their casing and tubing passed.

The second issue, given that a trespass occurs when there is an unjustifiable intrusion by one person upon the land in the possession of another, was whether Bocardo had or was entitled to possession of the underground strata through which the wells passed. It was difficult to say that the claimant had actual possession of the strata below the land as it had done nothing to reduce them into actual possession. Nonetheless, adopting the dictum of Slade J in *Powell v McFarlane*,[115] that in the absence of contrary evidence, 'the owner of land with the paper title is deemed to be in possession of the land, as being the person with the prima facie right to possession', both courts ruled that as the paper owner to the strata and everything within them (other than any gold, silver, coal and petroleum which belong to the Crown), Bocardo had the prima facie right to possession of those strata so as to be deemed to be in factual possession of them. As the paper title carries with it title to the strata below the surface, Bocardo must be deemed to be in possession of the subsurface strata too, given that no-one else was claiming to be in possession of those strata through the claimant as paper owner.

In that event, the defendants asserted a defence to trespass on the basis that the paper owner's *prima facie* factual possession of the strata (derived from his right to possession) could be displaced upon proof that someone else had both exclusive physical control of the land (or relevant substratum) and an intention to possess it. In the present case, the argument ran, Bocardo did not have exclusive physical control of the strata through which the pipes passed, because the defendants and their predecessors had been given a licence pursuant to section 2 of 1934 Act to bore for and get oil within the licensed area. Alternatively, the licence granted pursuant to section 2 was sufficient to justify the licensee entering the strata in pursuance of the right to bore for and get oil within the licensed area. Both courts disagreed, holding that the petroleum licence had not automatically given the defendants a right to gain access to the oil. Had Bocardo granted Star Energy the right to extract the petroleum, the principle of non-derogation from grant would have prevented Bocardo from doing anything to hamper Star Energy's use of the strata for the purpose that both parties contemplated at the time of the grant. However, the right to search and bore for and get the petroleum had been obtained under licence not from Bocardo but from the Crown and there was no common law principle to regulate the defendants' position in relation to a landowner who was not a party to that

[115] (1977) 38 P&CR 452, 470.

arrangement.[116] As a result, because the defendants had not sought a right of access either by agreement or by obtaining an 'ancillary right' to do so, the insertion of the pipelines had been a trespass, even though laying them, extracting the oil and pumping in water had not caused any physical or actual damage and the claimant's use and enjoyment of the land had not been affected.

IV. CLASSIFYING AND REGULATING PORE SPACE OWNERSHIP

The most straightforward way in which a CCS operator can acquire all the property rights it needs to sequester captured CO_2 is to purchase 'the entire and undivided fee simple estate' in the land in which the storage site is situated.[117] The application of the *cuius est solum* principle would then mean that, subject to obtaining the necessary licences and consents, it would be entitled to store CO_2 in the strata lying under the surface of the land. However, this is unlikely to be a practical option, given that hundreds of square kilometres of surface land may overlie a storage site and the operator will not necessarily need to own the surface in order to access the site. Moreover, complications occur particularly in the US where (as is commonly the case), title to strata in which minerals are to be found (the 'mineral estate') has been severed from the surface title.[118] As Wenzel explains, '[t]he owner of a fee simple may create'—by way of exception, reservation, grant, or lease—'as many separate estates as there are different minerals or strata of minerals under his or her land'.[119] Thus, for example, 'The owner of the entire interest [in land] may sell the surface to A, the stratum of iron to B, the stratum of coal to C, the stratum of oil to D, and a stratum of the air space above'.[120] The question then arises as to who owns the space left behind when the minerals have been extracted, i.e. the space in which other materials (including CO_2) may be stored. The issue of pore space ownership in such circumstances is unresolved in many American states, and authorities appear to be divided on whether the rights to pore space are held by

[116] Similarly in *In re Core Energy, LLC*, [2007] EPA App LEXIS 50 the United States Environmental Protection Agency Environmental Appeals Board found that the grant of a permit from the Agency for the conversion of a pre-existing test well to an injection well for the permanent sequestration of CO_2 did not confer the right to trespass, convey property rights of any sort, or authorize any injury to persons or property, or any invasion of other private rights. See Grave (n 27) 85.

[117] A Stamm, 'Legal Problems in the Underground Storage of Natural Gas' (1957) 36 TexLRev 161, 164.

