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Image operations of material exchange

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Media Ecologies of the 'Extractive View': Image Operations of Material Exchange

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Introduction: geographies of extraction

> It is through and in media that we grasp earth as an object for cognitive, practical, and affective relations. (Parikka, 2015)[1]

In 2016, the Canadian Exhibition at the Venice Biennale lined up with a 'counter-monument' titled 'Extraction' – a round golden survey stake the size of a hand with a peephole at the centre, affixed on the ground at the crossroads of the British and French Pavilions 'under the pines and planes of the Giardini'.[2] A screen was placed underground below the golden stake, accessible to one visitor at a time who would have to kneel to see the short film screened through the peephole. The 800-second-long film from physically beneath the ground showcased 800-year-long chronicles of resource mining and distribution practices of empire building in Canada, 'unpack[ing] the questions of extraction as a framework to think the nation state of Canada via the relationships between architecture and its material tendrils and flows from a global perspective'.[3]

As the exhibition manifesto proclaims, at the turn of the twenty-first century, extraction industries occupy the forefront of urbanisation – 'from gold to gravel, copper to coltan, iron to uranium, fur to forest', the maintenance of human life depends on the continuous supply of resources.[4] Having prospered as part and parcel of colonial histories, resource industries today are shaping patterns of urbanisation as sites of extraction are fully territorialised in the logistical networks of supply chain capitalism.[5] The scholarly take on the subject has been offering new research frameworks for re-conceptualising cities as 'materialisations of far more vast and often … distant global territories', rather than as things in themselves.[6] As actors of this material exchange, remote sensing technologies partake in the continuous recasting of the earth as a 'visual epistemological entity defined by geophysics, data, and its imaging; [whereby] the earth becomes a source and a resource through software-aided visualisations that assist mining and drilling companies'.[7]

In this essay I investigate the agency of remote sensing technologies in the growing imprint of extractive operations. Departing from Heidi Scott's elaboration of 'colonialism's vertical third dimension', the study joins a growing body of literature that navigates infrastructures of contemporary urbanisations by their vertical reciprocities – engaging with altitudes as much as processes, energies and ecologies beyond territorial inscriptions. Scott's thesis on the 'need for a stronger theorisation of verticality… in relation to the search for and exploitation of subterranean resources' is developed here from the domain of air survey, which has historically remained at the forefront of extractive colonialism.[8] A closer reading of the vertical dimension affords, following Scott, 'new insights into … the ways in which colonial landscapes were inhabited and given meaning'.[9] Thus attending the geographies of extraction from above, this article extends the research on colonialism's vertical third dimension from the physical to the sensory, numerical and temporal domains by a media-archaeological analysis of remote sensing applications in mining.

The extractive view

The ecologies of extraction, according to Macarena Gómez-Barris, materialise in the 'colonial paradigm, worldview and technologies that mark out regions of "high biodiversity" in order to reduce life to capitalist resource conversion'.[10] Historically, territorial demarcation had remained at the forefront of imperial growth. As postcolonial studies extensively argue, surveying practices have been operational in extending the colonial gaze and legitimising sovereignty over conquered land – marking out 'new worlds' by applications of modern mapmaking.[11] 'Seeing the globe and sensing the earth', Cosgrove states, 'have both shaped and been shaped by the Western imperial and colonial project of making the modern world'.[12] Equating the colonial gaze with the extractive view, Gómez-Barris illustrates how this 'cartographic impulse' is still operative in mobilising earth resources today:

> Before the colonial project could prosper, it had to render territories and peoples extractible, and it did so through a matrix of symbolic, physical, and representational violence … The extractive view, similar to the colonial gaze, … facilitates the reorganization of territories, populations, and plant and animal life into extractible data and natural resources for material and immaterial accumulation.[13]

Conventionally, the aerial view has been an ever-present measure of territorial knowledge and the rhetoric of seeing-is-controlling.[14] Any historical account of aerial survey will reveal a narration of technical advancement in the vertical that is often told in association with the 'utilitarian state, military, or municipal projects (reconnaissance, surveying, cartography, urban planning)' – taking off with the story of the 'originary watchtower' followed by 'the tethered war balloon, the reconnaissance plane, and geostationary satellites'.[15] Discourses of vertical mobilities, fantasies and representations are entwined around the triumph of human ascent and read as a progressive chronicle of the Western Enlightenment. In this account, the coupling of the aeroplane and the camera at the turn of the twentieth century emerged as a new information technology that, along with the apparent warfare applications, was integrated into early earth sciences such as geology and geography.[16] 'Erosion studies, agricultural assessments, land use practices and the counting of both domesticated and wild animals all were new uses for aerial images',[17] and soon, the potential of air photography in resource mapping was discovered:

> The emergence of techniques and technologies of seeing from the air moved hand in hand with … imperial exploration, colonial administration and development … Encouraging the cooperation of ecologists, soil scientists, foresters and airmen, aerial survey could correlate the patternings and dynamics of the relation between these different forms of disciplinary expertise and the material phenomena they wanted to understand.[18]

Twentieth-century advancements in surveillance technologies rendered aerial vision increasingly operational in managing natural resources. A new norm in earth observation was marked by the mid-century shift in remote imaging devices from airborne cameras to spaceborne sensors, enabling the physical world to be transcribed as 'electronically processible digital information'.[19] The planetary-scale infrastructures of remote sensing employed in mining industries today, from satellites to data centres to GIS applications, can be considered an outcome of this decades-old shift from analogue to computational. Remote sensing thus partakes in all stages of contemporary extractivisms from 'exploration' to 'after closure' – proving particularly strategic in monitoring surface mineralogy and potential mineral deposits.[20] In order to trace the image operations intrinsic in the growing exhaustion of earth resources, the following discussion opens the black box of remote sensing technologies – its makings, applications, and histories – by employing a media-archaeological methodology.

