10. Volcanic Deductions

Photography as a Purveyor of Visual Analogy, Geological Hypotheses, and Knowledge

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For his 1874 book *The Moon: Considered as a Planet, a World, and a Satellite*, which was among the first photomechanically illustrated texts, amateur astronomer James Nasmyth incessantly sketched views of volcanic craters as he peered through a telescope. After making dozens of drawings, he created plaster three-dimensional models based on imagined composites of these drawings. Nasmyth then photographed the plaster models to use as illustrations for his reports and articles, and took the models to scientific society presentations as illustrations of his theories. He went to such great lengths to grapple with and gain an multidimensional understanding of the structures and behaviors of volcanos, and to aid other astronomers in doing so, too.[1] Nasmyth's manner of thinking fit into broader Victorian-era scientific dialogues that privileged both the facticity gleaned from material *and* from virtual visual analogies. Perhaps

1 By 1874, the Moon had been photographed with and without the aid of telescope-mounted cameras. For more on the history of photographing the Moon and this endeavor's particular fervor in the mid-nineteenth century, please see: Kris Belden-Adams, "John Whipple, William Bond, and George Bond, *The Moon, No. 37*," *Smarthistory* (June 30, 2022) (accessed November 28, 2023): https://smarthistory.org/john-whipple-william-bond-and-george-bond-the-moon-no-37/; Mia Fineman and Beth Saunders, *Apollo's Muse: The Moon in the Age of Photography* (New York: Metropolitan Museum of Art, 2019). These images, offering full-frame views of the Moon, would have been of limited assistance to Nasmyth for studying enhanced, highly detailed views of craters. This drove Nasmyth, the son of established portrait painter Alexander Nasmyth and early student at the Edinburgh School of the Arts, to make his own using a combination of drawing, sculpture, and photography.

for this reason, Nasmyth's approach has been historicized as an approach to image-making that is locked in a distant analog past.[2]

However, Nasmyth's Moon images point to intellectual continuities between analog photography and analogical thinking across the analog/digital divide, and they call for a more fluid reconceptualization of these terms. The synthesis and translation of visual representations of geological forms – while moving from three dimensions, to two, and back – provide an analogy for the function of recent digital-photographic practices for volcano monitoring, the Japanese Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) sensor for collecting photographic data from aboard NASA's Terra satellite.

This chapter places Nasmyth's analog data visualizations in dialogue with digital ASTER images to explore photography's role in data visualizations. Nasmyth's analog practice provides a proto-history for the ASTER data visualization processes and photographic data modeling. These photographic practices also extend the notion of "realities" to accommodate malleable and variegated realisms that presents "the hypothetical," and "the virtual" as it has been defined by Philippe Quéau, as "neither the opposite of the real (the unreal) nor the opposite of the actual (the potential)," but as a hybrid of both.[3] Using Quéau's framing of the "virtual" as an analogy to speak of photographic data visualization enabled an opportunity for further examining moments of continuity and rupture between analog and digital photographic practices.

Introducing the ASTER Images

In January of 2014, the Japanese volcano Asosan – which has erupted a total of 172 times in our geological epoch – began to again show signs of instability.[4] More than two years of steady ash-blowing and explosion activity began with a small grayish-white plume that dusted the area just south of Nakadake Crater

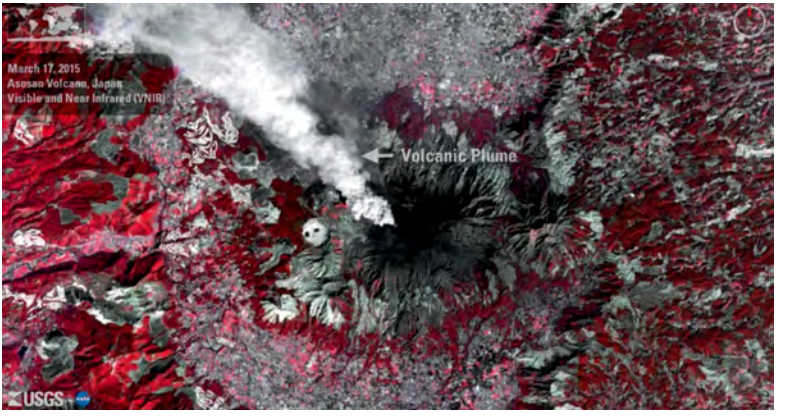
2 Jussi Parikka, *Operational Images: From the Visual to the Invisual* (Minneapolis, MN: University of Minnesota Press, 2023); Michelle Henning, *Photography: The Unfettered Image* (London: Routledge, 2018), 18.