[118] Traditionally, the mineral estate is regarded as the dominant estate so that the mineral owner 'has the right to the use and possession of so much of the surface as is reasonably required in the operation of his [or her estate]': *Getty Oil Co v Royal*, 422 S W 2d 59, 593 (Tex Civ App 1967). See ME Mansfield, 'On the Cusp of Property Rights: Lessons from Public Land Law' (1991) 18 Ecology Law Quarterly 43, 67.

[119] MA Wenzel, 'Comment: the Model Surface Use and Mineral Development Accommodation Act: Easy Easements for Mining Interests' (1993) 42 AmULRev 607, 618.

[120] *Davison v Reynolds*, 103 S E 248, 249 (Ga. 1920).

the surface owner or the owner of the mineral estate.[121] The question is said to be determined by application of either the so-called 'American' or 'English' rules. According to the American rule, the surface owner who transfers the mineral estate to a third party retains the right to use for storage the space which remains after the removal of underground minerals, oil, or gas while the English rule (which is said also to be practised 'in much of Canada') holds that the mineral owner has the exclusive right to use the subsurface space even after the minerals have been removed.[122]

In the US, the uncertainty as to pore space ownership coupled with an increasing international interest in carbon mitigation technologies has prompted a number of states—including Wyoming, Montana, and North Dakota—to pass legislation to regulate CCS.[123] In line with the assertion of the Interstate Oil and Gas Compact Commission that the varying legal treatment of subsurface pore space among US states can be reconciled by 'clearly identifying the surface owner as the person with the right to lease pore space for storage',[124] the relevant statutes all provide that where the mineral estate has been severed from the surface estate, the subsurface spore space will be owned by the surface owner.[125] Given that CO_2 may migrate laterally for more than 100 kilometres,[126] and that pore space does not stop at national boundaries let alone state borders,[127] concerns exist as to whether federal rather than state legislation might be a more logical and practical way of addressing the issue. Quite apart from these concerns, however, Klass and Wilson suggest that even if states statutorily designate ownership of pore space to surface owners, judicial application of *Causby* to subsurface rights may limit such a state-created property interest.[128] In other words, 'just as Wyoming could not vest in surface owners the right to the airspace far above their property, [so it]. . . cannot vest in surface owners the right to the deep subsurface'.[129] They maintain that the imposition of limitations on subsurface ownership would be consistent with Sprankling's proposition that property owners should have some rights below the surface to accommodate 'the foundation for her house, tree roots, and other normal surface facilities', but that those rights should extend only to 1,000 feet below the surface, with an exception for mineral

[121] For a list of authorities, see D Hayano, 'Guarding the Viability of Coal and Coal-Fired Power Plants: A Road Map for Wyoming's Cradle to Grave Regulation of Geologic CO_2 Sequestration' (2009) 9 Wyoming Law Review 139, n 16.

[122] E Wilson and M de Figueiredo, 'Geologic Carbon Dioxide Sequestration: An Analysis of Subsurface Property Law' (2006) 36 ELR 10114, 10123. See too J Lyndon, 'The Legal Aspects of Underground Storage of Natural Gas: Should Legislation Be Considered before the Problem Arises?' (1961) 1 Alberta Law Review 543, 545.

[123] Wyoming Statute section 34-1-152.

[124] IOGCC, *Storage of Carbon Dioxide in Geological Structures: A Legal and Regulatory Guide for States and Provinces* (2007) 22.

[125] Illinois, Louisiana, Oklahoma and Texas have legislated to provide for ownership of the sequestered CO_2, but have not addressed pore space ownership.

[126] Zadick (n 91) 267. [127] ibid, 266. [128] Klass and Wilson (n 90) 405.

[129] ibid.

rights.[130] He suggests that just as has been done with navigable airspace, federal legislation could be enacted declaring a 'public highway' in everything beneath the 1,000 feet threshold. A system could be established for compensating for existing uses of the subsurface below that depth and for cutting off the establishment of future private property rights and expectations. Endres agrees, pointing out that despite a 'propensity to allocate all property rights to the private sector . . . legislatures remain free to create or abolish non-vested rights', of which 'subsurface pore space not associated with hydrocarbon recovery' is an example.[131] Property rights in pore space may, he suggests, be a candidate for initial public ownership with subsequent allocation to the private sector. Not only would this clarify property rights but it would also minimize transaction costs.

