Viscosity

Historical geo-spatial mapping as a tool to understand the local development of port cities in a global context

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Chapter 3 VISCOSITY*

Nancy Couling & Carola Hein

Nancy Couling and Carola Hein explore the physical and metaphorical viscosity of two North Sea liquids–oil and seawater. Thickness and resistance to flow cause friction in planning and in the petroleum industry but installations erected to enforce the flow of petroleum, create unexpected viscous conditions in the North Sea as a whole.

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Viscosity refers to a fluid's resistance to flow. Fluids with a naturally high viscosity are thick and frequently valuable (oil), precious (honey), or essential to life (blood). Viscosity is inherently relational, depending not only on the composition of the fluid but also on temperature and environment. At high enough temperatures, even solid gold, steel, and sand become viscous fluids and can be poured into molds to take on new solid shapes. Viscosity disrupts assumptions of a clear boundary between solid and liquid.(1)

Spaces that resist binary assumptions are frequently transitional or intermediary. In the simple, material example of littoral zones where land meets sea, a viscous space of rich exchange exists where terrestrial and marine ecosystems intertwine and land- and seaborne urban systems converge. Port cities are located at this land/sea intersection, producing a specific type of friction which is discussed more fully in chapter 2. The port cityscape provides one possible perspective from which the urbanisation of the sea can be conceptualised. These are challenging places for planning and design, since viscosity is always changing but also volumetric and therefore requires space to maneuver. Planners have not always ceded space to viscous processes: in the interests of efficiency, security, and real estate values, they have encased waterways in concrete channels and drained estuary marshes to create new developable sites. In the process, they have tended to prioritize the binaries of fixity or flow, and in doing so have negated the inherent volumetric sovereignty of viscosity. On the other hand, principles of fluid dynamics — the flow of liquids and gases — steer innumerable urban services. Traditions have seeped into our contemporary behaviors, laws, and thinking, effectively creating viscous governmental structures and policies: despite the pressure to flow, our institutions themselves move slowly, clog, and stall. Hence, viscosity is all around us but seldom discussed.

To discuss the volumetrics of viscosity, the laws and principles by which it is shaped, and the spaces produced by interactions with viscous materials, it is necessary to consider both its physical and metaphorical properties and meanings. To explore the spatial potential of viscosity is to consider that in changing their state, viscous materials demand negotiation, temporal considerations, and tolerance for heterogeneity. Within the inherent thickness of viscous conditions, multiple unlike entities that are not easily separated or filtered out can potentially co-exist and adhere to each other in different ways. The ways in which viscous relations characterise urbanisation processes in the North Sea are explored more thoroughly in chapter 12 of this volume.

THE PHYSICAL PROPERTIES OF VISCOSITY, OIL, AND SEA

Within the North Sea, the organisation of the viscous materials of oil and the sea itself are closely linked and mutually transformative. Oil is a thick and coveted liquid which does not easily flow, but the petroleum industry has managed to convince the public that it is contained within a simplified, effortless, and flowing linear system of impenetrable pipelines, vehicles, and containers. The industry has promoted this impression largely to avoid debate over the ownership of oil and the environmental damage caused by extraction and production. The relations between water, oil, and land are characterized throughout by malleable policies favouring the oil industry and systems set in place to overcome the inherent friction.

At a distance of 280 km from the Norwegian mainland stands what the Norwegian Directorate for Cultural Heritage calls one of the "largest and most complex cultural monuments of our time,"(2) descending through 75 m of the North Sea to subsea formations 2,900-3,250 m below the sea-floor and rising around 100 m above the 30m extreme wave threshold: Ekofisk City,(3) a production hub and center of field operations for this extreme south-eastern corner of the Norwegian continental shelf. At its peak in the 1980s, this vast machine represented the greatest concentration of infrastructure on the North Sea, comprising eight oil and gas fields, thirty-two platforms, two flare stacks, and an oil storage tank the size of a city block.(4) Ekofisk City was constructed for the purpose of extracting petroleum—the driving force of our contemporary societies and perhaps the most characteristic viscous material of our time.