3 Philippe Quéau, "Virtual Multiplicities," *Diogenes*, no. 183, vol. 46, no. 3 (1998), 107.

4 "Asosan: Eruptive History," Smithsonian Institution – National Museum of Natural History: Global Volcanism Program. c. 2016 (accessed September 11, 2023): https://tinyurl.com/3hh3nu2p

with ash. More plumes followed until four very small and "gentle" explosions showered the area from late January until February 19. Asosan would continue erupting, throwing ash, and setting off tremors until April 30, 2016, and would reach level two on the Volcanic Explosivity Index or V.E.I. (with eight being the most severe category – the likes of which have not occurred for more than 27,000 years). While Asosan's eruptions were not even close to measuring in among the most devastating volcanic explosions in history, Asosan's – along with other twenty-first-century eruptions – was substantially and steadily photographed by ASTER's 14-band, visible-light and infrared sensors on the multinational-research Terra satellite (Fig. 10.1). ASTER's imagery is available online, resides in the public domain, and is available for free for amateur and professional vulcanologists and the general public worldwide to use and study. They provide vulcanologists with data for predicting not only Asosan's future explosions for the sake of evacuating the area's inhabitants, but also contribute to the field of knowledge for monitoring the behaviors of other volcanos for hints of imminent activity.

10.1 March 17, 2015, Asosan Volcano, Japan. Visible and Near-Infrared Composite Photograph. U.S. Geological Survey/Japan for the Ministry of Economy, Trade and Industry (METI)/National Aeronautics and Space Administration (NASA).



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Despite this image's contribution to scientific knowledge, it also conveys a view of a volcano that exceeds the purview of human vision by showing us things we cannot see: gradations of heat rendered visually, smoke-free landforms that to the unaided eye would have been covered by a dense fog caused by scorched Earth, and of course, an aerial view of a volcano without the corresponding danger of flying above it. Thus, the ASTER Asosan image is a virtual view, but one that is also an *actual* index of data gleaned from collected infrared light caused by differences in heat intensity.[5] Moreover, the palette of ASTER images differs from that of our known reality. In the overhead-view ASTER image *March 17, 2015, Asosan Volcano, Japan*, a plume rises from a landscape littered with ash and lava. Snow, clouds, and smoke are white – as they would appear to the unaided eye – and volcanic plumes arc to the left and appear in monochromatic gray. Vegetation is a dramatic shade of pinkish-red, whereas lava also is gray, with its newest flows appearing as black marks at the center of the crater. In this visible-light-meets-near-infrared image, the usual expectation – that volcanos will spew firey red-orange lava – is reversed, and red denotes "cool" areas of vegetation that embodied less heat.[6] According to the U.S. Geological Survey, an image with this color palette (characteristics of visual light combined with rays from the infrared-spectrum in a digitally combined composite image) particularly enables the analysis of the contents

5 This essay adopts the term "index" from Charles Sanders Peirce, who wrote that photographs may function as "indexes" when they have a causal or physical relationship with their subject matter. In the case of the Asosan image, differential heat (physically, causally) emanated as infrared light was collected by satellites (physically, causally) and converted to digital code to make a photograph. Charles Sanders Peirce, "Logic as Semiotic: The Theory of Signs," in *Semiotics: An Introductory Anthology*, ed. Robert E. Innis (Bloomington: Indiana University Press, 1985), 1–23.

6 Infrared light is the closest spectrum to the visible spectrum. Near-infrared light is not visible to the unaided eye. Night-vision cameras are an example of a technology that registers the near-infrared spectrum and makes it visible to us. A mid-far-infrared – or thermal – camera registers the relative temperature of a subject. And far-infrared light is detected as infrared heat. This end of the infrared spectrum is the closest to microwaves. Incidentally, astronomer William Herschel was an early reporter on the existence of the infrared spectrum: William Herschel, "XIV: Experiments on the Refrangibility of the Invisible Rays of the Sun," Reference number: L&P/11/125, *The Royal Society*, Read April 24, 1800. (accessed September 20, 2023): https://makingscience.royalsociety.org/items/l-and-p_11_125/paper-experiments-on-the-refrangibility-of-the-invisible-rays-of-the-sun-by-william-herschel?page=1 His son, John Herschel, would invent the cyanotype.