While Klass and Wilson acknowledge that the public ownership approach would facilitate the development of CCS by reducing acquisition costs of pore space, they suggest that it would invite takings challenges, creating uncertainty as to the total costs of CCS implementation.[132] Gresham is doubtful, however, as to the likely success of any takings challenges, given the absence of any 'demonstrable legal or economic rationale for compensating property owners who have no current or nonspeculative, investment-backed future use of the subsurface where pore space targeted for sequestration is located'.[133] As he points out, 'absent unrealistically high electricity prices or . . . subsidy, pore space currently has no net-positive, intrinsic economic value . . . [that can] be passed along to property owners',[134] although of course it should be borne in mind that 'in a carbon-constrained world, sites suitable for the geological storage of carbon dioxide may become a valuable commodity'.[135]

Prosterman and Hanstad explain that while a landowner's rights over the subsurface vary from country to country, three main approaches can be identified.[136] Thus, in the United States and many Western European countries, private ownership of land carries with it the right to use 'the entire subsurface'.

[130] Sprankling (n 84) 1021.

[131] AB Endres, 'Geologic Carbon Sequestration: Balancing Efficiency Concerns and Public Interest in Property Rights Allocation' UIllLRev 623, 628.

[132] Klass and Wilson (n 90) 406.

[133] RL Gresham, *Geologic* CO2 *Sequestration and Subsurface Property Rights: A Legal and Economic Analysis* (2010) Dissertations. Paper 8. <http://repository.cmu.edu/dissertations/8> 169–70.

[134] ibid 169.

[135] Department of Primary Industries, *A Regulatory Framework for the Long-term Underground Geological Storage of Carbon Dioxide in Victoria: Discussion Paper* (January 2008) para 5.2 <http://new.dpi.vic.gov.au/__data/assets/pdf_file/0012/10920/CCS-Regulatory-Framework-Discussion-Paper.pdf>. For a discussion of arguments for and against the assertion by the US federal government of ownership over all pore space below a certain depth, see T Brugato, 'The Property Problem: A Survey of Federal Options for Facilitating Acquisition of Carbon Sequestration Repositories' (2011) 29 VaEnvtlLJ 305 330–42.

[136] RL Prosterman and T Hanstad, *Legal Impediments to Effective Rural Land Relations in Eastern Europe and Central Asia* (The World Bank 1999) 32.

In other countries, even where land is privately owned, the state has explicitly asserted ownership over all subsurface minerals,[137] and either established national mineral extraction companies,[138] or granted licences to third parties for the exploration and abstraction of minerals.[139] Elsewhere, the state retains ownership of only valuable subsurface resources, leaving private landowners with ownership of 'commonly found subsurface resources'.[140] Therefore, the contention that in most jurisdictions outside of the United States the 'subsurface geology' is 'owned by the government' is unfounded.[141] Although it is often assumed that assertion by the state of subsurface mineral ownership means that title to the pore space in which those mineral are to be found is automatically vested in the state, it is by no means certain that this is indeed the case.

Some governments have sought to deal with the uncertainty regarding pore space ownership by express declaration. An example can be found in the Australian state of Victoria, where the Crown owns all land 50 feet (15.24 metres) below the surface except in the case of freehold land alienated before 1892.[142] In order to resolve the ambiguities which flow from a dual system of private and Crown ownership, the Greenhouse Gas Geological Sequestration Act 2008—which aims to 'facilitate and regulate the injection of greenhouse gas substances into underground geological formations for the purpose of permanent storage of those gases'—vests ownership of 'all underground geological storage formations below the surface of any land in Victoria' in the Crown.[143] 'Underground geological storage formations' are defined to include 'any seal or reservoir of an underground geological formation' and 'any associated geological attributes or features'.[144] The Act further provides that when making any 'grant, lease, licence or other tenure of any Crown land . . . on any person, the Crown retains all rights that it has in relation to any underground geological storage formation below the surface of that land, unless otherwise stated in the document by which the grant, lease, licence or

[137] See e.g. section 44(3) of the Constitution of the Federal Republic of Nigeria 1999.

[138] As in Chile where the three state-run mining companies are the Corporación Nacional del Cobre (CODELCO), the Corporación de Fomento de la Producción (CORFO), and Empresa Nacional de Minería (ENAMI).

[139] e.g. Spain.

[140] Prosterman and Hanstad (n 136) 32.