Media-archaeological approach

Media archaeology is commonly understood as excavating historical formations of new media, yet the variety of scholarly interpretations of the method challenges the possibility of an overarching definition.[21] As far as I am aware, there have been at least two initiatives that bring media-archaeological methods into architecture and urban research – the first being the Canadian Centre for Architecture's Archaeology of the Digital programme, founded in 2012, which focuses on a number of projects produced throughout the 1980s and 1990s to define an origin of the digital in architecture.[22] On a different scale and time span, Shannon Mattern's *Deep Mapping the Media City* investigates the physical spaces in which communication networks have been historically 'entangling' themselves, employing a materialist and multisensory method she calls 'urban media archaeology'.[23] Following a distinct trajectory, I employ here a later interpretation of the methodology by Wolfgang Ernst, namely operative media archaeology, to enter the 'parallel, hidden reality at work' behind the human-machine interface of remote surveillance and formulate an investigation of the 'extractive view' from within the infrastructures of digital images.[24]

Operative media archaeology

The foundation of Ernst's approach is often attributed to the German media theorist Friedrich Kittler and his take on Foucauldian archaeology. Kittler's work is distinguished by his emphasis on the hardware materiality of media and the autonomy he ascribes to technical apparatuses, turning Foucault's historical a priori into 'technical a priori'.[25] 'For Kittler, media studies was never to be reduced to the play of interpretations, semiotic connotations, or modes of representation … Media work on the level of circuits, hardware, and voltage differences' – an account that largely went unnoticed in the humanities.[26] He urged for 'media-specific ways' of formulating Foucauldian excavations into culture, offering a method for tracing material-discursive relations from within the media apparatuses and infrastructures.[27] Hence in Kittler's thesis, as Huhtamo and Parikka further demonstrate, in order to 'understand media technologies from the typewriter to the cinema and on to digital networks and coding paradigms, one must take their particular material nature into consideration'– a position later embraced by Ernst.[28]

Similarly, in Ernst's interpretation of media archaeology, the machine takes priority. This later approach is primarily occupied with the material dimension of media infrastructures and its 'hidden' programmes, including digital media. Ernst's exclusion of the human senses from his methodology characterises the recurring concept of the 'cold gaze' in his work: a gaze that is intrinsic to the apparatus and precedes any historical or media-archaeological inquiry. Also associated with Vertov's kino eye, the gaze results from the break that humans induced with their own cultural regime, having built intelligent machines.[29]

Taking this 'break' as the growing opacity of technological systems vis-à-vis the human cognitive capacity, the following inquiry conducts a media-archaeological reading that departs from inside the sensing machines – engaging with the cold gaze of extractive capitalism before resorting to the graphic surfaces that stand at the human-machine interface. It offers an object-oriented analysis of the sites through which earth observation images are produced and unfolds the inner workings of remote sensing machines in relation to the material displacement of natural resources.[30] The machinic intelligence of seeing from above is revealed here for its precise, reductive, and aggressive mechanisms that are appropriated for tapping planetary resources.

The discussion is organised in three parts after Sean Cubitt's thesis of geomedia – the three forms of 'mediated earth-observation' that represent different temporalities of tapping the Earth.[31] Accordingly, each section here pertains to a different form of (geo)mediation between the earth and its data, focusing on their operationality in mining industries. The inquiry thus begins with the first of these forms: the real-time inscription of earthly energy into 'entirely non-verbal [and] non-numeric' information, which Cubitt exemplifies with seismographic displays. In resource exploration, the first order of geomediation is found in the initial step of remote sensing, whereby the sensors are directly excited by the earth's electromagnetic energy and convert this stimuli into electrical signals, entailing a selective capacity that is highly functional in mineral detection. The next section follows the second form of geomediation, which represents the conversion of earthly measurements into numerical data 'in the interests of feeding a much larger machinery of integrated human and mechanical observations'. Here, the conversion of electrical signals into the computer-processable base of remote images – the numerical grid – is explored in relation to the extractive gaze. Lastly, conforming to the third geomedium which Cubitt defines as a machine-to-machine process exemplified by the 'financial visualisation software in commodity markets', the third section focuses on the predictive algorithms of metal futures in relation to the datafication of mining sites.[32]

Earth as electrical signal: selectivity

Remote sensing is the process of collecting data from a distance and processing the acquired data into information about the object, territory or phenomenon of interest. In the mining industry, sensing assumes various proximities – from aerial surveys for mineral deposits to on-site round-the-clock monitoring of excavations. The following discussion focuses on the sensing operations involved in the exploration phase of mining, which is examined under the broader practice of earth observation.

Earth observation systems typically rely on electromagnetic energy sensors to acquire data. 'All things on Earth reflect, absorb, or transmit energy', the sun being the main source of this radiation.[33] Sensors operate by measuring alterations in the intensity of this electromagnetic radiation that is either reflected by or emitted from the earth's surface. [Fig. 1] The entire scope of this energy is categorised by wavelength values along a spectrum, ranging from gamma rays to infrared to radio waves, with the human optical region occupying a tiny fraction in between.[34] [Fig. 2] An early distinction to be made here is between passive and active systems. The measurement of solar radiation as explained above commonly applies to passive sensors that are mere receptors of stimuli, examples being those aboard the Landsat, SPOT, Pléiades, EROS, GeoEye, and WorldView satellites.[35] Active systems, in turn, are themselves the energy sources that operate by emitting (typically microwave) radiation on the areas of interest and measuring the backscatter values, as in TanDEM-X, KOMPSAT-5 and Sentinel-1, along with the shorter-range laser light systems mostly found on drones. Both systems are consistently used for mineral exploration today.

