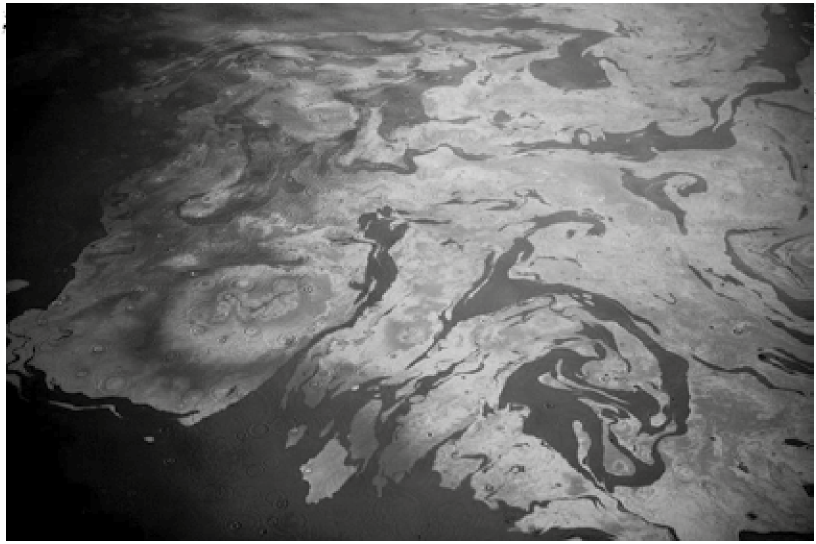
SLICK IMAGES: THE PHOTOGENIC POLITICS OF OIL

Susan Schuppli

> A new image costs humanity as much labor as a new characteristic costs a plant.
>
> — Jacques Bousquet[1]



In the late evening of April 20, 2010, an explosion ripped through the British Petroleum (BP) leased Deepwater Horizon oil rig, discharging a compressed stream of micro-image making particles into the coastal waters of the Gulf of Mexico. As these chains of carbon and hydrogen atoms were released from their subterranean containment 4 kilometers beneath the sea into the liquidity of the Gulf, their natural photonic properties began to interact with the unstable and energetic surface molecules of the water, recombining to produce an iridescent image of horror. Transfixed by the televisual coverage of a crude oil chimera whose tentacles grew daily in reach as it moved ever closer to the shores of the Mississippi River Delta, we watched as biological systems were ensnared and devoured by this creeping hydrocarbon hazard. By June 2010 the oil slick had reached the barrier islands of Alabama and the western Panhandle of Florida. Out of this refractive and monstrous shimmer a new breed of hybrids was being birthed as oil transformed living organisms into an abject surface of technogenic sludge. Birds and wildlife becoming co-extensive with the "black lagoon" that had spawned them and that would soon reclaim their brood. By the time the leaking exploratory well was finally capped on July 15, 2010, it had spewed an estimated 4.1 million barrels of crude into the Gulf, permanently damaging its marine biology, destroying coastal wildlife, polluting habitats, and shutting down the fishing communities reliant upon the ecological bounty of the Gulf.[2]

fig. 1. A bird is seen on the beach at East Grand Terre Island along the Louisiana coast after being drenched in oil. Source: ap Deepwater Horizon oil spill file photo, June 3 2010.

Timothy Morton utilizes the term "hyperobjects" to refer to large-scale entities that are "massively distributed in time and space relative to humans" and "viscosity" to designate the ways in which "time emanates from [such] objects, rather than being a continuum in which they float."[3] These characterizations of the hyperobject are resonant with my research around the accident at

Chernobyl wherein I invoked Gilles Deleuze's concept of the "radioactive fossil" to make similar suggestions as to the manner in which the nuclear operates according to radically different time scales that cut across vast bio-technical and eco-social networks.[4] Indeed the sinister image-making capacities of technogenic disasters such as Chernobyl and the Deepwater Horizon oil spill are perhaps more forcefully captured by the concept of the radioactive fossil described by Deleuze as an "alienated, off-balance, embryonic, and hallucinatory" force which expresses a kind of deviant vitalism that is always in excess of the object and suggestive of its power to transmute living matter into forms of deadly life.[5] Whereas the hyperobject, despite its spatial and temporal expansiveness, strikes me as somewhat less malevolent. Deleuze's ferocious material imaginary, to which I would also add the contemporary writings of geo-philosopher Reza Negarestani on petroleum as the black corpse of the sun, combine to elaborate the demonic nature of these sprawling entities. These are not "things" in their own right but "complicitous materials" that register the deeply implicated and distributed dynamics of events such as a nuclear accident or an oil spill.[6]