of volcanic plumes, in which sulfur-dioxide gas would appear cooler in tone. The colors of an ASTER can be adjusted and fine-tuned, according to the image-maker's preferences and the usual expectations of a combination of visible and near-infrared satellite photographs, or composite-source-images called "lithophanes."[7] The image thus reveals, in Roland Barthes's terms, that a photograph's power to certify a subject's *presence* may exceed its power to represent that subject's *appearance* accurately.[8] The differential heat emanating from the Asosan volcano is present in tangible visible form in the ASTER image, allowing the resulting composite image to be truthful to the *presence* of heat (which would not be present without the volcano itself), without describing the palette of the volcano's real-life *appearance*.[9] This tension between a photographic subject's *presence* and *appearance* is particularly complicated by the composite image's constituent infrared lithophane satellite photographs, which detect and record the presence of something invisible to the unaided human eye: heat. Its differential appearance in and around the active volcano is inscribed as an image, a data visualization that expands upon the knowledge gained from the visible-light spectrum alone as it tests our presumptions that photographs only capture our familiar wavelength of visible light.

For viewers accustomed to this color scheme – a characteristic of infrared photographs that is also adaptable by ASTER technicians – the image reveals contours of the crater, wind direction, the appearances of the smoke plume and snow (minus a significant blanket of haze), and it conveys the active spread of

7 The term "lithophanes" (from the Greek words *lithos*, or "stone," and *phainen*, or "cause to appear") emerged in 1820 to describe thin, translucent relief images moulded from a material such as porcelain. Different thicknesses appeared darker when back-lit, presenting an image. Lithophanes commonly appeared most often in domestic spaces that naturally involving backlighting, such as on lampshades or in windows, and they enjoyed peak popularity from 1840 to 1870. While lithophanes waned in popularity by the late-nineteenth century, they have enjoyed a revival in early-twenty-first century digital three-dimensional printing (an additive process), and in CNC router (subtractive process), and they are recognized as the building blocks for fully free-standing, fully-three-dimensional sculptural images that entirely break free from the flat surface and lose the background space altogether.

8 Roland Barthes, *Camera Lucida: Reflections on Photography*, trans. Richard Howard (New York: Farrar, Straus and Giroux, Inc., 1981), 5–6, 87.

9 The causal relationship between the heat and the volcano is therefore akin to Charles Sanders Peirce's analogy of the relationship between the foot and footprint in his definition of the "index": Peirce, "Logic as Semiotic," 1–23.

lava from the crater's center. Belief in these composite photographs necessitates a suspension of the expectations with which we approach visible-light images, a mindset framed by an understanding of the photographs' rooting in infrared light. It is also contextualized as an "operational image," a category of the medium proposed by Jussi Parikka to describe images that are "not necessarily representational or pictorial," and which emerged for military use around 1990 for observation during the first Gulf War.[10] In one sense, the virtual ASTER image is non-representational, as a representation that departs from the color palette and reveals surface details not visible through dust and smoke in known reality. As such, ASTER photographs create and convey a different kind of knowledge, one that is hypothetical, analogical, and allows humans to peer beyond the smoke and ash to see a "virtual" – representational, yet also real, "actual," and concrete. They present images that are used to speculate and anticipate volcanic events in the future, using the tangible visual language of the photograph as a medium for expressing scientific hypotheses.

As ASTER images such as *Asosan Volcano* digitally generate a legible digital tapestry for vulcanologists, they embody the very definition of "data visualization": the visual presentation of information to make it accessible and understandable, and to tease out patterns in datasets for new discoveries. As a result, these photographic practices extend the notion of photographic "realities" and "the virtual" that accommodate a malleable and variegated range of "the real" that allows for complexity and a greater mobilization of epistemologies.

Virtual Photography: A Little Proto-History of Data Visualization

But they also provide an opportunity for further examining moments of continuity and rupture between analog and digital photographic data visualizations that long predate 1990. After James Nasmyth (1808–1890) retired at age 48 from a successful and lucrative career as an engineer and inventor of the steam hammer, he pursued the hobby of his passion, astronomy. Nasmyth developed his own 20-inch telescope, through which he incessantly viewed and sketched the Moon – a which would not be visited firsthand by humankind for another 95 years. After making dozens of drawings, he then made plaster models – each nineteen-and-a-half-inches wide – based on an imagined compos-

10 N. Katherine Hayles, *Unthought: The Power of the Cognitive Nonconscious* (Chicago: University of Chicago Press, 2017), 24; Parikka, *Operational Images*, vii, 18, 91.

ite of his drawings. Nasmyth's transferal of observed visual surface data from the two-dimensional drawing to the three-dimensional model enabled him to view his own sculptural data visualization, experience the tactility and mass of its components and making, and discover new insights about the volcanic operations and formation of the Moon.[11]