A first glance at remote sensing reveals that there is not one all-seeing but numerous partially-sensing capacities monitoring the earth from above. Jacob Fraden describes a sensor as 'a device that receives a stimulus and responds with

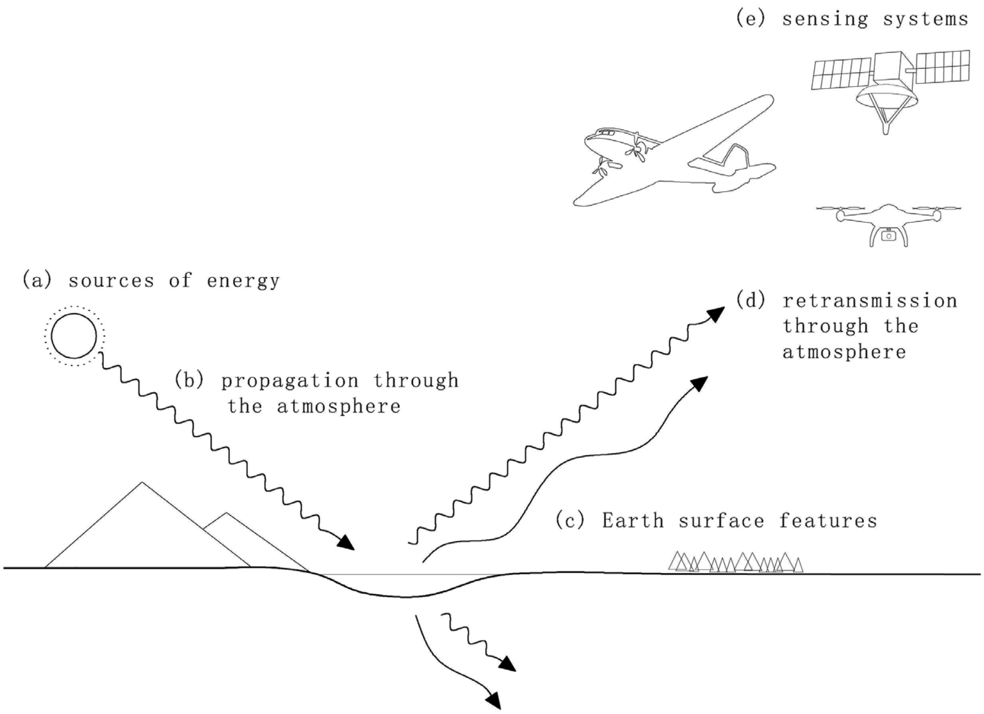


Fig. 1

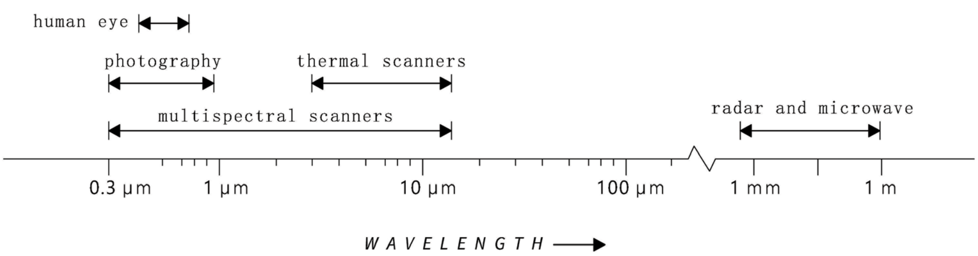


Fig. 2

Fig. 1: Electronic remote sensing of earth resources. Image drawn by the author based on Thomas M. Lillesand, Ralph W. Kiefer and Jonathan W. Chipman, *Remote Sensing and Image Interpretation* (New Jersey: Wiley, 2015), 3.
Fig. 2: Special characteristics of common remote sensing systems. Image drawn by the author based on Thomas M. Lillesand, Ralph W. Kiefer and Jonathan W. Chipman, *Remote Sensing and Image Interpretation* (New Jersey: Wiley, 2015), 11.

an electrical signal'.[36] In other words, sensors convert energy into electrical form, be it optical, acoustic, mechanical, or thermal, among others. In the search for mineral deposits, as in majority of earth observation missions, remote sensing begins with the process of data acquisition whereby the sensors on board of aerial platforms are stimulated by the electromagnetic energy reflected from the earth's surface. Collecting this energy involves an array of passive and active sensors as discussed above – ranging from multispectral (MS), hyperspectral (HS), light detection and ranging (LIDAR) and synthetic aperture radar (SAR), each operating within different spectral regions. The MS and HS sensors used in mineral exploration are sensitive to radiation wavelengths from approximately 0.4μm to 10μm – covering visible and near-infrared, shortwave infrared, and thermal infrared bands and proving most functional in detecting mineral species.[37] Whereas active sensors such as SAR typically rely on microwaves extending from approximately $3x10^3$μm to $3x10^4$μm (units kept in μm for comparison), and are most practical for detecting rock formations and eventually potential reserves. In targeting mineral deposits, data acquired from different spectral regions are often processed and combined with existing geological models, yielding viable information on several surface features like vegetation, mineralogy and geology, as well as groundwater upwelling or leakage.[38] Compared to the range of electromagnetic waves a photographic camera can register, which is limited to a span of 0.3μm to 1μm, the spectral expansion outlined above already points to a significant shift in the observational capacity of remote sensing systems – multiplying the extractive gaze in scope, sensitivity and precision.

Contrary to the rhetoric of omniscience prevailing in the contemporary cultures of planetary surveillance, namely the 'eye in the sky' phenomenon, a sensor's field of vision is hence highly specific and far from all-encompassing, limited by a number of operational parameters such as spectral sensitivity and spatial resolution, as well as several platform-dependent factors like manoeuvrability, repeat rate and ground coverage, among others.[39] Spectral sensitivity, as briefly outlined above, becomes an analytical entry point to the vertical dimension of extractive colonialism as it offers a particular technique of tapping earth resources.[40] All features on earth hold a unique reflection value called spectral signature – including minerals and rocks – and sensors pick up these signatures by measuring the electromagnetic energy emitted or reflected from the surface of earthly materials, thereby facilitating the targeting of potential mineral deposits in significant measures.