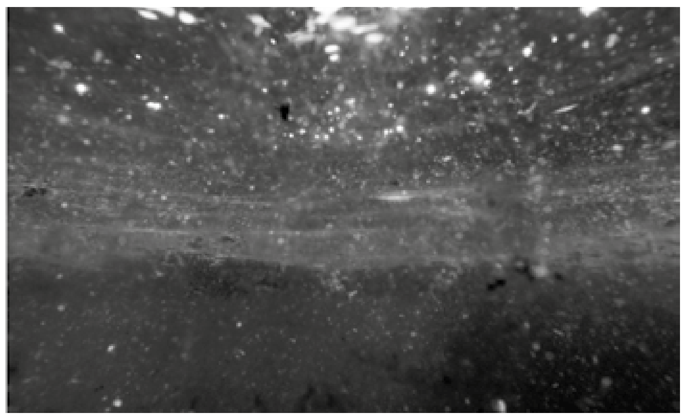


fig. 2. Globules of oil from the Deepwater Horizon spill are seen from an underwater vantage in the Gulf of Mexico south of Venice, Louisiana. Source: PA

The ecological fallout from such forms of experimentation, whether produced by scientific test labs or the result of aggregate carbon emissions, in the case of global warming, has inaugurated a new set of lethal agents that push at the limits of what constitutes moral responsibility and thus legal liability. Especially for events in which contributing factors and causalities are so dispersed and long-term consequences difficult, if not impossible, to predict; a difficulty that was at the heart of compensation for damages in the BP settlements. In the research I was engaged with during the Forensic Architecture ERC project at Goldsmiths University of London (2011–14), our work often rubbed up against the more instrumental demands that are made upon objects to speak as self-sufficient and autonomous agents especially in institutional contexts such as criminal courts and climate change forums. Demands to reduce, if you will, the narrative reach that a hyperobject such as a contaminated environment needs to perform in order to increase or strengthen the bond that links a perpetrator to a crime, such that an oil spill can enter into a legal arena as a "material witness."[7] Ours was not a claim for the irreducibility of the object but a proposition for new relations that brings technology, aesthetics, human rights, and the law into novel spatial configurations capable of forging alternate political ecologies. In doing so we countered more popular understandings of forensic science as invested in arriving at a definitive account of events.

The case of the ultra-deepwater semi-submersible mobile offshore drilling unit (MODU) known as Deepwater Horizon, in both its pre- and post-disaster state, is a classic doomsday scenario inevitably come-to-pass. Its failure is perhaps not so much a consequence of the accident having being invented alongside the engineering

technology that permits deep-water oil exploration and drilling, as Paul Virilio might have suggested in his seminal writings on the origins of the accident. But is also a consequence of the hyper-financialization of the biosphere's resources in which risk calculations are increasingly downgraded in favor of globalized profit margins and organized around near-futures rather than the deeper time of ecological conservation and technological prudence.[8] According to the US Department of the Interior Minerals Management Service, as of October 1, 2014, there are still some 3,060 offshore rigs in the Gulf of Mexico drilling at depths ranging from 200 meters to over 800 meters.[9]

Documents and testimony from Congressional hearings revealed a series of potential failures and warning signs at the well site in the hours leading up to the rig explosion, as well as questions that had been raised years earlier about the reliability of deepwater technology and the ability of the industry to deal with "worse-case scenarios" of accidents. The Minerals Management Service, the government agency with lead oversight of offshore oil and gas activity, came under heavy criticism for lax environmental planning and for sacrificing sound stewardship of a public natural resource for the narrow economic gain to private industry.[10]

Until things went horribly wrong, the smooth flows of finance capital were already pumping future dividends from the Macondo Prospect oil field, which included the Deepwater Horizon, into the combined coffers of BP, Halliburton, and Transocean Ltd., the three major corporations involved in developing the exploratory well.

The future image of oil translated into a series electronic ticker-tape digits flowing across the screens of market analysts and derivative exchanges. This defining image of BP oil was indeed confirmed by the callous remarks made by its then CEO Tony Hayward in the wake of the disaster, which also saw the death of 11 oil rig workers: "There's no one who wants this thing over more than I do. You know, I'd like my life back." However in as much as the Deepwater Horizon is a tale of technogenic failure and corporate malfeasance, it is also a foundational myth in the constitution of a new category of extreme aesthetic products derived out of toxic waste and environmental pollutants. This entanglement between the transformative agency of human culture and natural phenomena is both inversely prefigured in the example of the prehistoric Gwion Gwion rock paintings of Western Australia, which inspired this edited volume, as well as subject to its globalizing forces. Whilst the intervention of bacterial life and fungi that etched the rock paintings ever deeper into their geologic substrates and is credited with conserving the paintings' intense chromaticization despite enormous shifts in temperature and climate over a period of almost 40,000 years, nature sustained these cultural artifacts during the Holocene. Today the rock paintings of the Kimberley region are under threat by the super-pit mining operations that disarticulate the Australian outback and eviscerate its geology for economic gain; the natural forces that ministered to the paintings' delicate preservation no longer able to stave off the forces of human intervention and extractivism.

