Zeitschrift: Tsantsa : Zeitschrift der Schweizerischen Ethnologischen Gesellschaft = revue de la Société suisse d'ethnologie = rivista della Società svizzera d'etnologia

Herausgeber: Schweizerische Ethnologische Gesellschaft

Band: 26 (2021)

Artikel: From ashes to diamonds : making lab-grown afterlife

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DOI: https://doi.org/10.5169/seals-1007122

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SPECIAL ISSUE

FROM ASHES TO DIAMONDS

Making Lab-grown Afterlife

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Abstract

This article examines the making and makers of "memorial diamonds." These are "natural" diamonds identical to gemstones found in nature but produced in laboratories with carbon sourced from genetic material (cremation ashes) or other objects of symbolic and emotional value. Threading corporality and objectified life forms, we examine the transformation from ashes to the "afterlife" of these "living" objects that are at once synthetic and organic. We ask, first, what material and affective properties distinguish synthetic diamonds from those extracted from nature? Second, how are these living and memorialized representations of inert substances – in continuity with bodily elements of the deceased – valued and mediated through "real" human, though artificially grown, natural objects? Drawing from research with the leading companies in the memorial diamond business in Switzerland and the United States, this article suggests that these diamonds' singular connection to the human body offer a window into the transmutations between nature and the artificial, memory and material likeness, life and death.

Keywords: *memorial diamonds, synthetic, death, value, materiality*

Introduction

George, we will call him, was a charismatic, adventurous, and doggedly kind traveler from Canada, who, at age 22, tragically fell to his death while hiking in the Swiss alps in 2002. After the body's cremation, and without consulting his next of kin, George's mother mailed a little over the requisite 200 grams (8 ounces) of his ashes to Life Gem, a well-known producer of "memorial diamonds" in the US. After a couple of weeks of intense pressure and heat, the sample of ashes was rendered as a diamond stone to be worn as a pendant on a necklace. As the story was relayed to us, the decision to turn George's remains into a diamond was not approved by his sister, who felt that scattering the ashes in a park would have been more "natural", insisting that she would eventually throw the stone in the ocean when she inherited it from her mother so that George would be "with nature" as he would have wanted. As the mother used the physical token of her son to cope with the pain of her loss, George's sister softened her critical view of the "ashes to diamond." It was the perceived "realness" of George's physical body pressed against the mother's skin that made his presence felt every day. The stone was lost one year later, but this was explained by the mother as a sign that

George had moved on, carving his own path as he would have in life. Even in the stone's material absence, George was symbolically present.

Memorial stones, like objects of remembrance more broadly, allow the grieving to "preserve a material presence in the face of an embodied absence" (Hallam and Hockey 2001, 18). Unlike other natural-qua-synthetic products borne out of developments in synthetic biology, such as laboratory-grown meat (e.g. Wurgaft 2019; Abrell, this issue), these diamonds are unique in that they offer the possibility, literally and figuratively, of materially embodying the deceased in the form of a carbon-based stone. These synthetic stones made of human or animal remains can now be cheaply "cultivated" in laboratories, offering a reliable alternative to the social and ecological impact of mining extraction, or the negative reputation of "conflict gemstones." Having previously worked on diamond extraction in Angola and Canada's arctic where questions of ethics and value have always been front and center, we began by questioning to what extent synthetic diamonds would pose a threat to the "natural" mined industry. The pervasive ideology around diamonds' value insists that diamonds are expensive because they are rare in nature; similarly to other precious gemstones, the naturalness of diamonds would herald from "material worlds seen (at least within many European traditions) as outside of the social and even the human" (Ferry 2019, 110). Memorial diamonds challenge these assumptions as a particular subset of the synthetic gemstone market. They seem to create new ways of valuing gemstones by recasting the relation between death and life through the production of an organic-based synthetic material. By straddling the domain of synthetic substances while being produced from biological remains, no longer outside the domain of the human, these objects also trouble acquired notions of what is natural and artificial. We take up these concerns through a closer examination of the material transmutations taking place inside a laboratory-qua-factory aiming to replicate processes occurring in nature.

The production of memorial diamonds, and recent attempts to engineer and synthesize biological sciences and life itself (Rabinow and Bennett 2012; Roosth 2017), raise a new set of problems: how is the natural and the synthetic embodied? What distinguishes organic substances found in nature from those produced in laboratories, and how to account for the shifting boundaries between life and death, the "living" substance of a dead human being and its "inert" memorialization in the form of a diamond? As Sophia Roosth puts it (2017, 8): "Life' as an analytic object has come undone. Seeking answers, synthetic biologists build new living things, and in so doing they retroactively define what counts as 'life' to accord with the living things they manufacture and account to be living." In the context of memorial diamonds, this problem is compounded by the ontological uncertainty of what constitutes the organic in living substances, as when the term "lab grown" seemingly describes a process akin to a natural process.