This renders the sensor diversity aboard a given satellite – or the constellation of satellites – of an earth resources programme crucial for reserve detection. Landsat, as the longest-running of such missions, had launched a total of seven rockets from 1972 to date, throughout which its band capacity was updated from four to eleven, its wavelength range multiplied by almost ten, and its sensor technologies revised four times, each generation incorporating its predecessor with several adjustments. Of the two Landsats still operative today, the most recent, launched in 2013 (Landsat-8), carries two sensors, the Operational Land Imager (OLI) and the Thermal Infrared Sensor (TIRS), and covers a wavelength region of 0.43 to 12.51μm by eleven spectral bands in total – seven of which prove essential for mineral exploration. This already implies a leap from the earlier Landsat Multispectral Scanners that yield a coarser resolution extending from 2 to 2.5μm with fewer operational bands. The technical enhancements of the past four decades hereby represent a substantial upgrade in the programme's spectral sensing capabilities, resulting in an increased capacity for mineral detection.

In similar earth observation programmes with constellations that have gradually consolidated over time, like the SPOT and IRS families, comparable enhancements in resolution capacity and sensor variation are also evident. Over time, with every new launch, the number of bands per sensor multiplies while the bandwidth values continue to shrink – that is because a sensor operating in narrower spectral bands is able to distinguish the alterations in the reflected energy with higher precision, thereby providing higher spectral resolutions. Meaning, the narrower the spectral range of a sensor, the greater its resolution and the more valuable its data. With technical advancement, sensing devices are hence calibrated to see less and less in scope but with greater precision, growing all-the-more partial and network-dependent in their contribution to the 'world picture'. Here, as a media-archaeological inquiry into the sites of remote sensing begins to reveal, the extractive gaze is not one but many, and earth observation becomes a function of a sensing intelligence that is increasingly more specific rather than all-seeing – penetrating that of capital value and eliminating all other presence in between.

This selectivity in vision is what underlies the efficiency of sensors in the exploration phase of mining, ordering a world of – profitable – things that would otherwise remain underground. Similarly, active sensing also illustrates a degree of selectivity in its terrestrial contact, but by a different technique. Active sensors collect environmental data by transmitting pulses themselves and measuring the backscatter value, which characterises them in two distinct ways: unlike passive sensors, they penetrate the atmosphere regardless of atmospheric conditions, seeing through clouds, mild precipitation, fog and dust. Moreover, while their MS and HS counterparts provide spectral measurement, active radar sensors like SAR record two types of information per image pixel (picture element): amplitude and phase data – the former indicating the intensity of backscatter, depending on the terrain's surface roughness and moisture content, the latter referring to the distance between the sensor and the ground.

The wavelengths of transmitted pulses vary by sensor type and are often represented by letters, with X, C, S and L among the most functional bands in mining. In radar sensing, wavelength designation becomes critical, as 'it determines how the radar signal interacts with the surface and how far a signal can penetrate into a medium'; for example, while an X-band radar pulse with a wavelength of 3cm is able to penetrate cloud formations but is blocked by forest canopies, a 23cm L-band pulse begins to infiltrate the branches and tree trunks underlying the canopy, as well as certain types of soil or snow covering the land underneath.[41] Active sensing thus entails a physical process that exceeds mere seeing through – by a calibration of 20cm, signals move through layers of atmospheric formation, organic life and land cover, in order to tap surface topography. In targeting deposits, active sensors eliminate different registers of the visible – as in the removal of vegetation or snow from the ground – and facilitate the identification of certain topographic features like rings, shear zones, and lineaments, which, in some regions, may indicate the presence of volcanic pipes or base-metal mineralisation sites of capital value.[42]

An inquiry into the first geomedium of earth-sensing devices already begins to reveal the partial nature of an all-encompassing visual rhetoric that has been a currency in the history of extractive colonialism. Today, in mineral exploration, spectral and radar remote sensing data are used routinely and in conjunction with one another, often integrated with geology, geophysics, geochemistry.[43] By its multiplicity, range and precision, the electromagnetic dimension of the extractive gaze thus entails a surveillance regime that is symptomatic of what Bruno Latour defines as the 'oligopticon' – the spaces affording 'sturdy but extremely narrow views of the (connected) whole', from where a very tiny fraction of the world is seen, but is seen too well.[44] It is only in constellations that these views begin to resemble anything pertaining to the whole.

Evidently, the question of seeing that characterises Latour's oligoptica is already reframed here as one of sensing. The spectral element of the colonial vertical dimension reveals the 'unseen' mechanisms that significantly refine the scale and precision of extractive operations in contemporary mining practices. Sensors physically tap, sort and distil planetary resources through numerous spectral bands before on-site mining begins. The process of geomediation here thus endures a selective act of ordering and commodifying the earth's energy in the form of electrical signals, resonating in Gómez-Barris's argument that the extractive gaze 'mark[s] out regions of "high biodiversity" in order to reduce life' into materials of exchange.[45] It is from this real-time response of the sensor in the form of electrical signal that the second form of geomediation departs.

Earth as numerical data: enhancing image operations

Once the sensor converts the incoming stimulus into electrical output, the following step involves an analogue-to-digital conversion that quantises the electrical signal into a set of numerical values – making it eligible to be channelled, stored, and processed digitally.[46] 'Sensors intended for the artificial systems must speak the same language as the systems "speak". This language is electrical in its nature', as Fraden suggests, 'and the sensor shall be capable of responding with the output signals where information is carried by displacement of electrons, rather than ions'.[47] Figure 3 illustrates the process by which the (continuous) electronic signal from the sensor is sampled in evenly-fixed time intervals and recorded at each sample point as a (discrete) number corresponding to its frequency value. The process of conversion here – from electromagnetic radiation to electrical signal to binary numerical data – marks a critical moment of the abstraction of an earthly phenomenon into computer-processable information. Notwithstanding the graphic component of the term surveillance, the steps of remote observation investigated so far are still less about seeing than actually tapping earth resources to retrieve, refine and mobilise them across platforms, whether in the form of waves, currents or numbers – processes that are commonly associated with the more aggressive applications of on-site mining.

