

脚注

はじめに

- 1 World Gold Council data, <https://www.gold.org/goldhub/data/gold-demand-by-country>.
- 2 Leonard Read, 'I, Pencil', 1958, <https://fee.org/resources/i-pencil/>.
- 3 A. McAfee, *More From Less: The Surprising Story of How We Learned to Prosper Using Fewer Resources— and What Happens Next* (Simon & Schuster UK, 2019).
- 4 R.W. Clark, *Einstein: The Life and Times* (Random House, 1995).

第一部 砂

1章

- 1 R.A. Bagnold, 'Journeys in the Libyan Desert 1929 and 1930', *Geographical Journal* 78/1 (July 1931): 13, <https://doi.org/10.2307/1784992>; Major R.A. Bagnold, 'A Lost World Refound', *Scientific American* 161/5 (November 1939):261–3, <https://doi.org/10.1038/scientificamerican1139-261>.
- 2 T. Aboud, 'Libyan Desert Glass: Has the Enigma of Its Origin Been Resolved?', *Physics Procedia* 2/3 (November 2009): 1425–32.
- 3 David Hockney, *Secret Knowledge: Rediscovering the Lost Techniques of the Old Masters* (Thames & Hudson, 2006).
- 4 Alan Macfarlane and Gerry Martin, *The Glass Bathyscaphe: How Glass Changed the World* (Profile, 2011).
- 5 Pliny the Elder, *The Natural History*, trans. J. Bostock, H.T. Riley (Taylor and Francis, 1855), Book XXXVI, Chapter 65.
- 6 Reiner Zorn, 'A Wing Explained', *Nature Physics* 18/4 (April 2022): 374–5.
- 7 Seth C. Rasmussen, *How Glass Changed the World*, Vol. 3, SpringerBriefs in Molecular Science (Springer, 2012), <https://doi.org/10.1007/978-3-642-28183-9>.
- 8 Roy and Kay McLeod, 'War and Economic Development: Government and the Optical Industry in Britain, 1914–18', in J.M. Winter (ed.), *War and Economic Development* (Cambridge University Press, 1975).
- 9 *Official History of the Ministry of Munitions* (facsimile: Naval & Military Press, 2008), Vol. XI, Part III, p. 42.
- 10 Guy Hartcup, *The War of Invention* (Brassey's, 1988). Also see Adam Hochschild, *To End All Wars: A Story of Protest and Patriotism in the First World War* (Picador, 2011).
- 11 Stephen King-Hall, *A North Sea Diary, 1914–1918* (Forgotten Books, 2012).
- 12 *History of the Ministry of Munitions*, Vol. VII, Part 1, p. 1.
- 13 *Ibid.*, Vol. XI, Part 3, p. 83.

2章

- 1 Speech by US Admiral Harry Harris, commander of the Pacific Fleet, to the Australian Strategic Policy Institute, 31 March 2015.
- 2 Author's analysis of data from UN COMTRADE database.
- 3 UN COMTRADE database.
- 4 Anthony H. Cooper et al., 'Humans Are the Most Significant Global Geomorphological Driving Force of the 21st Century', *Anthropocene Review* 5/3 (2018):pp.222–9.
- 5 Emily Elhacham et al., 'Global Human-made Mass Exceeds All Living Biomass', *Nature* 588/7838 (2020): pp.442–4. The weight of biomass can be found in Yinon Bar-On, Rob Phillips and Ron Milo, 'The Biomass Distribution on Earth', *Proceedings of*