Debates are currently taking place amongst scientists as to whether we have entered a new geological epoch — the Anthropocene — to reflect humanity's considerable impact upon earth, the outcome of which would formally bring an end to the current period of the Holocene.[11] Yet it is not enough to understand these transformations purely in terms of their radical geological reorganization, we must also confront their violence as fundamentally imagistic. Anthropogenic matter is relentlessly visual in throwing disturbing images back at us from which we should recoil, were we not part of this same obscene metabolic order. I forward the proposition that we have, by extension, also entered a new geo-photo-graphic era in which planetary systems have been transformed into vast photosensitive arrays that are registering and recording the rapid transformations induced by modern industrialization and its contaminating processes. From the radioactive fallout at Fukushima, to the photochemical smog that enshrouds cities around the globe and the dark snow of the Arctic, a comprehensive material archive of global wrongs has emerged exemplified by the slick imagery of the Deepwater Horizon oil spill. These extreme pictures are quite literally earth-shattering and thus incommensurate with the epochal logic that would fold humans into their unifying orders as an agent amongst any other. On the contrary, the phylogenetic incident of humanity has mutated into a force as unpredictable and potentially cataclysmic as that of the meteorites that crashed into earth to inaugurate the Ice Age. It is this random anthropogenic violence that the unleashed oil molecules of the Deepwater Horizon ultimately pictured as slithered across the Gulf of Mexico.

Oil films, as they are properly called, are the thin emulsive layers of molecules that ride the surface tension of water, refracting light to create a form of natural photonics.[12] These proto-cinematic properties are not however unique to oil slicks and are to be found throughout the natural world, although as I have suggested the industrial-scale at which environmental systems are being provoked into producing anthropogenic image-assemblies is of a consequentially different nature. In animals, especially birds, insects, and fish, the metallic-like reflections we associate with a peacock's plumage, the iridescent properties of fish scales or a beetle's glittering carapace are produced not by solid metals — of which animals contain none — but by photonic crystals. And unlike colors achieved by genetic pigmentation, these are structural colors generated by the architectural organization of molecules as light waves move across the organism's crystalline surface structure. Such animals are, in effect, prismatic agents, whose spontaneous coloration is activated by the direct intercession of light. The shimmering variance of the organism's surface coloration suggestive of Isaac Newton's optical experimentation in his treatise *Of Colours I* (1665–6), in which he argued that the sunlight refracted by prisms was corpuscular and consisted of material globules that could change

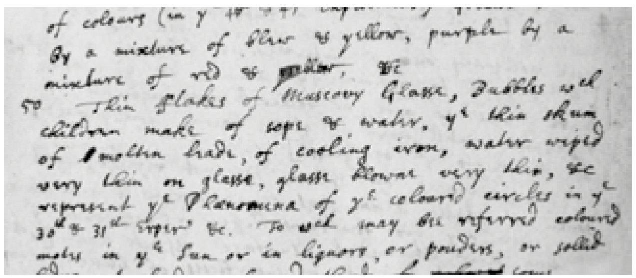

of colours (in [illegible]
By a mixture of blew & yellow, purple by a
mixture of red & yellow, &c
50 Thin flakes of Muscovy Glasse, Bubbles wch
children make of sope & water, ye thin skum
of molten leade, of cooling iron, water wiped
very thin on glasse, glasse blowne very thin, &c
represent ye Phenomena of ye coloured circles in ye
30th & 31th Experimt &c. To wch may bee referred coloured
motes in ye Sun or in liquors, or powders, or solid
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fig. 3, Thin flakes of Muscovy Glasse, Bubbles which children make of sope & water, the thin skums of molten leade, of cooling iron, water wiped very thin on glasse, glasse blowne very thin, &c represent the Phænomena of the coloured circles in the 30th and 31st Experiment &c. Isaac Newton's manuscript "of Colours", 1665–66. Source: The Newton Project, University of Sussex.

their color according to their speed.[13] Likewise the spectral effects returned to us by these quasi-photographic creatures is always in a state of continual transformation and change: unfixed and unstable, refracted, and diffused.

By comparison the natural chromatic potential of hydrocarbon atoms is activated by the change in density of the oil film's molecular arrangement as it spreads and thins, thus modulating the degree to which light wavelengths interact and interfere with one another. In fact, only one color is ever reflected by a particular thickness of an oil film, an attribute consistent with Newton's revised position of prismatic colors as immutable in *Of Colours II*. The rainbow-like hues that we witness in many petroleum-based products such as gasoline, lubricants, and soap bubbles, as well as in decaying vegetative matter is the result of an interplay between wavelengths of light and micro-variations in the molecular density of hydrocarbon atoms.

The film of oil creates two imperfect mirrors—surfaces that are flat, approximately parallel, but only partially reflecting. A light wave first encounters the surface between the air and the oil; some of it reflects, some continues on into the oil and encounters the surface between the water and the oil. Here again, some reflects and some continues.

fig. 4, Seifenbläser, Jean-Baptiste-Siméon Chardin (1699–1779), late-18th century.