Once the analogue-to-digital conversion has mediated earthly material as numerical value, or as binary code, the information is registered in a computational system for further processing. In earth observation systems, each converted number represents the average radiation intensity per 'sampling interval' of the sensor signal, constituting one pixel of the digital image. [Fig. 4] The resulting two-dimensional array is the widely known raster grid, which endows the image with an 'inherent mutability' as William Mitchell suggests. Reminiscent of Vilem Flusser's 'code of images' – a sign system ordering the world of things into 'significant surfaces' – the numerical grid, at this precise moment of conversion, points to a particular intelligence of making sense of the world. Shannon Mattern refers to this organising principle, or intelligence, as the 'code-space of machine vision'. In an inspiring gesture that stretches the discussion of 'mapping' from the GPS grid of self-driving cars to the cartographic subjectivity of animal Others, Mattern draws a discursive line from the machine to human to non-human sensors – navigating both computational and lived 'multisensorialities' not as the two ends of a spectrum but rather as different registers of knowing.[48] Understood in this vein, the numerical grid becomes the ordering structure that holds the sensor's electrical signal in computer-processable digits, rendering the earth readable for machine intelligence.

In histories of aerial views and settler colonialism, the grid comes as a loaded concept – or as a cultural technique, as Bernhard Siegert suggests.[49] It wasn't until the 1970s that computer-processable data

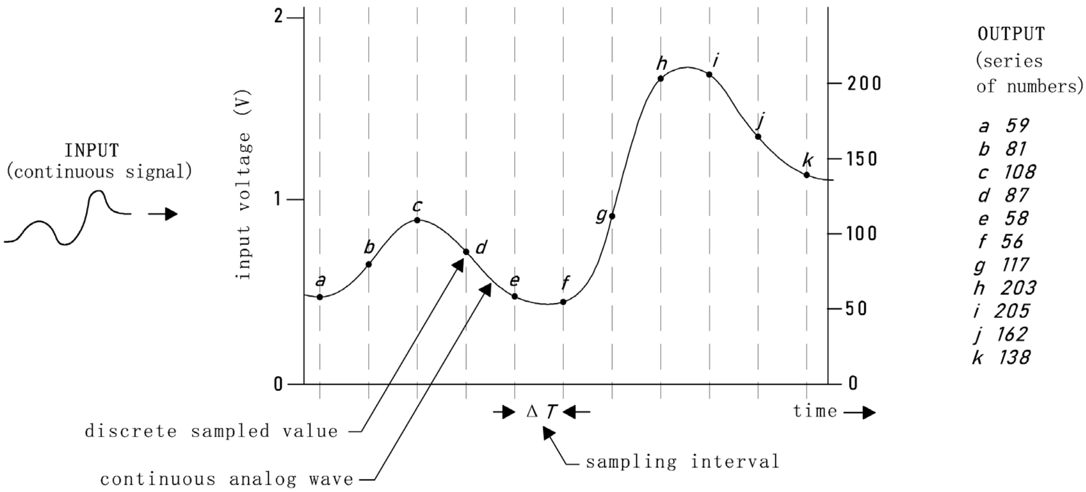
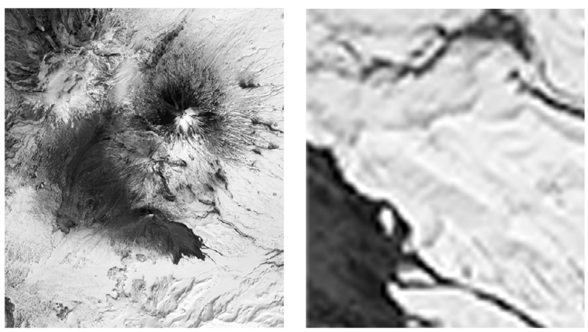


Fig. 3



22	39	92	93	88	85	86	90
26	45	91	92	90	84	81	85
51	58	94	91	87	79	82	93
69	55	93	91	77	72	81	98
75	74	74	85	85	91	89	97
33	46	36	85	95	95	91	97
28	24	24	39	90	96	89	95
33	35	34	23	52	94	95	92
62	54	53	38	28	47	85	97

Fig. 4

Fig. 3: Analog-to-digital conversion process. Image drawn by the author based on Thomas M. Lillesand, Ralph W. Kiefer and Jonathan W. Chipman, *Remote Sensing and Image Interpretation* (New Jersey: Wiley, 2015), 26.

Fig. 4: Basic character of digital image data. Top-left image Bezymianny Volcano Natural Color, April 25, 2011, Wikimedia Commons, https://commons.wikimedia.org. Last accessed: September 27, 2019. Rest is drawn by the author based on Thomas M. Lillesand, Ralph W. Kiefer and Jonathan W. Chipman, *Remote Sensing and Image Interpretation* (New Jersey: Wiley, 2015), 25.

became the picture element of earth observation. Earlier generations of analogue air photographs were captured on films, without the inherent numerical configuration of digital images; while they saw various – and comparatively coarser – applications of the grid on the picture plane. 'Colonist logics of grid imposition fixed the identity of land and its ownership not so its provenance could remain static, but *in order for its identity and properties to be circulated and exploited*', as Adey suggests, '[and] effectively liquefied the immutable properties of space into a region of transaction and exchange'.[50] In other words, the burgeoning practice of photographic survey in the early twentieth century saw the aerial grid become a pervasive geometry of power that satisfied a sovereign tendency to 'make a world that exists as binary order', allocating the land and all that is native to it as distinct, independent entities.[51] Otherwise understood as a radical separation between data and its address, the grid thus became a representational technique to identify, single out and mobilise those endemic properties of space – populations, vegetation, resources – within systems of material exchange.[52]