- the National Academy of Sciences*, 19 June 2018.
- 6 WWF-GreaterMekong/WWF Freshwater Practice, 'The Sands Are Running Out', WWF Water Case Study, 2018, https://www.wwf.org.uk/sites/default/files/2018-04/180419_Mekong_sediment_CS_external.pdf.
 - 7 Christian Jordan et al., 'Sand Mining in the Mekong Delta Revisited– Current Scales of Local Sediment Deficits', *Scientific Reports* 9, article number 17823 (2019).
 - 8 G.M. Kondolf et al., 'Changing Sediment Budget of the Mekong: Cumulative Threats and Management Strategies for a Large River Basin', *Science of the Total Environment* 625 (2018): pp. 114–34.
 - 9 Pascal Peduzzi, 'Sand, Rarer than One Thinks: UNEP Global Environmental Alert Service (GEAS) – March 2014', United Nations Environment Programme, 2014.
 - 10 Yang Zekun, 'Crackdown on Yangtze Sand Mining Stepped Up', *China Daily*, 2 March 2021.
 - 11 Debashish Karmakar, 'Bihar: 4 Cops Injured as Sand Mafia Attacks Police Party in Nawada District', *Times of India*, 2 June 2021; 'Policeman Injured After Being Shot at by Two Unidentified Men in Rajasthan's Sikar', *Times of India*, 20 July 2021; Avinash Kumar, 'Bihar: 18 Cops Found Protecting Illegal Sand Mining Shifted, More Under Radar', *Hindustan Times*, 12 July 2021; Vivek Trivedi, 'Another Forest Dept Team Attacked by Sand Mafia in MP's Morena', *News18*, 30 July 2021.
 - 12 Pascal Peduzzi et al., *Sand and Sustainability: 10 Strategic Recommendations to Avert a Crisis* (United Nations Environment Programme, 2022).
 - 13 Andrew Rabeneck, 'The Transformation of Construction by Concrete', in *Nuts & Bolts of Construction History Vol. 2* (Picard, 2012), pp.627–36, <https://structurae.net/en/literature/conference-paper/transformation-of-construction-by-concrete>.
 - 14 Charles Kenny, 'Paving Paradise', *Foreign Policy* (blog), <https://foreignpolicy.com/2012/01/03/paving-paradise/>.
 - 15 Rocio Titunik et al., *Housing, Health, And Happiness*, Policy Research Working Papers (The World Bank, 2007).
 - 16 The best description and explanation I've encountered of the formation of concrete, upon which my condensed version is based, is from Mark Miodownik, *Stuff Matters: The Strange Stories of the Marvellous Materials that Shape Our Man-made World* (Penguin, 2013).
 - 17 L.M. Seymour et al., 'Hot Mixing: Mechanistic Insights into the Durability of Ancient Roman Concrete', *Science Advances* 9/1 (2023).
 - 18 For a more comprehensive account, a good place to start is Robert Courland, *Concrete Planet: The Strange and Fascinating Story of the World's Most Common Man-Made Material* (Prometheus, 2011).
 - 19 Andrew Rabeneck, 'Thomas Edison and Modern Construction: The Longue Duree of the Long Kiln', *Proceedings of the Sixth Annual Construction History Conference* (Queen's College, Cambridge, 2019), p. 13.
 - 20 Data based on cement statistics from United States Geological Survey.
 - 21 Ugo Bardi, professor of physical chemistry at the University of Florence: <https://cassandralegacy.blogspot.com/2019/01/what-happened-in-2015-that-changed.html>.
 - 22 コンクリート生産量を算出するのは容易ではない。累計生産量を算出するのはさらに困難である。セメント生産量に関する統計データは、アメリカ地質調査所（USGS）のデータをはじめとする、比較的信頼できるものはいくつか存在する。本稿ではこれらのデータに加え、ロバート・W・レスリー著「アメリカにおけるポルトランドセメント産業の歴史」（'History of the Portland Cement Industry in the United States', *Journal of the Franklin Institute* 5 March 1898;pp. 324–336.）に掲載されている歴史的データも参考にした。しかしながら、これらのデータ系列は1926年以降の世界全

体のデータしか網羅していない。世界全体の生産量を推定するため、この期間における米国とその他の地域との生産量比率を1:1とした。これは1920年代半ばの比率とほぼ一致している。そして、セメント:砂:骨材の比率を1:2:3とする標準的なセメント配合比率を用いて、コンクリート総生産量を推定した。他の配合比率ではセメント含有量が少なく、また混合物中に残る水の重量を考慮していないため、最終的なコンクリートの総質量を過小評価している可能性がある。しかし、同様に、この計算では古いコンクリートを新しい建物にリサイクルすることは考慮されていない。