[141] Global CCS Institute, *The Global Status of CCS: 2010* (2011) 107 <http://cdn.globalccsinstitute.com/sites/default/files/publications/12776/global-status-ccs-2010.pdf>. Similar statements appear in other policy and guidance documents, e.g. International Risk Governance Council, *Regulation of Carbon Capture and Storage* (2008) 13 <http://www.irgc.org/IMG/pdf/Policy_Brief_CCS.pdf>; International Energy Agency, *Carbon Capture and Storage Model Regulatory Framework* (OECD/IEA 2010) 3.2.3 <http://www.iea.org/publications/freepublications/publication/model_framework.pdf>; EL Aldrich, C Koerner and D Solan, *Analysis of Existing and Possible Regimes for Carbon Capture and Sequestration: A Review for Policymakers* (Energy Policy Institute/Centre for Energy Studies 2011) 16 <http://epi.boisestate.edu/media/9042/epi%20liability%20regimes%20for%20ccs_review%20for%20policymakers.pdf>.

[142] Section 339 of the Lands Act 1958.

[143] The 2008 Act is based on the Victorian Petroleum Act 1998.

[144] Greenhouse Gas Geological Sequestration Act 2008, section 3.

other tenure is conferred'.[145] On surrender of the relevant injection and storage authority, the CO_2 stored in the formation becomes the property of the State, although the former authority holder will remain liable for any harm arising as a result of its actions even where the harm arises after surrender.[146] Similar legislation enacted in the Canadian province of Alberta provides that the pore space below the surface of all land in Alberta is vested in and is the property of the Crown in right of Alberta',[147] and that no Crown grants of any land, or mines and minerals in any land in Alberta has ever operated to convey title to the pore space.[148] Significantly, it also provides that the declaration is not an expropriation of rights.[149]

The law of England and Wales has adopted a slightly different approach, making no express provision for the ownership of pore space or underground storage formations. Instead, delegated legislation has been put in place to vest the right to store gas (including CO_2) in offshore sites in the Crown. Once a site has been identified for detailed exploration, the operator must secure a carbon storage licence from the Secretary of State for Energy and Climate Change or the Scottish Ministers (depending on the location of the proposed activity).[150] The operator will also need to obtain a lease from the Crown Estate to use the relevant area of the subsurface and seabed. Future legislation to regulate on shore storage would doubtless follow a similar model. This establishment of what Logan describes as a 'monopoly' on the 'new resource' of underground formations not only 'eliminates the risk of one surface owner blocking storage in an entire formation', but also means that potential CCS operators simply have to deal with 'a single, predictable owner' rather than 'every party who *may* have an interest in a specific formation, however remote'.[151] As Endres observes, if pore space ownership is vested in multiple owners, each of whom has a power to exclude, 'the process of negotiation may be so difficult and time-consuming that the market becomes too costly to operate as a means to achieve an economically efficient outcome.[152] Another advantage is that the Crown's assumption of the exclusive right to store captured CO_2 makes it possible to create a system for granting private benefits which can yield significant revenue streams. By this simple approach, the law of England and Wales has avoided the complexity which surrounds pore space ownership in

[145] ibid, section 15.

[146] See M Gibbs, 'Australian Regulation of GHG Storage' in I Havercroft, R Macrory and RB Stewart (eds), *Carbon Capture and Storage: Emerging Legal and Regulatory Issues* (Hart Publishing 2011) 169.

[147] Section 15(1) of the Mines and Minerals Act, as amended by the Carbon Capture and Storage Statutes Amendment Act 2010.

[148] Section 15(3).

[149] Section 15(4).

[150] The Storage of Carbon Dioxide (Licensing etc) Regulations 2010.

[151] Logan (n 102) 561.

[152] Endres (n 131) 638. It may be added that in a world of zero transaction costs, it would not matter who held the initial entitlement to pore space on the basis that the parties would negotiate an efficient solution. In the real world, however, where transaction costs are ubiquitous, the initial entitlement is crucial.

the United States, thereby clearing one of the most difficult legal hurdles standing in the way of CCS.