Sprawling North Sea agglomerations such as Ekofisk City have transformed the sea into a viscous space in ways that are quasi-independent from littoral port cities, thereby presenting an alternative starting point for reflections on the urbanisation of the sea. These installations are designed to force petroleum to flow—from the sophisticated injection of high-pressure liquids into reservoirs deep under the sea-floor, pressing hydrocarbons up to the preliminary processing stations on makeshift steel settlements high above the waves to the pumping of oil through pipelines and into the global supply networks downstream. All of these actions require powerful machinery, complex infrastructure, multinational investments, purpose-built legal frameworks, and a constant workforce that circulates around the North Sea (each person on rig tours of two–three weeks). Brent crude, one of the five major international oil benchmarks against which oil is evaluated and priced, initially referred to oil from the North Sea Brent field, but has since been expanded to include the Forties, Oseberg, and Ekofisk fields, also in the North Sea. It is a sweet, light crude with a dynamic viscosity of 16 mPa.s (5), which is less than crude from the Opec Reference Basket and easier to pump, transport, and refine—and hence more valuable. Transported by ship until the late twentieth century, crude oil is now mostly delivered through pipelines that criss-cross the bed of the North Sea. Minimizing viscosity and maximizing flow through these lines is an industry priority.

Compared to petroleum, water is fluid, but compared to freshwater, the sea is viscous. Although both the public and institutional perception of the sea is overwhelmingly focused on the surface (literally superficial), the body of the sea is a volume composed of distinct water-masses differentiated by currents, salinity, temperature, and atmospheric pressure. Stratification occurs when bottom currents and salinity differ from those of the surface, creating saline boundaries and temperature gradients that vary seasonally. So, in the North Sea, denser, saltier water of a higher viscosity flows seasonally below less saline surface water in an arc through the North Sea from the Atlantic to the Skagerrak and the entrance to the Baltic Sea.

Compared to land, however, the sea has a low viscosity.(6) At sea, border and ownership conditions that create resistance on land are reduced and subject to interpretation. Subsea pipelines and cables hold a privileged position in international law — their installation cannot be prevented by bordering states. Public and corporate actors can achieve undisputed large-scale interventions and companies can simply drop cables into the sea from vessels in open waters.(7) The sea is therefore a favored site for network infrastructure, and companies steer valuable flows through fibre-optic cables, (8) gas- and oil pipelines.

METAPHORICAL PROPERTIES

In relation to oil, the sea's volume is ruled by viscous sovereignty. The United Nations developed the 1982 Convention on the Law of the Sea (9) — the comprehensive legal framework for ocean space — largely in response to pressure from the post-war oil industry and to President Truman's claim that the US had sovereignty over resources on its continental shelf.(10) The resulting Exclusive Economic Zone rule stipulated that littoral nations have the right to exploit resources up to 200 nautical miles offshore, in what are still legally international waters. Governments license surface blocks to oil companies, temporarily "renting them out,"(11) but those blocks are merely abstract outlines far above the space of true interest — ancient geological formations thousands of metres below the seabed [Fig. 1, p. 50]. Measuring 9 km in width × 12 km in length and 300 m in height, the Ekofisk reservoir is only one of many within the Ekofisk formation; it in turn is part of the vast Mandal-Ekofisk system of sedimentary rocks, an area below the central North Sea of around 90 × 280 km.