- 23 William J. Mallett, 'Condition of Highway Bridges Continues to Improve', Congressional Research Service report, 19 May 2020, <https://crsreports.congress.gov/product/pdf/IN/IN11395>; George Greenwood and Graeme Paton, 'Half of Bridges on England's Busiest Roads in "poor condition"', *The Times*, 3 December 2020, <https://www.thetimes.co.uk/article/half-of-bridges-on-englands-busiest-roads-in-poor-condition-3vpwhg6c9>.
- 24 Johanna Lehne and Felix Preston, 'Making Concrete Change: Innovation in Low-carbon Cement and Concrete', Chatham House, June 2018.

3章

- 1 Anton Howes, 'Age of Invention: Where Be Dragons', <https://antonhowes.substack.com/p/age-of-invention-where-be-dragons>.
- 2 Vaclav Smil, *Making the Modern World: Materials and Dematerialization* (Wiley, 2013).
- 3 Ernest Braun and Stuart Macdonald, *Revolution in Miniature: The History and Impact of Semiconductor Electronics* (Cambridge University Press, 1978).
- 4 <https://computerhistory.org/blog/patricias-perfect-pull/>には、こうした結晶引き上げ技術者のひとりによる、素晴らしいオーラル・ヒストリー（口述歴史）が掲載されている。
- 5 Braun and Macdonald, *Revolution in Miniature*.
- 6 Gordon Moore, 'The Role of Fairchild in Silicon Technology in the Early Days of "Silicon Valley"', *Proceedings of the IEEE* 86/1 (January 1998).
- 7 'A look inside the factory around which the modern world turns', *The Economist*, 21 December 2019.
- 8 Chris Miller, *Chip War: The Fight for the World's Most Critical Technology* (Simon & Schuster, 2022).
- 9 Jeremiah Johnson et al., 'Dining at the Periodic Table: Metals Concentrations as They Relate to Recycling', *Environmental Science & Technology* 41 (2007): pp. 1759–65; Brian Rohrig, 'Smartphones: Smart Chemistry', American Chemical Society, April/May 2015, <https://www.acs.org/content/acs/en/education/resources/highschool/chemmatters/past-issues/archive-2014-2015/smartphones.html>.

第二部 塩

4章

- 1 John Julius Norwich, *A History of Venice* (rev. edition, Penguin, 2003).
- 2 Toyin Falola ' "Salt is Gold": The Management of Salt Scarcity in Nigeria during World War II', *Canadian Journal of African Studies/Revue Canadienne des Études Africaines* 26/ 3 (1992): p. 416.
- 3 Cecilia Lee-fang Chien, *Salt and State: An Annotated Translation of the Songshi Salt Monopoly Treatise* (University of Michigan Press, 2004), p. 5.

- 4 Ibid., p. 6.
- 5 *Discourse on Salt and Iron*, ‘Chapter One: The Basic Arguments, The Discourses on Salt and Iron’, http://www.8bei8.com/book/yantielun_2.html.
- 6 Pierre Laszlo, *Salt: Grain of Life* (Columbia University Press, 2001).
- 7 S.A.M. Adshead, *Salt and Civilization* (Palgrave Macmillan, 1992), pp. 218–30.
- 8 Roy Moxham, *The Great Hedge of India* (Constable, 2001).
- 9 Mahatma Gandhi, *Selected Political Writings*, ed. D. Dalton (Hackett, 1996), pp. 76–8.

5 章

- 1 K.L. Wallwork, ‘The Mid-Cheshire Salt Industry’, *Geography* 44/3 (July 1959), pp. 171–86; Paul G.E. Clemens, ‘The Rise of Liverpool, 1665–1750’, *Economic History Review* 29/2 (May 1976), pp. 211–25.
- 2 J.M. Fells, ‘The British Salt Trade in the Nineteenth Century’, *Economic Journal* 11/43 (September 1901), pp. 421–31; Ralph Davis, ‘Merchant Shipping in the Economy of the Late Seventeenth Century’, *Economic History Review* 9/1 (1956), pp. 59–73; Bank of England Millennium of Data spreadsheet.
- 3 Lion Salt Works Museum, Northwich.
- 4 Fells, ‘British Salt Trade’, p. 427.