This article draws from research on the emergent market for memorial diamonds, produced with carbon from human remains. As we were told very matter-of-factly in January 2017 by Rinaldo Will, the CEO of Algordanza, a Swiss-based memorial diamond producer, "we're in the business of personified diamonds". These modern-day alchemists collect, create, and manipulate genetic and symbolic material of human provenance to chemically produce pure carbon molecules from human remains. Primary data was collected between 2016

and 2017, based on interviews and observations at two of the world's leaders in memorial diamond production, Life Gem, headquartered in Chicago, and Algordanza, based in Domat / Ems, in the Swiss canton of Graubünden. Interviews followed a semi-structured questionnaire, paying heed to the situational perspective of the interviewee, each company's commercial and technological strategy, and the broader communicative register in which notions of ethical value, memory, commoditization, and materiality were conveyed. We also draw from the relevant academic literature, as well as industry association reports and regulations on synthetic diamonds, media accounts, and other synthetic diamond producers' online presence.

The article suggests that the qualities of natural and synthetic are not always distinct, but are negotiated inside labs and outside them. As unstable material substances, these diamonds allow us to interrogate the original referents – a carbon-based molecule abundantly found in nature – and the work put into reinforcing the categories of synthetic, lab-grown, or man-made. More than simply rendering in material form the life of a deceased, these objects create new forms of unstable value through precarious transmutations between an emotional absence (memory) and real presence (a wearable object). The first section of the article examines the technology that makes these synthetic transformations possible. The second section looks at how these diamonds mediate the notion of "real-ness". In-between the source material and their symbolic power, we question how these singular objects are at once the product of a synthetic process – the natural body of a diamond – that uniquely connects to the human body. The third section conjures more specifically notions of valuation, from the desired qualities of diamonds expressed by clients to the material likeness of the end product to the memory of the deceased, and the ability to manipulate material features in a process largely left to the whims of technology. Finally, as these synthetic diamonds represent a shift away from the "affective power" of natural gemstones (Walsh 2010, 109) and the widely reported impact of mining extraction, we conclude with a reflection on the nature of matter and extractivism. We now move on to examine the technical process allowing for the making of these provisional and shifting assemblages of humans and non-humans.

Material transmutations and synthetic transformations

Recent scholarship concerned with natural resource extraction has aptly proposed new ways of understanding how resources are known, transformed, and experienced in the distributed and assembled relations of materials, labor, infrastructures, and knowledge (Richardson and Weszkalnys 2014; Anand, Gupta, and Appel 2018; Rolston 2013; Ferry, Vallard, and Walsh 2019). Examining how material processes of extraction hinge upon the cultural, social, and biophysical value ascribed to natural resources, this literature has further sought to destabilize the domains of culture and nature, human and non-human by bringing these categories into provisional assemblages, oscillating between contrasting material and ontological states. The move toward the production of man-made or lab-grown "natural" substances implies three important conceptual shifts: first, the move away from extraction in nature onto the terrain of man-made minerals from nature; second, the recentering of use-value, in a classic

Marxist interpretation of commodity value, through the transmutation of the memory of the deceased into a new biological shape; and third, the growing recognition of the importance of new bioeconomies of biocapital and biovalue, as well as the ensuing recomposition of artificial-natural landscapes (Birch and Tyfield 2013; Cooper 2008; Rajan 2006; Waldby 2002). But what exactly are man-made, cultured, lab-grown, or created diamonds, and how has this technological revolution set in motion shockwaves felt across the industry? Let us now consider these transformations by a closer examination of the technical and material processes underpinning the production of synthetic diamonds.

The technology for making synthetic diamonds has been available for decades, but it was not until the late 1990s that Chemical-Vapor Deposition (CVD) and High-Pressure, High-Temperature (HPHT) processing techniques made serious inroads on an industrial scale, with man-made diamonds now prevalent in industrial use, with 99 % of the US industrial diamonds of synthetic origins (USGS 2021). Partially enabled by energy improvements (Ali 2017), technological advancements, and lowering prices in HPHT and CVD techniques, start-up companies dedicated to manufacturing synthetic diamonds and other gemstones have sprouted over the last decade across Europe, Asia, and North America, posing a significant commercial and existential risk to the mining industry (Dobrinets, Vins, and Zaitsev 2013, 231 ff). Some estimates calculate that 200 000 carats of synthetic diamonds enter the "natural" gemstone market every month, which may pose an existential threat to an $ 80 billion industry premised on the artificial scarcity of a natural product.