Nasmyth also used these three-dimensional models as the persuasive centerpieces for lectures and demonstrations, and he took them to meetings with other fellow polymaths, amateur "gentleman" astronomers. Before long, Nasmyth's telescopes and astronomical observations – including the ones illustrated by the plaster models, were so well-regarded by amateurs and professional scientists that he was welcomed into the inner circle of the United-Kingdom scientific intelligentsia, which including esteemed astronomers such as Sir John Herschel and son William Herschel.[12] Later, Nasmyth photographed his Moon models (Fig. 10.2) for publication in the 1874 book *The Moon: Considered as a Planet, a World, and a Satellite*, which was among the first photomechanically illustrated books. What began as two-dimensional sketches became three-dimensional models, which then returned to two dimensions as the subjects of photographs for dissemination in print publications, which enabled this knowledge to spread to even larger audiences. Historians have casted Nasmyth's images of the plaster models as examples of scientific photography's embrace of the medium's ties to veristic "truth," but which presented a handmade Moon view that looked so realistic it could have been the actual thing.[13] By reciting the binary truth-versus-fiction debates about Nasmyth's use of the

11 His explanations of volcanic activity and crater formation still are considered valid theories today. For more on his astronomical discoveries, see: Frances Robertson, "Science and Fiction: James Nasmyth's Photographic Images of the Moon," *Victorian Studies*, vol. 48, no. 4 (Summer 2006), 595–623.

12 Louise Devoy, "Lunar Crater Models Tools of Persuasion, Popularization and Shared Knowledge," *Nuncius*, vol. 35, no. 2 (2020), 300–332.

13 Stephanie O'Rourke, "The Hand-Made Moon," in *Thinking 3D: Books, Images, and Ideas from Leonardo to the Present*, eds. Daryl Green and Laura Moretti (Oxford: Bodleian Library, 2019); Omar Nasim, "James Nasmyth on the Moon: Or, On Becoming a Lunar Being, Without the Lunacy," in *Selene's Two Faces: From 17th Century Drawings to Spacecraft Imaging*, ed. Carmen Pérez González (Leiden/Boston, MA: Brill, 2018), 147–187; Boris Jardine, "Made Real: Artifice and Accuracy in Nineteenth-Century Scientific Illustration," *Science Museum Group Journal*, no. 2 (Autumn 2014). http://dx.doi.org/10.15180/140208

medium, our histories risk overlooking an opportunity to define and historicize data visualization, and to consider the merits of a more nuanced conceptualization of photography's involvement in analogical thinking.

10.2 James Nasmyth, Normal Lunar Crater, Plate 17, Source: Nasmyth and Carpenter, The Moon: Considered as a Planet, a World, and a Satellite, 1874.

Public Domain.

Trained by his artist father to sketch everything around him – alongside his likewise artistically talented siblings – Nasmyth approached science from a perspective that was not purely positivist or concrete, but expressive, imaginary, and visual. His approach thus embraced what this book explores: "the virtual." Philippe Quéau proposes that "the virtual" is "neither the opposite of the real (the unreal) nor the opposite of the actual (the potential)," but as a hybrid of both.[14] Nasmyth's nimble movement from 2D, to 3D, and back again (via photography) to access new understandings of volcanism, offers a conceptual precursor to the current processes of scientific information visualization using 3D printing to make models from photographs to access new perspectives and scientific insights. In addition, Nasmyth also drew analogies between the

14 Quéau, "Virtual Multiplicities," 107.

geological processes on the Earth and those of the Moon, and between random everyday phenomena – such as wrinkles on his outstretched hand or the wrinkling of a spoiling apple to the formation of mountains – using photographs (Fig. 10.3). Nasmyth's plaster models were based on copious sketches and presuppositions of the crater's appearance based on views from other angles and his drawings of Moon craters through telescopes. He looked to the Moon to understand the Earth – and vice-versa. This analogical strategy helped make the remote Moon more accessible, familiar, concrete, and grounded in the accessible logic of everyday-life phenomena.

10.3 James Nasmyth, Back of Hand and Wrinkled Apple to Illustrate the Origin of Certain Mountain Ranges Resulting from the Shrinking of the Interior, Plate 11, Woodburytype. Second edition. Source: Nasmyth and Carpenter, The Moon: Considered as a Planet, a World, and a Satellite, 1874.

Public Domain.