6 章

- 1 Harold Blakemore, *From the Pacific to La Paz: Antofagasta and Bolivia Railway Company, 1888–1988* (Imprint unknown, 1990).
- 2 Patricio García Méndez, *The Reinvention of the Saltpeter Industry* (A Impresores, 2018).
- 3 John Mayo, ‘The Antofagasta Nitrate Company and the Outbreak of the War of the Pacific’, *Boletín de Estudios Latinoamericanos y del Caribe* 28 (June 1980), pp. 3–11.
- 4 Thomas O’Brien, ‘“Rich beyond the Dreams of Avarice”: The Guggenheims in Chile’, *Business History Review* 63/1 (Spring 1989), pp. 122–59.
- 5 Thomas Hager, *The Alchemy of Air: A Jewish Genius, a Doomed Tycoon, and the Scientific Discovery that Fed the World but Fueled the Rise of Hitler* (Crown, 2008).
- 6 United Nations Food and Agriculture Organisation, *The State of Food Security and Nutrition in the World*, 2020 and 2022 reports (United Nations, 2020/2022).

追記

- 1 オンライン上では、ゼヒシュタイン海の形成に関する優れた解説が数多く存在する。例えば、ロタンダ地質学グループ (Rotunda Geology Group, http://www.rotundageologygroup.org/2012_11_01/ZechsteinPotash) や、地質学会 (the Geological Society, <https://www.geolsoc.org.uk/Policy-and-Media/Outreach/Plate-Tectonic-Stories/Zechstein-Reef>.) のものがあげられる。

第三部 鉄

7 章

- 1 ‘Enver Tskitishvili about Azovstal–Plant Shut Down Competently’, Metinvest Media, 19 March 2022, <https://metinvest.media/en/page/enver-cktshvl-pro-azovstal-kombnat-zupinili-gramotno-ekologchno-zagrozi-nema>; also, author interview with individual from Metinvest.
- 2 J.E. Gordon, *The New Science of Strong Materials: Or Why You Don’t Fall Through*

- the Floor* (rev. ed., Penguin, 1991).
- 3 Stefan Pauliuk, Tao Wang and Daniel B. Muller, ‘Steel All over the World: Estimating in-Use Stocks of Iron for 200 Countries’, *Resources, Conservation and Recycling* 71 (February 2013): pp. 22–30.
 - 4 United Nations Environment Programme, *Global Resources Outlook 2019: Natural Resources for the Future We Want* (United Nations, 2020). Also the associated database on the UNEP website, which includes data for 2019: [https:// www.resourcepanel.org/global-material-flows-database](https://www.resourcepanel.org/global-material-flows-database).
 - 5 Vaclav Smil, *Energy and Civilization: A History* (The MIT Press, 2017) and *Still the Iron Age: Iron and Steel in the Modern World* (Butterworth-Heinemann, 2016).
 - 6 Paul Gait, ‘Valuing Jevons’ “Invaluable Metal” ’, Bernstein, September 2018; Tao Wang, Daniel B. Muller and Seiji Hashimoto, ‘The Ferrous Find: Counting Iron and Steel Stocks in China’s Economy’, *Journal of Industrial Ecology* 19/5 (25 August 2015): pp. 877–89.
 - 7 Jung Chang and Jon Halliday, *Mao: The Unknown Story* (Vintage Digital, 2012).
 - 8 Wei Li and Dennis Tao Yang, ‘The Great Leap Forward: Anatomy of a Central Planning Disaster’, *Journal of Political Economy* 113/4 (August 2005): pp. 840–77, <https://doi.org/10.1086/430804>.
 - 9 Serhii Plokyh, *The Gates of Europe: A History of Ukraine* (Penguin, 2015).
 - 10 James Kynge, *China Shakes The World: The Rise of a Hungry Nation* (Weidenfeld & Nicolson, 2010).
 - 11 Blast furnace count from Global Energy Monitor: https://www.gem.wiki/Main_Page; data on Chinese production from USGS and World Steel Association.
 - 12 Stephen Kotkin, *Magnetic Mountain: Stalinism as a Civilization* (University of California Press, 1997).
 - 13 Michael Schwirtz, ‘Last Stand at Azovstal—Inside the Siege that Shaped the Ukraine War’, *New York Times*, 24 July 2022, <https://www.nytimes.com/2022/07/24/world/europe/ukraine-war-mariupol-azovstal.html>.