In 2019, soon after entering the lab-grown fashion jewelry market, the diamond corporate group De Beers announced a 40 % decline in sales of natural diamonds (Biesheuvel 2019). Shortly after De Beers cut its prices, reckoning with a 40 % decline in sales for 2018, Gem Diamonds and Lucara, two of the largest sellers of expensive diamonds, also reported lower prices in November 2019. In an ironic turn of events, De Beers turned its back on its brand message of "rare is natural" by entering the lab-grown fashion jewelry market with its own brand, Lightbox Jewelery. After decades of developing techniques to detect "fake" diamonds, De Beers responded to the emergent consumer desire for lab-grown diamonds by launching a cheaper line of diamonds. Unlike natural diamonds, De Beers' brand does not provide a grading report for lab-grown stones, deemed to be the exclusive purview of a diamond's rarity, although the company launched its own screening device in 2018, aptly called "SYNTHdetect." But with declining production costs, from $ 4000 per carat in 2008 to anywhere between $ 300 and $ 500 today, according to Bain & Company's Global Diamond Report (Bain & Company 2018), De Beers could no longer ignore the importance of this growing market, creating what has been termed a "demi-fine" brand. According to David Prager, De Beers executive vice president, these diamonds should not be priced "as inherently rare or precious things" (Bates 2018), thus justifying their more affordable and accessible price target. Other luxury brand companies, like Tiffany's, remain committed to consumer desire for the "rarity and amazing story of natural diamonds," for whom lab-grown diamonds does not constitute a "luxury material," according to Andy Hart, senior vice-president of diamond and jewelry supply for Tiffany's in statements widely reported to the press (Danziger 2019). Instead, the company recently unveiled its effort to render transparent the

provenance of all individual diamonds sold to its customers, in what it calls Diamond Source Initiative.

In tandem with these transformations, the US Federal Trade Commission revised in 2018 its definition of a diamond as a "natural mineral consisting essentially of pure carbon crystallized in the isometric system." After a request from Diamond Foundry to remove "natural" from the definition, the commission eliminated the reference to reflect the new reality of lab-created diamonds (FTC 2018, 114), joining a more widespread effort by the industry to revise its guidelines for disclosure, nomenclature, and regulations.[1] Alongside the creation of an International Grown Diamond Association, established in 2016, the share of lab-grown diamonds in the market looks more expansive every year. For diamond producers, the tide of synthetic or lab-grown minerals seems unrelenting: in May 2019, one commercial entity owned by the largest retailer of diamond jewelry, Signet Jewelers, began selling lab-grown diamonds; that same month, the Dubai Diamond Exchange held the first ever tender of lab-grown rough diamonds with 50 000 carats on offer and the Guagzhou Diamond Exchange, for its part, signed an agreement between its partners and China's synthetic suppliers by promoting an event during the 2019 Shenzhen Jewellery Fair called "Discover the magic of lab-grown diamonds." Most certification laboratories, including the International Gemological Institute and HRD Antwerp, announced that each graded synthetic diamond would be inscribed with the words "Lab Grown."

The Diamond Producers Association, one of the main lobbying bodies of diamond mining companies, unveiled in late 2017 its "Real is Rare" marketing campaign to enhance the value of natural diamonds. De Beers also launched its first synthetic diamond detection course and the company is stepping up its own synthetic diamond knowhow to distinguish "fake" from "real" diamonds. Despite the industry's improved verification and detection technology, most experts and traders are unable to pick up on improved and ever more refined "faking" techniques or stop man-made diamonds from entering the market (Bolay and Calvão 2020). These efforts may well prove spurious if the value of "authentic" gemstones is thrown into question in a more profound move toward socially aware consumption. After investing in a US-based company specialized in man-made diamonds, actor Leonardo DiCaprio expressed a more widespread sentiment: "I'm proud to invest in Diamond Foundry Inc., cultivating *real diamonds* [our emphasis] in America without the human & environmental toll of mining."

The industry of lab-grown diamonds can be divided between jewelry business and industrial manufacturers, largely based in Europe, Asia, and North America.[2] The first category of companies goes at great lengths to explain the distinction between man-made and mined

[1] See, *inter alia,* the Kimberley Process's Administrative Decision on the Use of Unified Diamond Nomenclature and Terminology as a Best Practice (2018); Responsible Jewellery Council Code of Practices (2019) for product disclosure and grading; GIA's updates on education materials and grading reports for laboratory-grown diamonds (March 2019), as well as the IGI and HRD's updates on grading and laser inscription of synthetic diamonds.

[2] The former includes companies such as Amiable Diamond, Scio Diamond, Pure Grown Diamond, Diamond Foundry, Cred Jewellery, or LightBox. The latter include industrial manufacturers such as Applied Diamond Inc, IIa Technology, New Diamond Technology, or Lake Diamond.

diamonds. Brand positioning hinges in great measure on their ability to posit their product as real and by appealing directly to consumers as co-constructed agents, namely in social media and online presence. Cred Jewellery, the self-proclaimed "original ethical jeweller," presented the "Ultimate Ethical Engagement Ring," combining lab-grown diamonds with Fairtrade gold. By "emulating nature's process" in a laboratory, the company suggests on their website, they create a diamond that "sparkles like a mined diamond, as pure as a mined diamond, 100 % socially responsible." If the luxury retail segment has predominantly refused marketing and commercializing synthetic gemstones, new jewelry actors have emerged to question the monopoly in natural gemstones, such as Courbet in the Parisian Place Vendôme. Other retail agents produce jewelry lines that combine lab-grown diamonds with Fairtrade mined gold.