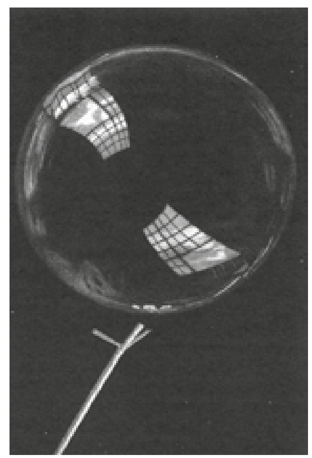

fig. 5, La Bulle de Savon, Amédée Guillemin Source: British Library 8705.f.28, 1882.

When we look at an oil slick, we see the combination of reflected light waves. Because the two mirrors are close—the distance between them is similar to the wavelength of light—light reflecting from them interferes with itself: that is, waves of light reflecting from one mirror augment or annihilate waves reflecting from the second.[14]

Historian of science Simon Schaffer has explored the extension of Newton's *Optiks* into the commodity forms of "mass science" through the 19th century convergence between physics and image-making technologies that aligned themselves to capture and fix the transient phenomena of everyday life. Of specific interest were efforts to photograph the interference colors of soap films, which generated what Schaffer has called a cinematography of the soap bubble. "In the hands of late-nineteenth century physicists and entrepreneurs, the ephemeral soap bubble became a stock object of engineering, image-making and commerce. Techniques that could turn seemingly intransigent and unstable things into fixed and stable commodities were essential components in market capitalism."[15] In the objectification and commodification of the trembling soap bubble we can already see — reflected — the kinetic image of the Deepwater Horizon oil spill yet-to-come, which is itself a product of turbo capitalism.

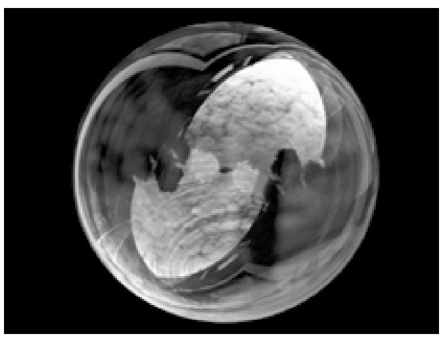

fig. 7, Soap bubble, Source: Iman Sadeghi, 2007.

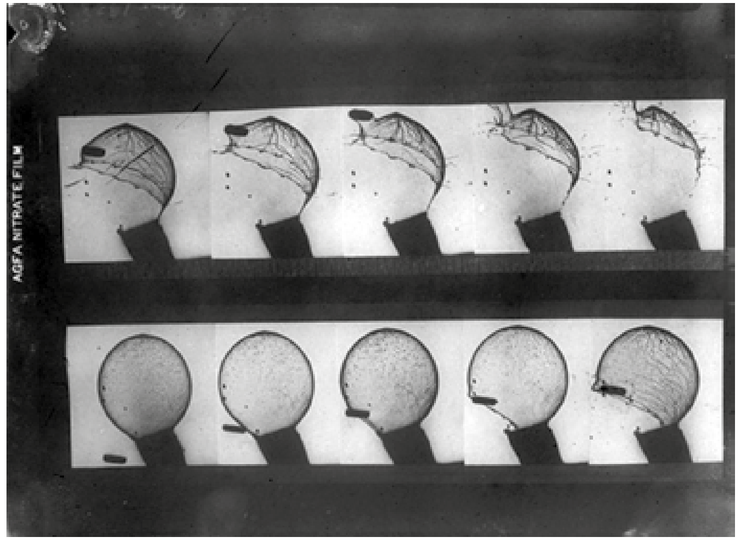

fig. 6, Soap Bubble movies, Harold E. Edgerton, nitrate negative, November 23 1933.

The image-making capacity of the oil film isn't simply a question of its ability to mirror or project some kind of image-like event back at us — abstracted and lurid patterns of reflected light — but is a cinematic feature of its very ontology, its molecular structure and behavior. It is not a representation of an oil spill, but an oily picture (in a conceptual nod to Whitehead's "smelly feeling") or what I call a slick image. Unlike the satellite transmissions or underwater video feeds depicting the Deepwater Horizon spill — all images produced through technological mediation — the slick was already destined to become image-matter at the moment when hydrocarbon atoms were released from their pressurized containment to conjoin with water and light. While I would concur that this conjunction is, itself, a form of technicity in the wider sense exemplified by Deleuze and Guattari's concept of the machinic, which posits that all relations, whether naturally inhering or socially articulated are machined. For the purposes of this discussion however, I would like to maintain a distinction between matter that can produce spontaneous or natural images by virtue of its inherently optical architecture, filmic morphology and energetic disposition — the capacity of nuclear materials for spontaneous illumination offers perhaps one of the clearest examples of this order of the nature-image-hybrid that I am invoking — and images that are organized into representational configurations or pictorial compositions by external mediators: camera systems and/or sensor technologies.[16]