8 章

- 1 Smil, *Still the Iron Age*.
- 2 Data on metallurgical coal from the IEA; data on blast furnaces collated by the author from the Global Energy Monitor database: https://www.gem.wiki/Main_Page.
- 3 Daniela Comelli et al., ‘The Meteoritic Origin of Tutankhamun’s Iron Dagger Blade’, *Meteoritics & Planetary Science* 51/7 (2016): pp.1301–9.
- 4 Roger Osborne, *Iron, Steam & Money: The Making of the Industrial Revolution* (Pimlico, 2014).
- 5 Peter Appleton, *A Forgotten Industry—The Alum Shale Industry of North-East Yorkshire* (Boroughgate, 2018).
- 6 Simon Winchester, *Exactly: How Precision Engineers Created the Modern World* (William Collins, 2018).
- 7 Vaclav Smil, ‘Energy (r)evolutions take time’, *World Energy* 44 (2018): pp.10–14; Maddison Project Database 2020, University of Groningen, <https://www.rug.nl/ggdc/historicaldevelopment/maddison/releases/maddison-project-database-2020?lang=en>.
- 8 J.M. Allwood and J. M. Cullen, *Sustainable Materials: With Both Eyes Open* (UIT Cambridge, 2012), <http://publications.eng.cam.ac.uk/400536/>.
- 9 Daniel E. Sichel, ‘The Price of Nails since 1695: A Window into Economic Change’, *Journal of Economic Perspectives* 36/1 (2022): pp. 125–50.
- 10 Robert J. Gordon, *The Rise and Fall of American Growth: The US Standard of Living since the Civil War* (Princeton University Press, 2017); Marc Levinson, *The Box: How the Shipping Container Made the World Smaller and the World Economy Bigger* (Princeton University Press, 2016).

- 11 Tom Standage, *A Brief History of Motion: From the Wheel to the Car to What Comes Next* (Bloomsbury, 2021).
- 12 Steven Watts, *The People's Tycoon: Henry Ford and the American Century* (Vintage, 2009).
- 13 World Steel Association, *The White Book of Steel* (World Steel Association, 2012).
- 14 Julian M. Allwood, *A Bright Future for UK Steel* (Cambridge University Press, 2016).
- 15 Katherine Felkins, H.P. Leigh and A. Jankovic, 'The Royal Mail Ship Titanic: Did a Metallurgical Failure Cause a Night to Remember?', *JOM* 50/1 (January 1998): pp. 12–18; Tim Foecke, 'Metallurgy of the RMS *Titanic*', National Institute of Standards and Technology, 1998.
- 16 Dinny McMahon, *China's Great Wall of Debt: Shadow Banks, Ghost Cities, Massive Loans and the End of the Chinese Miracle* (Little, Brown, 2018).
- 17 Adam Minter, 'China's Latest Innovation? The Ballpoint Pen', Bloomberg, 16 January 2017, <https://www.bloomberg.com/opinion/articles/2017-01-16/china-s-latest-innovation-the-ballpoint-pen?sref=n6On5IIq>; Adam Taylor, 'Finally, China Manufactures a Ballpoint Pen All by Itself', *Washington Post*, 18 January 2017, <https://www.washingtonpost.com/news/worldviews/wp/2017/01/18/finally-china-manufactures-a-ballpoint-pen-all-by-itself/>.
- 18 Kim Browne, '“Ghost Battleships” of the Pacific: Metal Pirates, WWII Heritage, and Environmental Protection', *Journal of Maritime Archaeology* 14/1 (April 2019): pp.1–28.