The two companies we examine in this article, Life Gem and Algordanza, explicitly try to avoid entering the competitive market of synthetic jewelry. Rather, as Algordanza's CEO, Rinaldo Willi, explained to us, his work is dealing "with death and people." The company specializes in extracting carbon and graphite contents from a deceased's lock of hair or cremation ashes, and less frequently, from personal objects rich in carbon and emotional value such as letters or personal diaries. This chemical extraction is usually done with a chlorine bath or a purification process that heats a ceramic container and vaporizes all the elements until only carbon or graphite is left. Once the carbon-based human material is obtained, it is placed in a growing cell or core – akin in size to a small seed – which will meld the various chemical components under a large 16-ton press. In two weeks or less, depending on the size of the desired stone and stable conditions of approximately 2500 degrees Celsius, companies like Algordanza – along with an entire cottage industry of diamond manufacturing facilities mushrooming across the world – have mastered the ability to create extremely rare "natural" diamonds, at very low cost and in everything identical to gemstones sourced in nature.

The term "lab grown" is interesting as it alludes to a naturalistic process in a way the word "synthetic" does not. To start the process of a lab-grown diamond, one puts a "seed" of a mined diamond in with the carbon remains. This follows the principle of HPHT techniques, when the growing cell is put under a large multi-ton press, where it will be subject to high pressure and high temperatures. The reproductive diamond then yields another. This act of reproduction further emphasizes the production as being at once natural and technological, akin to In Vitro Fertilization (Davis-Floyd and Dumit 1998; Franklin 2013).

From our interviews, we learned that these manufacturers of memorial diamonds are not particularly concerned about providing ethical alternatives to mined stones. By tapping into the emotional value of "knowing where our diamonds come from", the Swiss company, similarly to its American counterpart, is not intent on producing a dent in the jewelry market nor does it hold the logistical capacity to compete with mass-produced synthetic diamonds in large facilities of hundreds of presses. Rather, they see the company as providing "not a product" but "an emotional service". This attachment to the emotional dimension of the company stemmed from the CEO's own personal story, as he described it. After being diagnosed with cancer, Algordanza's founder "played with these thoughts, death, what options do you have, how would you like to be remembered," which eventually led to the creation

of the company and its emphasis on the "emotional side." Unlike the "negative" weight of visiting a cemetery or keeping ashes at home, Rinaldo Will explained to us, "a diamond is sexy, it's a gem, it's clean, ... you are more aware of the nice memories you shared with the person than with the loss." If you "can't touch the ashes", he concludes, memorial diamonds valorize the positive memories by extending the material connection to the deceased in the form of a wearable gem. The company also privileges a personalized relationship with clients, and each "token of memory" is inscribed and personally inspected by the CEO. Although exporting to over 30 countries, the company has an annual output of only 1000 diamonds and 12 employees in its workforce.

Putative "clients" are faced with a paradoxical problem: on the one hand, they seek a natural product, made from carbon traces of intimate kin, that respects the final wishes of their loved ones. Algordanza, for example, makes sure to communicate to their Japanese customer base that they don't use nuclear energy. On the other hand, the company has no direct control over the production of these diamonds, left to the whims of time, high temperature and pure pressure. As we were told during our visit, "once we have the carbon and we put it into the growing cell and put it into the presser we have no in-process control, no one has." Admitting their powerlessness over the manufacturing process would expose the lack of genuine emotional value of synthetic stones and potentially reveal the company's inability to produce diamonds that reflect the deceased's personal and physical traits. This associative process linking the bodily material to the end product, as we will see, threads a fine line between the desired "humanness" and the "real" artificiality of these diamonds. On the other hand, having a modicum of control over a process eminently chemical and mechanical would betray the pure naturalness of these gemstones, meant to emulate those found in nature. It is around the mediation of this paradox – between what is real and fake, synthetic and natural about these gemstones – that we now turn to.

Mediations: realness, symbolic matter, and natural humanness

In this section, we explore how memorial diamond makers attempt to configure meaning-making across material orders as human ashes are turned into diamonds. We show how the emphasis on the "real-ness" exposes the tensions and transmutations between material orders and conceptions of life and death. In an industrial park near O'Hare airport in Chicago, Life Gem's unassuming office and production lab are staffed by two of the company's owners, Greg and Rusty. Both men were dressed casually in converse sneakers, jeans, and button down shirts the day we arrived for a tour and interview. Their upbeat tone during our discussions almost seemed cavalier when contrasted with expected norms of service providers who deal with the deceased. It was clear that the pair did not see themselves as mortuary workers, yet notions of death and the deceased were paramount to meaning-making for their services. As Greg explained, although the material properties of Life Gems are nearly identical to mined stones, synthetic stones could not be sold for a worthwhile price at a small scale. The added symbolic value of the memorialized changed that. Yet the pair weren't trained in grief counselling. They essentially outsourced the client interfacing work to

funeral homes, or conducted most business online. While the dead are what make "Life Gems" valuable, the emotional labor of talking to those at a loss was not part of what they did. They had a long-term vision of welcoming visitors and adding a space for guests to sit and have a drink. They already brewed beer during "down times" and had a bar room with a high top counter on which a half empty bottle of Jack Daniels stood. For them, allowing people to see the technological process of conversion would, in and of itself, provide comfort.