> Surfaces are also, in a sense, a separate state of matter, distinct from solids, liquids, and gases: surfaces are where the properties of matter change most rapidly.[17]

When the smooth viscosity of oil comes into contact with the rough surface tension of the sea — the point at which water molecules are exposed to air — rapid transformations in the thickness of the oil film occur and therefore also extraordinary and rapid shifts in color. Molecules achieve maximum stability when in proximity with other like-molecules, which is why the energetic surface agitation of water molecules is smoothed over when a film of oil molecules shields their partial nakedness, thus also improving its overall reflective potential. Anyone who has scuba-dived has experienced this strange transition between the agitated movement of surface turbulence and the almost immediate tranquility below. Unless contained or broken down by dispersants (naturally occurring or introduced), over time these filmic molecules will thin themselves out to a mere few hundred, which is why an oil spill is so devastating in terms its potential magnitude of coverage. For example, one tablespoon of oil thinned to a single molecular layer will cover an area of 0.0053512151 square kilometers.[18] Extrapolating from this figure we can produce an approximate

calculation as to what 4.1 million barrels of liquid oil or 651,847,909 liters leaked into the Gulf could represent if the spill was left unabated to thin and spread, eventually arriving at a figure of 196,426,648 square kilometers. Given that 71% of the earth's surface (361,740,000 square kilometers) is made up of water, this figure represents coverage of more than half of the earth's liquid surfaces. Whilst this calculation is of course hypothetical and cannot properly take into account the many variables that would skew this figure, including the particularity of the Deepwater Horizon's molecular oil and gas profile, nor the natural chemistry of the Gulf that would partially breakdown the floating petroleum hydrocarbons as they spread, it does help to understand the scale of the spill's potential reach and thus also the scale of its image-making capacities: an attribute of extension dramatically captured by the remote sensing technologies that monitored its oily progress.[19]

fig. 8, Deepwater Horizon, April 21 2010. Source: us Coast Guard.

As the disaster unfolded, its image morphology too underwent a series of transformations. During the initial days — before the drilling rig sank into the sea — its image regime was localized at the site of the blowout (not necessarily the scene of the crime, which was massively distributed across global actors as the various investigative commissions would eventually demonstrate) and dominated by spectacular shots of the burning rig engulfed by flames and bilious toxic smoke. When the oil spill began to spread the image of a highly sophisticated technical object set ablaze in the Gulf morphed into a dispersed laminar flow of hydrocarbons — a mobile image no longer capable of being contained within the picture planes of conventional camera systems. As the disastrous object disappeared from view into the murky depths, its image-making capacities and modes of image capture began to multiply across technical media and distribution platforms. Soon our public gaze was suspended between two new media geographies, the real-time underwater cameras that streamed blurry images of gushing crude as it defied all efforts to cap the leak and the earth observation satellites that transmitted aerial datasets as they tracked the spill's molecular expansion and migration across the surface waters of the Gulf. This transition from the disaster's fiery eruption, to its gushing expulsion from below and eventual hypnotic horizontal creep combine to produce a regime of increasingly decelerated and distributed image-matter. Not the decisive snapshot of the initial blowout, but the slow leaking violence of representations that are nonetheless stunningly brutal. The greatest mobilization of image-responders to the event was no doubt that of the various aerial surveillance systems that directed their ultra-precision lenses and sensors towards the spill. From the

Landsat 7 earth observation satellite system that charted the migratory menace of the Deepwater Horizon spill as it expanded and moved, to the NASA near-infrared AVIRIS instrument that was repeatedly flown across the spill to map the location and distribution of thick oil floating on water. The following images and brief technical descriptions help to provide further insight into the range of remote sensing technologies that were deployed.

fig. 10, Landsat 7, earth-observation satellite image acquired May 1 2010

The NASA Airborne Visual Infrared Imaging Spectrometer (AVIRIS) instrument flew repeated flight lines over the oil spill on May 17, 2010 in order to map the locations of thick oil floating on water. This system requires cloud-free access, and was able to cover about 30% of the spill. NASA's Moderate Resolution Imaging Spectroradiometer (MODIS), an instrument carried about their Terra satellite also took images on the same day and was able to fill in the gaps of the AVIRIS flight plan through extrapolation.

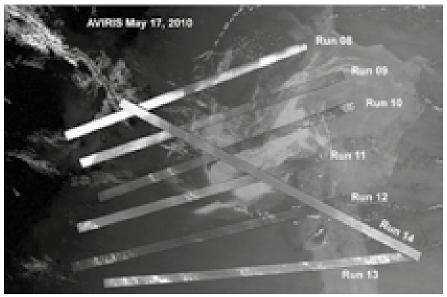

Fig. 12. AVIRIS flight lines over the Deepwater Horizon oil spill. The background image is from MODIS Terra acquired the same day, May 17, 2010.