'If an imperial eye brought certain objects into sharp focus, it did so by a process of selective blindness'.[53] Earth observation sensors today have refined this selectivity by the precision of micrometres, while the numerical grid allows multiple strands of the earth's electromagnetic energy to be stored in a single picture element simultaneously. [Fig. 5] The conversion from analogue signal to digital number here marks the transformation of earth resources into Latour's 'immutable mobiles,' often transmitted to ground stations in vast quantities but one pixel at a time.[54] Once quantified in separate groups, the-earth-as-data becomes available to operations of sorting, retrieval, distribution and exchange, enabled by a series of manipulation and interpretation algorithms known as digital image processing, seeking to optimise specific parameters of the image for predefined end-uses. The representational separation of data (natural resource) from its address (geolocation) here affords an extractive capacity symptomatic of, yet considerably beyond, the proto-computational colonial grid.

With geolocation as one of the many layers assigned on the raster grid, the image begins to resemble a stack of numerical arrays – each layer holding different spectral, temporal and spatial information. In mineral exploration, the number of spectral layers stored per pixel – or the spectral profile – becomes a critical parameter for image processing. For example, for an MS sensor, the spectral profile can go up to twelve depending on the satellite model. For an HP sensor, the band information per ground pixel can commonly exceed two hundred. In either case, the numerical stacks registered on grids offer a significant malleability for further image processing – as imaging algorithms typically work with combinations of three or more of these layers.

Most common image processing applications in mining are calibrated for surface mapping – examples of which include the merger of different bands to acquire colour composites for lithologic discrimination, particularly if the contrast levels are enhanced; or the comparison of band ratios to enhance rock alterations. Another prevalent algorithm for mapping is classification, whereby pixels with common spectral properties are identified by predefined categories or assigned to separate groups to distinguish between land cover types, proving particularly useful for ore detection and for creating thematic maps. Among others, filtering algorithms are also used for processing surface conditions, as they help to eliminate undesired ground features – like vegetation or snow – by removing their bands from calculations, or to suppress spectral noise for higher component analysis.[55] Important to note here is the range of image-related operations enabled by the numerical interface of computational algorithms:

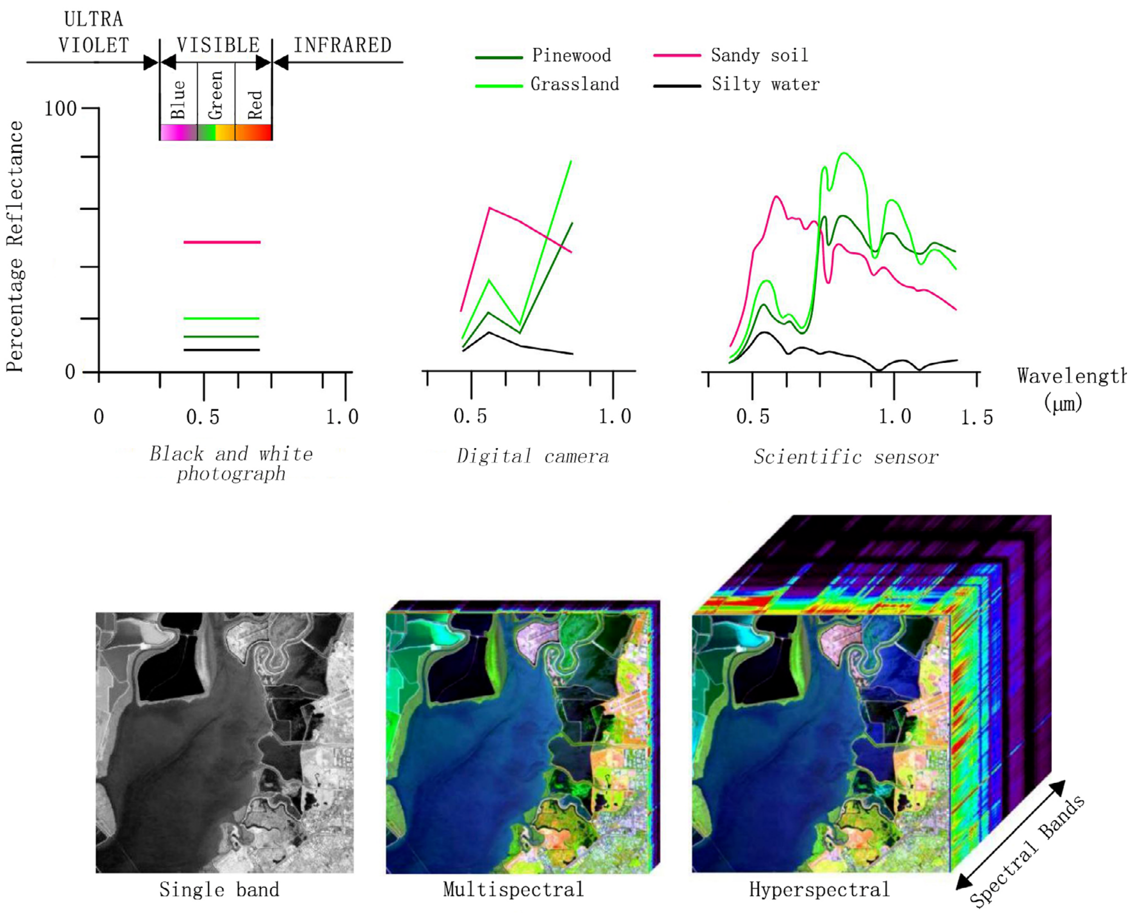


Fig. 5: Differences in the spectral resolutions of single, multi and hyperspectral bands and their impact on resource detection. Image edited by the author based on Wikimedia Commons, https://commons.wikimedia.org. Last accessed: February 8, 2021.

once converted into integers, the-earth-as-data is fed into a series of (digital) processes that are conventionally associated with on-site mining rather than remote sensing, such as sampling, grouping, filtering, removing, separating, digging out and circulating, among others. The exhaustion of land thus begins not on site but with the datafication of the earth from above, rendering resources at once visible, malleable, and profitable. The operational capacity here is bound by a platform interoperability afforded by the logic of digits and mathematical calculation – or what Ernst calls the 'numerical sublime'– of sensors, computing platforms, high-bandwidth networks, and database systems.[56] This interoperability today points to the arithmetic subface of digital images, from where we will turn to the third form of geomedia.