As we learned the process involved in making and marketing memorial diamonds, our conversation that day tacked back and forth between notions of real and not-quite-real, between ideas of what is natural and what is not, and between what is human and what is no-longer-human. At Life Gem, the owners stressed that mediating the "real-ness" of synthetics through marketing and customer interactions was vital to the semiotic production of value. Yet the notion of the lab-made "real" was an unstable target due to the material and symbolic properties and processes involved. Ideas of "natural" and "real" were at times conflated and at other times convoluted. This was not the result of trickster marketing-speak; rather, the ambiguity stemmed from the challenges memorial diamonds pose to established ontological categories.

The emphasis in our discussion was on the ability and what it meant for Life Gem to produce "real" diamonds. In our conversation, we observed that the owners of Life Gem, much like our interlocutors at Algordanza, tried to establish real-ness in three ways. 1. Emphasizing the molecular properties of finished memorial diamonds, in all identical to natural, mined diamonds 2. Matching carbon from human remains with "naturally occurring" carbon to establish material likeness and, finally, 3. Enmeshing material endurance with symbolic endurance of connection to the deceased. We elaborate each of the facets of mediation below as integral to the translation of meaning as ashes are turned into diamonds.

What the owners of Life Gem stressed to us in our tour was the specifics of the physical composition of the finished product. Greg explained "this is a real diamond, it's 10 on the Mohs scale, it's hard, you know?"[3] Life Gem sends their stones for physical evaluation to the Gemological Institute of America (GIA) headquartered in California, one of the leading institutions for certification and evaluation of diamonds and other precious gemstones. Each Life Gem product is issued a certificate that establishes the gemstone's attributes in similar lexicon as mined stones, thus drawing attention to the material similarities between lab-grown and mined stones, while making clear when a particular stone is lab-grown. However, after GIA's laboratory in Hong Kong identified in 2016 a CVD grown diamond in an undisclosed batch – the largest ever detected at the time – GIA decided to adapt its certification nomenclature by relying on clarity and color-equivalents.[4]

[3] The Mohs' hardness scale was developed by German mineralogist Frederich Mohs in 1812. This scale is a chart of relative hardness of the various minerals (1 – softest to 10 – hardest). "Hardness" is the resistance of a material to being scratched. Diamonds are the hardest mineral and have a score of 10.

[4] According to a statement by Tom Moses, GIA's chief laboratory, to the National Jeweler, "[w]hen identifying clarity, the lab only uses VVS, VS, SI or I for synthetic diamonds," without attributing specific color and clarity grades (The Diamond Loupe 2016). According to GIA's 2019 updates to education materials and grading reports, in response to new FTC regulations, "The new GIA Laboratory-Grown Diamond Report will feature the same visual representation of the scales for color, clarity and cut as GIA's grading reports for natural diamonds. The updated reports will continue to use descriptive terms for color and clarity, for example,

The second piece to establishing "real-ness" is adequation of source material. Greg remarked that "a natural diamond is, really, just maybe that oak tree or that dinosaur", by which he meant that that, ultimately, all diamonds come from carbon. The distinction between what is made at Life Gem and what emerges from the mine is, from the company's perspective, the carbon source. In this way, the transformation of a carbon source is a diminished aspect of what makes a diamond a diamond, instead what matters is that it begins with carbon at all. With the Chemical Vapor Deposition (CVD) method, a substrate of carbon-containing gases is ionized in a growth chamber and energized at high temperatures to create the diamond. This method can also be used to grow a diamond film onto natural diamonds or to adhere it to other materials, raising the possibility of this technique being used to enhance the clarity of natural diamonds. Simply put, a synthetic diamond with highly-sought features may hide a less valuable diamond. It is precisely the prospect of synthetic-natural hybrid diamonds, also known as "composite" stones, that most haunt the industry and defy existing screening methods, such as when GIA detected a natural white diamond covered in a thin blue synthetic layer.[5]