A method of near-infrared imaging spectroscopic analysis was developed to map the locations of thick oil floating on water. Specifically, this method can be used to derive, in each image pixel, the oil-to-water ratio in oil emulsions, the sub-pixel areal fraction, and its thicknesses and volume within the limits of light penetration into the oil (up to a few millimeters). The method uses the shape of near-infrared (NIR) absorption features and the variations in the spectral continuum due to organic compounds found in oil to identify different oil chemistries, including its weathering state and thickness. The method is insensitive to complicating conditions such as moderate aerosol scattering and reflectance level changes from other conditions, including moderate sun glint.[20]

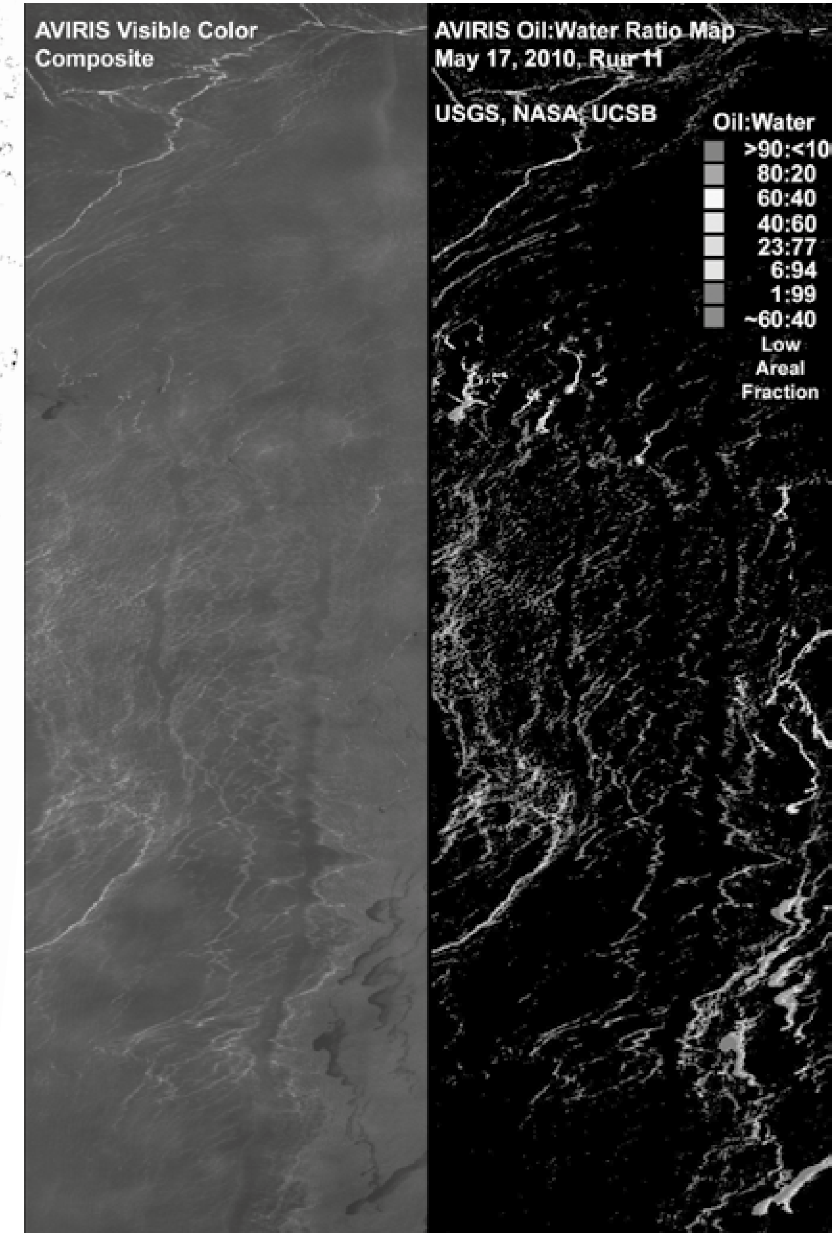

Fig. 11. Mapping results for oil-to-water ratio for a portion of AVIRIS run 11. The width of the scene is about 5.5 kilometers. Black areas on the right panel are where no thick oil was detected. The center of this image is about 12 kilometers west-southwest of the incident site.