The legislative framework in England and Wales which provides for securing access to the storage site also avoids the burden and expense of dealing with multiple landowners. Even though judicious routing of onshore pipelines can mitigate risks associated with obtaining rights of way and planning approval, the choice of route will be limited in some areas and, in any case, any onshore pipeline which is longer than 100 kilometres will be problematic because of the number of potential landowners involved.[153] Thus, the Storage of Carbon Dioxide (Access to Infrastructure) Regulations 2011 (which extend to all CCS infrastructure, including on- and offshore pipelines, storage sites and associated infrastructure (e.g. pumps and interim storage facilities) echo the regime contained in the Petroleum Act 1998 by providing that a person who has previously sought to secure access, or to make modifications, to an existing or proposed pipeline or storage site but has been unable to reach agreement with its owner, may apply to the appropriate authority for a notice granting access or consent to modifications.[154] The notice may also provide for payment by the applicant to the owner for any right secured by the notice.[155]

As regards England and Wales, the Crown's entitlement to gold, silver, and petroleum, etc does not mean that the Crown also owns the space in which that gold, silver, petroleum, etc is located. Rather, it is submitted, the legal position is analogous to land which was formerly copyhold, where the landowner has no property in the minerals themselves but nonetheless possesses the whole of the land in which they are found. This means that once the minerals are removed, only the landowner is entitled to occupy and use the space which is left unless he grants such right to a third party or the Crown steps in to reserve specific rights for itself.[156] As indicated above, assertion of ownership rights by the Crown over pore space in the UK has not been necessary to secure rights of storage. However, it may become relevant in the context of liability not only in the period between cessation of injection and regulatory closure (ie the point at which responsibility for the storage site is transferred to the competent authority) but in the post closure period as well.[157] A separate but related issue

[153] Pöyry Energy Consulting, *Carbon Capture and Storage: Milestones to deliver large-scale deployment by 2030 in the UK* (2009) 18, 35<http://downloads.theccc.org.uk/Poyry_-_CCS_Timelines_and_Milestones_for_CCC_2009_final.pdf>.

[154] Storage of Carbon Dioxide (Access to Infrastructure) Regulations 2011, regs 7, 10 and 12.

[155] ibid, reg 12(9).

[156] M West, 'The Ownership of Surface Voids Created by Mineral Extraction' (2011) 1 Conveyancer and Property Lawyer 30, 43. Such an approach is consistent with the reasoning underpinning the decision of the Supreme Court in *Bocardo*.

[157] CCS involves what have been described as 'low probability but nevertheless high consequence risks' with the potential to affect, e.g. freshwater aquifers, mineral deposits and wildlife: A Abazari and TW Wussow, 'Carbon Capture and Storage: We're Almost There' (2011) 74 TexBJ 398, 401.

concerns the ownership of CO_2 which, once it has been injected underground and has merged with the surrounding geological structures, may have become part and parcel of the land and—arguably therefore—the responsibility of the pore space owner.[158]

V. CONCLUSION

From a legal perspective, two major hurdles lie in the way of the successful adoption and implementation of CCS. These are, first, acquisition of the necessary rights to secure sufficient space within which to store captured CO_2 (alongside access to such space) and, second, liability for any damage which might result from unanticipated migration of the injected CO_2. In the US, the first hurdle has yet to be cleared and uncertainty over the ownership of the pore space and the transaction costs involved in acquiring property rights from numerous landowners present substantial obstacles for sequestration operators. The fact that pore space may be put to other uses further complicates the issue.

There is a widespread—but oft-repeated—misapprehension that in many jurisdictions outside the US, the state owns the 'subsurface geology'. It is true that in most countries the state owns the rights to extract the most important minerals but it does not follow that the state also owns the land in which those minerals are located. Indeed, in England and Wales, the Supreme Court has made it clear in *Bocardo SA v Star Energy UK Onshore Ltd* that, in contrast to airspace, the surface owner of land also owns the strata beneath the surface unless those strata have been transferred, in whole or in part, to someone else. However, this does not give the landowner the exclusive right to utilize subterranean space or to permit its utilization by, for example a CCS operator. Instead, the vesting of pore space ownership in the state (or Crown), as in Victoria and Alberta, or the conferment upon the state (or Crown) of the exclusive right to store captured CO_2 (as in the UK) means that the first hurdle (involving access to storage space) has been successfully negotiated and that attention in those jurisdictions can now focus on issues of liability.

[158] G Severinsen, 'Towards an Effective Legal Framework for the Geo-Sequestration of Carbon Dioxide in New Zealand' (2010) 16 Canterbury Law Review 331.