The volume of a surface block's water column — its composition, currents, temperature, and marine life — is of no relevance to companies' interests in either the two-dimensional 200 nautical mile border extensions or the grid of licensing blocks. Oil platforms are either fixed directly to the sea-floor by steel or concrete foundations, or they are floating vessels connected solely by anchor lines and risers delivering oil from wellheads attached to the sea bed. They are connected to submerged land, as if the viscous sea did not exist and the waters that swept in to flood "Doggerland" in the central North Sea roughly 10,000 years ago had again retreated.(12)

The North Sea has the world's largest agglomeration of drilling rigs (13) which are up for decommissioning as mature wells run dry. Over the last fifty years, this infrastructure has filled up the North Sea floor, water column, and surface and increased the sea's overall resistance to flow—a process currently being continued in the wind-energy sector. Other North Sea artefacts are being removed; in April 2017 after ten years of preparation, the "topside" of the Brent Delta —a Shell-operated platform located 115 miles north-east of the Shetland Islands—was removed and transported to the UK port of Hartlepool for dismantling and recycling. Brent Delta weighed 24,000 tons, was 131 m tall, provided accommodation and recreational facilities for 161 workers and included drilling equipment and a production plant: "all the facilities that were needed to produce and export oil and gas."(14) [Fig. 2, p. 51]. Trawlers have systematically swept the once stony sea-floor of the southern North Sea bare, leaving only sand, and marine life has colonised petroleum and wind-energy hardware, infiltrating metal surfaces that provide a diversification of habitat.(15)

These evolving relations of infrastructural and habitat construction and decay are exemplary of viscous conditions that, while frequently contradictory, are potentially rich and emergent. They offer important opportunities to develop more inclusive, comprehensive, adaptive, and spatial understandings of the "cultivated sea"—a unique cultural product formed over time through the interactions of a multitude of agents and events; human and non-human, organic and mineral. In her reflections on Hurricane Katrina, Nancy Tuana points out the impossibility of drawing lines between the natural and the human-induced, arguing instead for the "viscous porosity" of these categories: "We must attend to the porosity and to the in-between of the complex interrelations from which phenomena emerge."(16) In the chapters that follow, authors present their different contributions to this challenge, based on specific sites and experience.

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(2) "Kulturminne Ekofisk," accessed 7 May 2017, http://www.kulturminne-ekofisk.no/.
(3) Stig Kvendseth K, *Giant Discovery. A History of Ekofisk through the First 20 Years* (Norway: Phillips Petroleum Company, 1988).
(4) H. D. Trotter, 'The Ekofisk Tank—A Concrete Gravity Structure In The Norwegian North Sea' (Annual Meeting Papers, Division of Production, American Petroleum Institute, 1974), https://www.onepetro.org/conference-paper/API-74-B001.
(5) millipascals/second at 0˚C. Sweet crude has a lower sulphur content, and light crude is less dense than water.
(6) The dynamic viscosity of seawater at 0˚C and 35 g kg^{-1} salinity is 1.88mPa.s. (http://www.kayelaby.npl.co.uk/general_physics/2_7/2_7_9.html)
(7) Nicole Starosielski, *The Undersea Network* (Durham, NC: Duke University Press, 2015).
(8) See chapter 8, this volume
(9) UN, "UNCLOS 1982," 1982, http://www.un.org/Depts/los/convention_agreements/convention_overview_convention.htm.
(10) Keith Chapman, *North Sea Oil and Gas: A Geographical Perspective*, (Newton Abbot a.o: David & Charles, 1976).
(11) See chapter 7, this volume.
(12) Laura Spinney, "Searching for Doggerland," *National Geographic Magazine*, December 2012.
(13) Statistica, "Number of Offshore Rigs Worldwide as of January 2018 by Region," Statistics (London ; New York: Statistica Ltd., 2018), https://www.statista.com/statistics/279100/number-of-offshore-rigs-worldwide-by-region/.
(14) David Wilkes, "How Do You Dismantle 'the Mother of All Meccano Sets'?," *Daily Mail Online*, 10 May 2017, http://www.dailymail.co.uk/~/article-4493586/index.html.
(15) See chapter 11, this volume.
(16) Nancy Tuana, "Viscous Porosity: Witnessing Katrina," in *Material Feminisms*, eds. Stacy Alaimo and Susan Hekman (Bloomington: University of Indiana Press, 2008), https://www.academia.edu/12103511/Viscous_Porosity_Witnessing_Katrina.