9 章

- 1 M. Grant Norton, *Ten Materials that Shaped Our World* (Springer, 2021).
- 2 <https://en.wikipedia.org/wiki/HarryPageWoodward>.
- 3 William Finnegan, 'The Miner's Daughter', *New Yorker*, 18 March 2013, <http://www.newyorker.com/magazine/2013/03/25/the-miners-daughter>.
- 4 *The Splash*, ABC (undated), <https://www.youtube.com/watch?v=IdXonJowDT0>.
- 5 David Lee, 'The Ghost of Lang Hancock', *Inside Story*, 19 August 2020, <https://insidestory.org.au/the-ghost-of-lang-hancock/>; *Australian Dictionary of National Biography*, <https://adb.anu.edu.au/biography/hancock-langley-frederick-lang-17492>.
- 6 この記述は、リオ・ティント社やプートゥ・クンティ・クラマ族を代表する団体であるPKKPなど、オーストラリア議会がジュカン渓谷調査委員会に提出したさまざまな資料、および中間報告書と最終報告書にもとづいている。
- 7 Rio Tinto Supplementary Responses to Questions, Inquiry into the destruction of 46,000 year old caves at the Juukan Gorge in the Pilbara region of Western Australia, Submission, 20 August 2020.
- 8 'World Steel in Figures 2022', World Steel Association, 2022.
- 9 Stefan Pauliuk et al., 'The Steel Scrap Age', *Environmental Science & Technology* 47/7 (2 April 2013): pp. 3448–54.
- 10 Allwood and Cullen, *Sustainable Materials*.

第四部 銅

10 章

- 1 Richard Pence (ed.), *The Next Greatest Thing* (National Rural Electric Cooperative Association, 1984).
- 2 Robert Caro, *The Path to Power: The Years of Lyndon Johnson* (The Bodley Head,

- 2019).
- 3 Gordon, *Rise and Fall of American Growth*.
 - 4 Henry Sanderson, 'Copper Miners Pin Hopes on Electric Cars as China Falter', *Financial Times*, 8 April 2016, <https://www.ft.com/content/0e091ff8-fd5a-11e5-b5f5-070dca6d0a0d>; Nicholas Snowden et al., 'Green Metals Copper Is the New Oil', Goldman Sachs, 13 April 2021.
 - 5 この電磁効果のわかりやすい例は、
<https://www.youtube.com/watch?v=sENgdSF8ppA&t=85s>や
<https://www.youtube.com/watch?v=5BeFoz3Ypo4>で見ることができる。
 - 6 William D. Nordhaus, 'Do Real-Output and Real-Wage Measures Capture Reality? The History of Lighting Suggests Not', in *The Economics of New Goods* (University of Chicago Press, 1996), pp. 27–70, <https://www.nber.org/books-and-chapters/economics-new-goods/do-real-output-and-real-wage-measures-capture-reality-history-lighting-suggests-not>.
 - 7 'Olympic Cyclist Vs. Toaster: Can He Power It?', 2015, <https://www.youtube.com/watch?v=S4O5voOCqAQ>.
 - 8 <https://www.ge.com/steam-power/products/steam-turbines/nuclear-arabelle>.
 - 9 IEA, *The Role of Critical Minerals in Clean Energy Transitions* (IEA, 2021), pp. 45–9, 58, 65–6.
 - 10 マーティン・リンチ著『Mining in World History』(Reaktion Books, 2003年)。これは私がこれまでに会った鉱業の歴史に関する本のなかで間違いなく最高の一冊であり、銅だけでなく、他にも多種多様な鉱物資源について取り上げられている。
 - 11 Andrew Bloodworth, 'A Once and Future Extractive History of Britain', in E. Hunger, T.J. Brown and G. Lucas (eds), *Proceedings of the 17th Extractive Industry Geology Conference* (EIG Conferences, 2014), pp. 1–6.
 - 12 Chris Evans and Olivia Saunders, 'A World of Copper: Globalizing the Industrial Revolution, 1830–70', *Journal of Global History* 10/1 (March 2015).
 - 13 Huw Bowen, 'Copperopolis: Swansea's Heyday, Decline, and Regeneration', lecture, Legatum Institute History of Capitalism Series, 2016.
 - 14 Lynch, *Mining in World History*.