Earth as futures: aerial prospect and feeding data forward

The 'extraflood' of observational data continues to challenge computational models by an increasing demand for the 'interoperability' of information – its transfer, systematisation and use across platforms. As part of a new line of computing technologies developed for managing, visualising and analysing the growing number of datasets, tracking technologies emerged as a procedure of predictive analytics that derive prospects – that is, futures, probabilities and forecasts – from retrospective readings of accumulated data.[57] Predictive algorithms search through large amounts of historical datasets to track and reveal previously unknown patterns that 'might suggest a continuity, a propensity, a taste of what is to come', as Jordan Crandall defines – a process that extracts tendencies from formerly undecipherable configurations of archived data, by far exceeding the capacities of unaided human cognition. Enhanced by the developing technologies of sensing, data storage, processing power and data-mining, this statistical operation (of 'deriving from the past … a silhouette that models future positions') brings about a new form of geomedium in earth observation practices.[58] This section taps into the temporalities of the synoptic view through the concept of the prospect – a term that both pertains to histories of aerial views and metal markets as the rationale of looking forward in time and space.

Surface and subface prospects of aerial view

The noun prospect registers in the cultural history of aerial vision almost concurrently with the development of the bird's-eye view as a Renaissance art tradition. Typically associated with earlier oblique views as experienced from high vantage points like hilltops, watchtowers or the belvedere, a prospect etymologically signifies 'looking forward' – both in the sense of 'an extensive or commanding sight or view', and of seeing into the future. 'In the seventeenth century', as Mark Dorrian remarks, 'both "magic mirrors" (mirrors that foretold the future) and field glasses, spy-glasses, and telescopes were called "prospective glasses"'.[59]

In his article 'Prospect, Perspective and the Evolution of the Landscape Idea', Denis Cosgrove refers to the historical connotation of the 'prospect eye' as both pertaining to a gesture of 'seeing at a distance' and to a financial investment in land: 'the verb "to prospect" emerged in the nineteenth century referring to the particularly capitalist activities of speculative gold mining and playing the stock exchange. It is interesting to note how "speculation" has itself roots in visual terminology'.[60] It is from this critical connection between looking forward and looking for deposits – or between the synoptic view and what is today called the 'metal futures markets' – that we will enter the third form of geomedia.

Subface prospects of the digital earth

Today, the term prospect continues to expand toward predictive analytics and financial speculation by the developing technologies of data visualisation. As briefly outlined at the outset of this section, the predictive capacity of automated data processing lies in its ability to uncover patterns and simulate emergent ones from existing datasets, at scales radically beyond what human cognition affords. In environmental monitoring, as Parikka and Gil-Fournier suggest, 'forms of future-making [as such] have been part of the geographical and geological visualisation that is of significant economic and security related importance'.[61] For understanding how future-makings – as predictive algorithms and financial speculation – continue to mobilise mineral deposits by the organisational logic of world markets, Cubitt's third geomedium offers valuable insights.

Quite unlike the former two, the third mode of geomediation elaborated by Cubitt, namely the 'financial visualisation software in commodity markets', conforms to a machine-to-machine process that is not only an index of change, as are the preceding examples of 'vectoral analogues' and 'numerical translations', but itself induces change. The author locates this third form in automated (or algorithmic) trading, which is the last phase of an ongoing process of computerisation in finance sector since the 1980s. Automated trading is the computer-aided method of placing buy and sell orders using a set of (execution and proprietary-trading) algorithms, at speeds and extents that are only achievable by the processing power of computers. 'Seventy-five percent of trades in contemporary financial markets are algorithmic', Cubitt further remarks, with the highest rate in futures markets.[62]

The futures, as implied here, are 'highly standardised forward contracts' that enable a certain asset (gold, grain, mortgages, electricity, and so on) to be bought or sold at a fixed price on a future date.[63] 'The goal is … a time-annihilating one: to collapse the future into present [profit]' through processes of speculation and hedging.[64] This is why futures deals are also understood as financial derivatives, for they derive value from variations of the underlying assets, be it commodities, currencies, stocks or bonds. The size of futures markets today, however, radically outpaces the world's gross domestic product. Orit Halpern, in her inspiring study of the Malartic gold mine, explains how derivates shape metal industries, both in the present and in prospect:

> Facing limits to planetary resources and maybe even life, we have turned to ubiquitous computing, geo-sensing, and algorithmic trading. To avoid these terminal thresholds of resources and toxins, the mine must conquer the limits of space by deriving value from the future. Enter derivatives … To achieve this seemingly sisyphean hedge-bet, we transform space into logistical movements grounded in a most literal connection between data mining and metal mining.[65]

Indeed, the 'pervasive' infrastructures of sensors, computing platforms and relational databases confuse any clear divide between the two forms of mining through a continuous conversion of metals into data, and vice versa, as Halpern suggests, 'not as metaphor, but in practice'. Cubitt locates the third form of geomedia precisely in this numerical translation between reserves and futures: 'Financial visualisation software in commodity markets', he argues, 'not only gives direct accounts of geology (reserves), human interventions in them (extraction) and simulations of their likely use (futures) but actively produce those futures by fixing future trading prices'.[66] It is in this future-making capacity of finance software that it differs from other forms of geomedia – for it is not only an index of change or a simulation of the future, but it induces change by betting in future values. At any given time, one can sell or otherwise swap these bets with other bets to make a profit, meaning, speculate on the futures contracts.[67] Precious metals and gold in particular, as Halpern argues, are long-standing hedge bets in these speculative markets.