> Ribbons and patches of oil that have leaked from the Deepwater Horizon well offshore are silver against the light blue color of the adjacent water. Vegetation is red. In the sun glint region of a satellite image—where the mirror-like reflection of the Sun gets blurred into a wide, bright strip—any differences in the texture of the water surface are enhanced. Oil smoothes the water, making it a better "mirror." Oil-covered waters are very bright in this image, but, depending on the viewing conditions (time of day, satellite viewing angle, slick location), oil-covered water may look darker rather than brighter. The relative brightness of the oil from place to place is not necessarily an indication of the amount of oil. Any oil located near the precise spot where the Sun's reflection would appear if the surface of the Gulf were perfectly smooth and calm is going to look very bright in these images.[21]

In contrast to these highly technical images, which appeared primarily in scientific contexts and government reports, the underwater cameras returned the accident to the domesticated sphere of online consumption allowing us to peer into the proximate and abject space of the accident with the click of a mouse. While the enormity of the oil slick is clearly manifest in the satellite images in which the spill gains equal billing with the terrestrial features it threatens to dwarf, the magnitude of the leak registers its full visceral impact in the low-res underwater footage. It is gushing matter out of place. I confess I too was mesmerized by the underwater battle being waged to plug the leak in the blowout preventer. As the days, weeks, and months passed we collectively learnt a

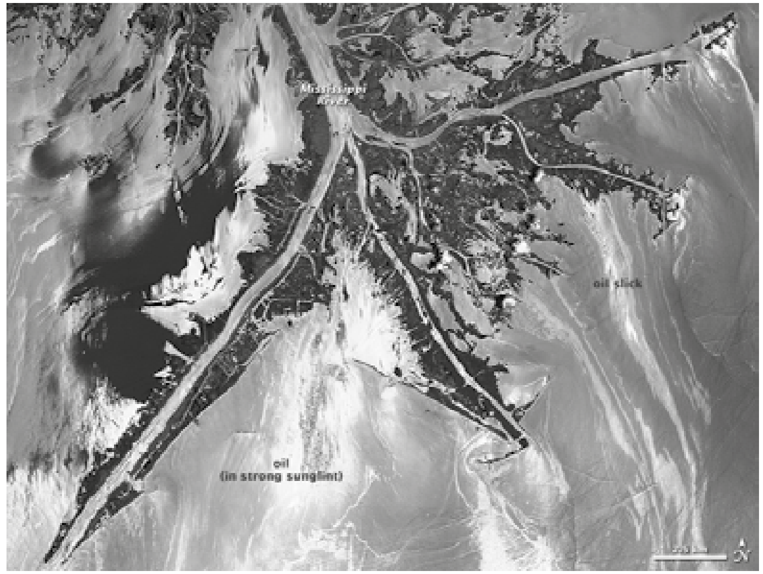

fig. 13. Advanced Space-borne Thermal Emission and Reflection Radiometer (ASTER) on NASA's Terra satellite captured this false-color, high-resolution view of the very tip of the Mississippi River Delta, May 24, 2010

fig. 14. Frame from an underwater video feed. Source: BP

new lexicon: top kill, junk shot, cut-and-cap, static kill, and relief well—a petroleum patois that marked each stage and strategy in efforts to arrest the flow.
Yet this impoverished and murky image was somehow deemed insufficient to BP who decided at a certain point to doctor a scene of their employees monitoring the remote-controlled underwater cameras in their Houston Command Center. In the original photograph three of the video feeds were turned off but in the altered image, all video streams are in full operation suggesting comprehensive round-the-clock coverage. This mock-up featured prominently on BP's website with the caption "HIVE at Houston Command Center July 16, 2010" and was positioned as visual evidence of their continued and comprehensive oversight of the accident. Blogger John Aravosis, who was following the crisis in the Gulf, noticed the crudely Photoshopped additions and remarked: "I guess if you're doing fake crisis response, you might as well fake a photo of the crisis response center. The photo doctoring comes as BP has promised transparency in a bid to regain the public's trust."[22]

The history of photography has always been in equal parts a history of trickery and deception from the moment that sunlight was first enlisted to aid in the production of visible proofs, yet the political role of the image to provide evidence of wrong-doing and injustice remains one of its most important and urgent functions. Our task now is precisely that of attending to the extreme and disputed images that matter itself is throwing up at us. Oily images that not only grasp our attention, but grasp at us—that claim us as part of them. The pollution that filters the streaming radiance of the sun over China's megacities, the thermal inversions that twist and bend the crystalline structures of ice and snow

fig. 15. HIVE at Houston Command Center July 16, 2010. Original image. Source: BP.

fig. 16. Altered image. Source: BP.

in the Arctic, the drought that provokes the hallucinatory heat shimmer of the Sahel, the oil spill in the Gulf whose incandescence both horrifies and seduces. The material base of production has been transformed into a planetary laboratory whose economic experiments are creating ever-more hazardous photogenic events. When Jacques Bousquet wrote that "a new image costs humanity as much labor as a new characteristic costs a plant", he may not have realized the degree to which new forms of labor, historically in the service of industrial manufacturing and now increasingly shareholder profit, would literally be the force that induces this new image regime. Any renewed political struggle over the relations of production must take into account this material production of the image itself — understood not simply as a geo-photo-graphic archive that exposes the effects of global capital, but as the slick images of capital itself.