Nasmyth's process of analyzing the Moon makes him an important forefather to today's practices of information visualization. He trafficked in the "virtual" and "hypothetical" by introducing the appearance of the craters, synthesized, analyzed, and processed not by artificial intelligence and algorithms, but by his mind. As Nasmyth wrote, "Where the material eye is baffled, the clairvoyance of reason and analogy comes to its aid. The mind's eye fills in the sensual gaps and constructs its moonscape, filling it up with processes over

time, and things in space."[15] His models and stereo photographs also convey a way of making unprecedented, speculative, inaccessible, impossible, and virtual views *possible*, yet also *believable*, and portable as photographs. Nasmyth contributed an understanding of these geological features in a tactile way that formed new multi-dimensional knowledge.

Theoretical Implications of "Virtual" Photography: An Expanded Epistemology

Media theorist Joanna Zylinska suggests that the digital and post-digital ages are synonymous with the increasingly common use of applications to create photographic images that "can be mobilized to help us imagine, visualize and frame the future."[16] Furthermore, Zylinska sees in today's Anthropocene moment a unique wrangling with "truth" and "post-truth," a struggle that has been encouraged, echoed, problematized, and kindled by digital media.[17] Part-optimism over reinventing and revisualizing the future, and part-pessimism over our fatal destiny to remain mired in an existential and polarized battle over truth and fiction, Zylinska's conceptualization of the Anthropocene sees human consciousness itself as the subject to digital media's molding.[18]

However, other media theorists – pointing to our embrace of virtual reality and hyper-realistic video games – have suggested that not only have humans possessed the temporal capacity to understand a range of various realisms, but humans are not so undiscerning that we associate "the digital" with "the virtual." Philosopher Brian Massumi has suggested that "the virtual" is an antonym for "the real," and thus is part of the binary relationship Zylinska characterized.[19] As an alternative that speaks more directly to the operation of images such as Nasmyth's and ASTER's, this chapter's leaning on Quéau's concep-

15 James Nasmyth and James Carpenter, *The Moon Considered as a Planet, a World, and a Satellite* (London: J. Murray, 1874), 158.

16 Joanna Zylinska, "Does Photography Have a Future? (Does Anything Else?)," *The Future of Media* (London: Goldsmiths Press, 2022), 319–320.

17 Ibid., 4.

18 Ibid., 326.

19 Brian Massumi, *Parables for the Virtual: Movement, Affect, Sensation* (Durham: Duke University Press, 2002), 137. Other suggestions from digital-culture discourses for defining "the virtual" have included "the imagined" and "the fictional." Nathan Wildman and Richard Woodward, "Interactivity, Fictionality, and Incompleteness," in *The Aes-*

tion of "the virtual" accommodates a sliding scale of realisms that resist categorization as wholly fact or fiction, but which instead has the capacity to convey different truths for the sake of ideation and knowledge-production.

Conclusion

In the composite volcano imagery by Nasmyth and ASTER, "the virtual" is implied to be an experimental space where data are collected as lithophanes (from drawings or from photographic satellite feeds), synthesized by either Nasmyth or human-generated algorithmic directives (in processes the viewer is not privy to experiencing), and converted into plaster models and photographs for further discussion and analysis. This is to say, the goal of these images – whether analog and digital – is innately synthesized, innately both "real" and "actual." They aid in accessing new understandings of how volcanos are structured, how they function, and predicting and hypothesizing what volcanos are likely to do in the future. All of this knowledge – though expressed in photographic composite form (as a model photograph of photograph in itself) – is deeply rooted in scientific materialism, existing objects and conditions, and concrete realities.[20] Thus, Nasmyth's analog photographs and ASTER's digital volcanic images collectively call for a redefinition of a photographic realism and "the virtual," inspired by Quéau, that enables nuance, multidimensional synthesis, and embraces analogical thought, as it highlights continuities across analog and digital image-making practices.

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thetics of Videogames, eds. Job Robson and Grant Tavinor (New York: Routledge, 2018), 7; Grant Tavinor, *The Aesthetics of Virtual Reality* (New York: Routledge, 2002), 9.

20 ASTER algorithms are recalibrated to make images as accurate as possible. National Aeronautics and Space Administration, "Aster: Advanced Spacebourne Thermal Emission and Reflection Radiometer," N.A.S.A.: Terra – The E.O.S. Flagship," (accessed September 7, 2023): https://terra.nasa.gov/about/terra-instruments/aster
Nasmyth also went to great pains to make his drawings and composite models as accurate as possible: James Nasmyth, *James Nasmyth, Engineer: An Autobiography* (London: J. Murray, 1883), 329.