Cubitt refers to this form of geomedium as 'direct data' in the sense that it is not intended for meeting a human end but rather acts upon 'algorithmic, machine-to-machine plays on the market … with APIs capable of running on an ordinary laptop to handle data streams from twenty-three exchanges … including quotes, trades, and indexes at speeds of over two million updates per second', where a single nanoseconds of delay turns into competitive disadvantage.[68] This is not a system for a human to trade, intervene, or even comprehend, but merely observe as far as the software interface allows, like an opening to an arithmetic world. In this regard, the computing platforms involved in trading do not require such interface visualisations to complete transactions, as they 'know' time merely as a mathematical function:

> At this level, 'real-time' no longer means the time of human perception. It belongs to a concertinaing of time, where past performance becomes standing-reserve, future repayments (permanently deferred) become present profits, and the present itself is truncated into a vanishingly small, relativistic point.[69]

What allows planetary prospects – of geology, ores and minerals, among others – to crystallise in speculative markets, as this article has so far outlined, begins with the 'datafication' of mineral reserves. The fabric of remote, airborne, and ground-based sensors covering the mine partakes in the reconstruction of these reserves as numerical value to be communicated not only across networks, platforms and space, but also across pasts and futures. Yet what renders finance markets a curious case here also lies in their negotiation of surface-subface relations: following the line of three geomedia, one might suggest that data (or the-earth-as-data), although exponentially multiplying in quantity, reveals itself ever less on the graphic interface. The growing subface operationality hence results in a diminishing surface visibility, as ecologies of sensors, cognisers and processors become less and less 'human'.

Conclusion: registers of the visible

The summer of 2019 saw the outbreak of a nationwide outcry in the Biga peninsula, Turkey, when the Canadian-based company Alamos Gold removed 195 000 trees during the development of the Kirazlı gold mine, situated in the immediate vicinity of the Mount Ida National Park.[70] The protests flared up as soon as the aerial photographs of the site were made public, revealing the aggressive scope of deforestation in the area, only fourteen kilometres away from the largest freshwater reservoir in the region. Thus began the activists' 'Water and Conscience Watch', promoted with the popular slogan 'Mount Ida is more valuable on the surface than the subsurface'.

Yet Alamos Gold's presence above and below the district predates this incident by almost a decade. The company has been navigating the 'surface' of Kirazlı, Ağı Dağı and Çamyurt regions in the peninsula from 2010 onward, and has quantified a total gold reserve of three million ounces throughout the exploration phase, estimated to be worth over €4 billion.[71] Alamos received the final environmental approval for excavation as early as 2013, yet the public unrest has halted the project twice since then: initially by a 2013 court order suspending further exploration activities, and later by the Turkish Department of Energy and Resources denying the company's licence renewal request in 2019, amid escalating civil dissent. The drone photographs of the deforested area became the symbol of the second and the more radical wave of protests, sparking the largest public uprising ever to run against a mining project in Turkey.

An object-oriented examination of Ernst's 'cold gaze', or what Mattern calls 'machinic sensibilities', reveals violence to be an intrinsic capacity of 'looking' down, as the 195 000 trees, along with the biodiversity they host, are algorithmically eliminated by remote sensing systems prior to their physical removal from the site.[72] The Kirazlı mine today remains closed, but the extractive gaze has already tapped the ground before on-site drilling began, extracted the gold in digits before it was chemically recovered from the ore by cyanidation, and quantified the asset, the three million ounces, in order to feed it into 'the circulatory system of capital' as stock futures, eliminating all 'Other', non-profitable presence in between. Notably, the view from above here works both ways, simultaneously sustaining the extractive gaze alongside the activists' rhetoric against resource exhaustion and water pollution in the Mount Ida region.

Scott considers a closer reading of colonialism's altitudes to yield 'interconnections of the material and the discursive', as she 'vertically extend[s] scholarly explorations of colonialism to subterranean spaces'.[73] A focus on the digital image here overturns the author's vertical reading upward, toward the sites of remote surveillance, and shows the processes of imaging in mineral exploration to be capable of tapping, selecting, eliminating, removing and mobilizing resources – operations more commonly ascribed to on-site mining. The non-human logic of relating to the environment examined so far interrupts the inherent linearity of the 'vertical dimension' by unfolding its spectral, numerical, and temporal elements; and brings forth multiple registers of the earth beyond surface visibilities – in the substance of waves, currents, numbers and algorithms.

From inside the sensing machines, new material-discursive relations emerge between machine vision, cultural histories of the aerial view and extractive capitalism. Thus extending the study of the mining site into the domain of surveillance infrastructures, the article contributes to the burgeoning field that examines the spaces of extraction 'beyond the mere wresting of minerals from the soil … as one that vastly transcends the territoriality of extraction'.[74] Latent configurations of extractive violence comes into view through a close examination of the 'machinic sensibilities', offering a renewed lens for considering contemporary forms of urbanisation within systems of material exchange.

Following the line of 'mediated earth observations' from rare earth minerals to spectral waves, electric currents and digital integers, well-established rhetorics of the aerial view as ubiquitous, all-seeing and omnipotent begin to yield contradictory aspects: that the extractive gaze in not one but many, not omniscient but narrow, and is indeed limited by several platform-dependent parameters like manoeuvrability, orbiting rate and coverage area. The remote image is understood here as an ecology rather than a (graphic) screen phenomenon, while seeing becomes a question of sensing in tapping the earth's resources. A media-archaeological reading thus brings forth the extractive codes of the remote view, exposing its precise, selective, vectoral, and speculative capacities of ordering natural resources into materials of exchange – enabled by the datafication of the earth from above.

Notes

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Biography

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