1 Jacques Bousquet quoted in Gaston Bachelard, *Water and Dreams: An Essay on the Imagination of Matter*, trans. Edith R. Farrell (Dallas: Pegasus Foundation, 1983), 3.

2 A *Center for Biological Diversity Report* estimates that over 82,000 birds; about 6,000 sea turtles; and nearly 26,000 marine mammals were killed from either the initial explosion or the oil spill. Anon., "A Deadly Toll: The Gulf Oil Spill and the Unfolding Wildlife Disaster," in *April Report* (Center for Biological Diversity, 2011). "The U.S. Fish and Wildlife Service reported that up to 32 National Wildlife Refuges were potentially affected by the spill. Concerns were raised about the environmental impacts of chemicals known as dispersants that have been used to dissipate the oil slick. By June 2, 2010, the National Oceanic and Atmospheric Administration (NOAA) had banned fishing in about 36% of federal waters, or 229,270 sq. km of the Gulf." Cutler J. Cleveland, "Deepwater Horizon Oil Spill," *The Encyclopedia of Earth* (2010), 4.

3 Timothy Morton, "Hyperobjects: Philosophy and Ecology after the End of the World," *Reference and Research Book News* 28.6 (2013), 1 and 33, respectively.

4 Susan Schuppli, *Material Witness: Forensic Media and the Production of Evidence* (London: MIT Press, forthcoming 2015).

5 Gilles Deleuze, *Cinema 2: The Time Image*, trans. Hugh Tomlinson and Barbara Habberjam (London: Continuum, 1989), 112–13.

6 Reza Negarestani, *Cyclonopedia: Complicity with Anonymous Materials* (Melbourne: re.press, 2008).

7 For a discussion on the limits of current legal frameworks to account for the emergence of new non-human actors, see Susan Schuppli, "Deadly Algorithms: Can Legal Codes Hold Software Accountable for Code that Kills?," *Radical Philosophy* 187 (2014).

8 Paul Virilio, *The Original Accident* (Cambridge: Polity, 2007).

9 www.data.bsee.gov/homepg/data_center/platform/platform.asp

10 Cleveland, "Deepwater Horizon Oil Spill," 5.

11 Ian Sample, "Anthropocene: Is This the New Epoch of Humans?," *The Guardian* (October 16, 2014).

12 Bernard Horstein, "The Appearance and Visibility of Thin Oil Films on Water," in *Environmental Protection Technology Series*, ed. National Environmental Research Center Office of Research and Monitoring (Cincinnati, Ohio: US Environmental Protection Agency, 1972).

13 See William R. Newman, "Newton's Early Optical Theory and its Debt to Chymistry," in *Lumière et vision dans les sciences et dans les arts, de l'Antiquité du XVIIe siècle*, ed. Danielle Jacquart and Michel Hochmann (Librairie Droz, 2010), 10–11.

14 Felice Frankel and George M. Whitesides, *On the Surface of Things: Images of the Extraordinary in Science* (London: Harvard University Press, 2007), 14.

15 Simon Schaffer, "A Science whose Business is Bursting: Soap Bubbles as Commodities in Classical Physics," in *Things that Talk: Object Lessons from Art and Science*, ed. Lorraine Daston (New York: Zone Books, 2004), 190.

16 See the discussion of French physicist Henri Becquerel experiments with uranium salts and phosphorescence in Susan Schuppli, "Radical Contact Prints," in *Camera Atomica*, ed. John O'Brian (London: Black Dog Publishing, 2014).

17 Frankel and Whitesides, *On the Surface of Things*, 8.

18 Ibid., 14.

19 "Quantitative information regarding the endmember composition of the gas and oil that flowed from the Macondo well during the *Deepwater Horizon* oil spill is essential for determining the oil flow rate, total oil volume released, and trajectories and fates of hydrocarbon components in the marine environment…Based on the measured endmember gas-to-oil ratio and the Federally estimated net liquid oil release of 4.1 million barrels, the total amount of C1-C5 hydrocarbons released to the water column was 1.7 × 1011 g." www.pnas.org/content/109/50/20229.

20 Gregg A. Swayze Roger N. Clark, Ira Leifer, K. Eric Livo, Raymond Kokaly, Todd Hoefen, Sarah Lundeen, Michael Eastwood, Robert O. Green, Neil Pearson, Charles Sarture, Ian McCubbin, Dar Roberts, Eliza Bradley, Denis Steele, Thomas Ryan, Roseanne Dominguez, and the Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) Team, "A Method for Quantitative Mapping of Thick Oil Spills Using Imaging Spectroscopy," in *USGS Open-File Report* (Washington: USGS, 2010), 1.

21 NASA Earth Observatory image created by Jesse Allen, using data provided courtesy of NASA/GSFC/METI/ERSDAC/JAROS, and U.S./Japan ASTER Science Team. Description provided by NASA.

22 Steven Mufson, "Altered BP Photo Comes into Question," *Washington Post* (July 20, 2010).