Finally, the real-ness of the memorial diamond comes from its connection to the deceased. Greg explained it this way: "We're going to create a diamond that's going to last forever out of your loved one that you can pass down for generations. This is Grandpa Joe, this is, you know... 50 years from now you'll still have that diamond in your family and, you know, it will be more than just a natural diamond that someone brought into the family". As Greg understands it, the Grandpa Joe diamond is "real" insofar as it is made of human remains. Because of the connection between the diamond and the deceased kin, it becomes "more than just natural". Stones that get brought into the family (from mines) are seen as lesser than those that emerge from within it. Algordanza's CEO echoes this sentiment, when he posited the demand for this service as an index of emotional value: "only people who really liked the deceased will request the service. You wouldn't do it for an uncle you didn't like ... people you like you do the diamond." Paradoxically, the real memorial diamond has human traits, whereas the natural is "fake" – or not quite real – to the extent that it does not contain an added value of humanness, even if it indexes kin through past ownership. Algordanza claims a certain "naturalness" to its diamonds by stressing that they are made without additives to enhance colors other than those already present in the human body. The diamond is just the body, the material vessel of what remains of its humanness. As Verdery explains, dead bodies are "heavy symbols" (1999, 127). They are the thing that is always more than a thing (Engelke 2019). This presents an opportunity to create distinction from mined counterparts, which are unable to materially embody this symbolic weight as efficiently as memorial lab-grown stones.

Near Colorless and Very Slightly Included, as shown on the scales. The report will also include a QR code linking to GIA's online Report Check service with more information about the growth processes of laboratory-grown diamonds. All detected clarity treatments will be disclosed" (The Diamond Loupe 2016).

[5] This layer was measured at about 80 microns, or 0.003 inches. According to a Diamond Loupe report on the discovery, the "0.33-carat stone was a composite of CVD synthetic Type IIb diamond overgrowth on a natural Type Ia diamond," and GIA warned at the time that "more such composites might be on the market" (The Diamond Loupe 2019).

For synthetic stones to generate new forms of value, it is imperative that memorial diamond makers attempt to establish their samenes / difference from mined counterparts. In Saussurean terms, this means assessing their comparative position in a broader system of value understood as meaningful difference. For Ferry (2013, 18), value can be defined as "the politics of making and ranking differences and deciding what differences are important" (see also Ferry 2019). The value of memorial diamonds, in other words, is perceptible in a total system of distinction and contrast. For memorial diamond makers, thus, differences in production (mined versus lab-grown) are downplayed while differences in their capacity to symbolize and memorialize a loved one are heightened.

Valuation: likeness, reference, and semiotic instability

While makers of memorial diamonds stress the material and symbolic "real-ness" of their products in various ways, how do clients take up these meanings? Do they see the same hierarchy of difference? Not always, as we learned from George's story that introduced this article. The deceased's attachment to nature complicated the immediacy of the stone-as-relative. This section focuses on the instability of valuation of memorial diamonds as it emerges from the nexus of material, biological, and technological domains. We illustrate how the outcome of lab-grown diamonds has the capacity to both create and undermine value in that the relationship between materiality and imaginative process is as generative as it can be unpredictable. As signs, memorial diamonds are semiotically flexible enough to be "more than just" a diamond, and more like a loved one, but also less like one as well.

Memorial diamonds have much in common with objects of commemoration more broadly. Cultural anthropologists and (bio)archaeologists have long been interested in the connections between loss, memory, and material culture as it "mediates our relationship with death and the dead" (Hallam and Hockey 2001, 2; see also Bille, Hastru, and Soerensen 2010; Engelke 2019; Maddrell and Sidaway 2010). Memorial diamonds are by no means the first example of human remains acting as a memory artifact. All of the major religions of the world have historically incorporated relics into their spiritual practices at some point. Usually consisting of the physical remains or personal effects of a saint, these objects were preserved and displayed as tangible memorials that could serve as sites of veneration. An example of "everyday" people memorializing the deceased through their physical remains is the production of hair jewelry between the 17th and 19th centuries in Northern Europe (Luthi 1998). Alongside precious stones and metals, hair was used to create broches, lockets, rings, and bracelets. Much like the tensions we heard in learning about disappointed clients whose lab-grown stones did not reflect their loved ones, "hair work manuals published in the 19th century provided instructions on how to make hair jewelry which would call to mind the deceased" (Luthi 1998, 139). Like memorial diamonds, for which hair is one possible base component, hair jewelry could be passed from one generation to the next. Memorial objects made from human remains are especially appropriate, even if contested, memory forms because of the "... the quality of endurance and the specificity of reference to a particular individual" (Hallam and Hockey 2001, 136).

In the case of memorial diamonds "the specificity of reference" cannot be taken for granted. Part of how clients establish "real humanness" of a lab-grown diamond is by attributing meaning to aspects of finished stones that, ultimately, emerged by chance. More than size or shape, the feature that draws parallels between the object and humans is the color; Algordanza, for example, claims that some clients will make associations such as "if the deceased had blue eyes, [and the stone is blue], it's blue like his eyes." The company encourages these associations in their marketing: "The unique blueish colouration emphasizes the uniqueness of your personal Memorial Diamond".[6] While memorial diamond makers stressed the uniqueness of lab-grown diamonds, the chemical process leaves open the possibility of a range of colors for finished stones. These colors can be useful in connecting object to human but this associative process potentially means that the client doesn't see "the real" person in the finished gemstone. As representatives from Algordanza explained to us, there was one instance where the customer was not happy "because the diamond was too dark, almost black. [The client] said 'my wife was not a bad person' ... it was a problem. He associated the black color with the character of his wife." When a client is not able to connect ideas of their loved one to the finished product, the object fails to hold its projected value. Companies like Life Gem try and work through this tension by using various chemical processes to control for color or colorlessness. Competitors like Algordanza recast such practices as making stones more synthetic and less natural and, by extension, less like the deceased.

One of the unique features about these two companies, and man-made jewelry more broadly, is the ability to create, at very low cost, extremely rare natural diamonds. While stones larger than 4 carats (rough) are still technically challenging to produce, it is very common to fabricate blue, pink, or yellow diamonds. Blue or pink colored diamonds – devoid of nitrogen impurities, or that carry specific concentrations of boron impurities – are easily produced in laboratory conditions by either removing nitrogen from the carbon concentrate or by adding powdered boron to the mix. Whereas colorless diamonds are far more complex to produce in laboratory than colored diamonds, moreover, the same techniques can also be applied to enhance the clarity of natural diamonds. Algordanza, for its part, claims to not include any additives other than those already present in bodily remains, stressing their singular connection to the humanness of diamonds.

That diamonds are marketed as "forever" and that they are materially difficult to destroy is crucial to become legible as memorial objects. When asked about the possibility of other memorial gems (rubies, sapphires), Life Gem staff's response was quick and certain: other stones were unlikely as "diamonds are forever!". Hallam and Hockey have described how

> *[t]he perceived duration of an object – its capacity to endure time and to operate across time by encoding aspects of the past or future in the present moment – is crucial to its memory function ... the materiality of memory objects often alludes directly to the bodily process of dying, death and decay and such objects maintain tensions between physical presence and the threat of disintegration and absence.* (2001, 48)

[6] As explained in Algordanza's "Symbol of Love. Your Memorial Diamond," a 14-page glossy brochure given to prospective customers.

In this regard, memorial diamonds are materially and symbolically ideal memory objects as they are able to hitchhike semiotically off of De Beers famous marketing campaign of the late 1930s (Falls 2014) and are known for their hardness and indestructability. Yet their well-suitedness to becoming memorial objects does not make the process of valuation straightforward.

The work of American conceptual artist Jill Magid can assist this reflection. In a series of pieces using memorial diamonds, Magid shows how value creation is cultivated at the blurred and often tense boundaries between incommensurable categories such as organic and mineral; person and thing; life and death. In her 2005 piece, *Auto Portrait Pending*, a brightly lit display case houses an engagement ring set without the expected diamond solitaire. Alongside the stone-less ring are documents that, upon the artist's death, commit her remains to be sent to Life Gem for transformation into the diamond that will ultimately complete her self-portrait installation. Her instructions, written alongside the display case, are clear: "Make me a diamond when I die. Cut me round and brilliant. Weigh me at one carat. Ensure that I am real" (Magid 2005).

In Magid's own words, her art deals with "the question of artistic legacy: How is it constructed, manipulated, accessed and owned?" (Hirsch et al. 2016, 6). *Auto Portrait Pending* plays with the boundary between an artist's physical body and her body of work. It asks the viewer to consider: What makes the piece valuable? Is there value in the promise of a body alone? Or will the transformation of body into gemstone render the piece valuable? What differences are helping to create value here? The artist's labor, her physical body, or something else? This conceptual art piece lays bare the enmeshment of synthetic, digital, and natural materialities. As we have seen, memorial diamonds in general, and in *Auto Portrait Pending* in particular, make it difficult to separate the synthetic from the biologic, the natural from the artificial. The semiotic efficacy of this art piece lies in the punctum (Barthes 1981) created by the simultaneous future presence / present absence of the artist's material body in the lab-grown diamond. What makes the piece possible are technological advances in synthetic gemstone production we described earlier, as well as enduring ideologies of value in the perceived permanence of diamonds (as in "diamonds are forever") and a western emphasis on individual legacy.

Magid deepened her conversation about artistic legacy using memorial diamonds through a second piece titled *The Proposal.* In 2014, she organized the exhumation of the remains of Mexico's acclaimed architect Luis Barragán. Magid sent the cremated remains to Algordanza where the architect's ashes were transformed into a single synthetic diamond. Magid put the architect-turned-diamond in an engagement ring to stage a "proposal" to the private holder of Barragan's professional archive, Frederica Zanco, who had previously received Barragan's collection of work as an engagement gift from her husband. Zanco kept the archive at the Vitra Design Museum in Basel, Switzerland, but Magid's "proposal" invited Zanco to return Barragán's archives to Mexico in exchange for the ring made of the architect's remains. Essentially, Magid was offering to trade the architect's material body for his body of work, exchanging one form of legacy for another. Magid's "proposal" to Zanco was never accepted, yet the offer of the gift binds them in a perpetual chain of obligation that can never fully be dissolved (Povinelli 2016). The proposal's value as "real art" and as a "real pro-

posal" came from the human-indexing qualities of the stone.[7] It was, after all, *really* Barragán who made that particular stone possible. An identical stone could not have been produced. However, at least for Zanco, the architect's archive holds more value and better indexes his human worth than the fabricated stone.

In sum, lab-grown diamonds are, quite literally, given a "vibrant" and vital force (Bennett 2010) to grow and expand from a carbon seed, forcing us to rethink the unstable forms of "matter" (Ingold 2012) as it composes inert and living substances, not quite alive nor dead. Approaches in the vein of the new materialism offer a privileged vantage point to reflect on the shifting nature of matter as it is reconstituted within the setting of these laboratories. Following Coole and Frost (2010, 16), these diamonds would be suitable sites of inquiry to examine "the blurring of clear boundaries or distinctions between bodies, objects, and contexts [as] evident in the myriad biotechnological and digital technological developments that are changing the landscape of the living." Threading corporality and objectified life forms, as we have seen, the transformation from ashes to "afterlife" and the unpredictable and indeterminate qualities of these "living" objects complicate the capacity of matter to generate social and commercial relations – in objectifying the memory of relatives, artists, or architects in the shape of a commodified objects – and to be given specific agentive capacities.

Conclusion

As the world economy inches closer to decarbonization and de-materialized production, while simultaneously pursuing new extractive frontiers, this article repositions the centrality of carbon to think through the materiality of lab-grown synthetic substances, nature, and human life. As materiality is redefined in human geography and anthropology in the study of natural resources, accounting for a more dynamic and relational definition of resources extracted from nature (Bridge 2009; Richardson and Weszkalnys 2014), a new set of challenges emerge on the problem of agency, the precarious assemblages of human and non-human actors, and the problem of material causality "without straying into object fetishism or without attributing intrinsic qualities to entities / categories whose boundaries are 'extrinsic' – defined, at least in part, socioculturally" (Bakker and Bridge 2006, 8). This was also the challenge we faced at the outset of this research.

Memorial diamonds appeared to stand apart from the contexts of extraction we were most familiar with in large industrial diamond mines in Canada (Bell 2017) and Angola (Calvão 2011, 2015, 2017) in that lab-grown stones are often positioned as an ethical and sustainable alternative to mined gems. What our work with memorial diamond producers revealed was the ways in which these two types of objects (lab-grown and mined diamonds) had a high volume of semiotic, material and value traffic, and transmutations – lest we forget that Dominion's CEO (the world's third largest diamond producer) and Alrosa's president (the Russian

[7] Since the time of its inception, *The Proposal* has been turned into a film (Magid 2018) and an exhibit that travels to art galleries around the world.

diamond giant) left these companies to start their own synthetic diamond start-ups – that defy a siloed and compartmentalized understanding of these objects.

Memorial diamonds are discursively linked to mined stones through an emphasis on the molecular properties of finished lab-grown stones and the equation of carbon from human remains with "naturally occurring" carbon. They gain distinction from their mined counterparts through the enmeshment of diamonds' material endurance with symbolic endurance of connection to the deceased. Yet these connections are destabilized by the unpredictable effects of the technology itself, the qualities ascribed to the deceased made real with the product, competing sentimental values – to recall George's family disputed significance of the material body-qua-diamond and what the object stood for in relation to nature – as well as incommensurable ideas about value, legacy, and artistic and emotional expression, as in the art proposal examined earlier.

As an object of adornment that memorializes a deceased relative, lab-grown diamonds discursively and materially recast the relationship between the living and the dead, nature and technology, humans and non-human entities. The value of these material objects and immaterial signs are encompassed in their capacity for relational subjectivity and for activating inanimate objects (Masuzawa 2000, 256). We have extended conversations of materiality and value (Pietz 1985; Ferry 2013; Graeber 2005; Masuzawa 2000) to synthetic substances and the biological (Roosth 2017) by theorizing more explicitly the socio-cultural and ethical value in the creation of synthetic-qua-natural substances, at once objects of deep affective and economic value. The approach we have suggest here privileges relations over bounded objects, in particular as they manifest in moments of conflicted enmeshments of life and death. Critically, the question remains as to whether synthetic diamonds contest or restate the assumption of discrete entities and the very borders mounted between the social and natural.

If critical geographers and political theorists (Arboleda 2019; Gago and Mezzadra 2017; Mezzadra and Neilson 2017) have called for an "expanded conception of extractivism" to account for the ways in which primary commodity production becomes intermingled with finance, logistics, infrastructures, or urbanization, this article invites an even wider conception anchored in the lived worlds of those tasked with transforming the bodies of the dead and "alchemise" nature. Although memorial diamonds are not "extracted" from nature in the classical sense, their value is linked to the shifting cultural, symbolic, and affective terrain on which they rest. What is more, they are inextricably real insomuch as they are attached to human life, precarious and tenuous as this relation can be. Scholars of extractivism, we suggest, must account for this co-creation of objects of value as they enliven and make all more complicated already familiar circuits of production.

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