11章

- 1 チュキカマタ鉱山に関する情報の多くは、2022年5月下旬に鉱山を訪れた際に得たものである。特に銅に関するデータについては、アメリカ地質調査所 (USGS) の通常のデータソースを除けば、国際銅研究グループ (International Copper Study Group = ICSG) が最良の情報源といえるだろう。ICSGの年次報告書は、さらなるデータを得るための良い出発点となる。チュキカマタ鉱山とその周辺鉱山の現在および過去の生産量に関する数値を含め、私のデータの多くはICSGから得たものだ。
- 2 Barry Golding and Suzanne D. Golding, *Metals, Energy and Sustainability: The Story of Doctor Copper and King Coal* (Springer, 2017), p. 137ff. This excellent reference book also contains plenty of further material on the history of Chuquicamata.
- 3 チュキカマタ鉱山とその姉妹鉱山の現在および過去の生産量に関する数値は、コデルコ社、コチルコ社 (1980年代までさかのぼる過去の数値) のデータにもとづき、私自身が算出した。累積生産量については、アレハンドロ・ファウネス他による論文「Chuquicamata, Core of a Planetary Scale Cu-Mo Anomaly」(Alejandro Faunes et al.) や T. M. ポーター編「Super Porphyry Copper and Gold Deposits—A Global Perspective」(T.M.Porter, PGC, 2005) を参照した。参考までに、執筆時点では、チ

ユキカマタ鉱山の累積生産量は4500万トン弱だったが、エスコンデューダ鉱山の累積生産量は3000万トン弱だった。これまでに採掘された銅の総量は、アメリカ地質調査所（USGS）のデータにもとづいている。

- 4 Jochen Smuda et al., 'Element Cycling during the Transition from Alkaline to Acidic Environment in an Active Porphyry Copper Tailings Impoundment, Chuquicamata, Chile', *Journal of Geochemical Exploration* 140 (May 2014): pp. 23–40.
- 5 Sandra Cortes et al., 'Urinary Metal Levels in a Chilean Community 31 Years after the Dumping of Mine Tailings', *Journal of Health and Pollution* 6/10 (June 2016): pp. 19–27.
- 6 Paul R. Ehrlich, *The Population Bomb* (Ballantine, 1989).
- 7 Paul Sabin, *The Bet* (Yale University Press, 2013).
- 8 Pierre Desrochers and Christine Hoffbauer, 'The Post War Intellectual Roots of the Population Bomb. Fairfield Osborn's "Our Plundered Planet" and William Vogt's "Road to Survival" in Retrospect', *Electronic Journal of Sustainable Development* 1/3 (2009): p. 26.
- 9 Andrew McAfee, *More from Less: The Surprising Story of How We Learned to Prosper Using Fewer Resources— and What Happens Next* (Simon & Schuster, 2019).
- 10 Julian L. Simon, 'Resources, Population, Environment: An Oversupply of False Bad News', *Science*, 27 June 1980.
- 11 Ira Beaman Joralemon, *Romantic Copper: Its Lure and Lore* (D. Appleton- Century Co., 1934).
- 12 David Cohen, 'Earth's Natural Wealth: An Audit', *New Scientist*, 23 May 2007; Richard A. Kerr, 'The Coming Copper Peak', *Science*, 14 February 2014.
- 13 Manuel Méndez, Damir Galaz-Mandakovic and Manuel Prieto, 'Tele-Production of Miningscapes in the Open-Pit Era: The Case of Low-Grade Copper, Bingham Canyon, US and Chuquicamata, Chile (1903–1923)', *Extractive Industries and Society* 8/4 (1 December 2021).
- 14 T. LeCain, *Mass Destruction: The Men and Giant Mines that Wired America and Scarred the Planet* (Rutgers University Press. 2009).
- 15 Ernesto Che Guevara, *The Motorcycle Diaries*, trans. Che Guevara Studies Center (Penguin, 2021).
- 16 Paul Gait, 'Metals & Mining: Why Isn't the Price of Copper US\$24,000/t (or US\$11/Lb)? An Overview of the Impact of "Moore's Law in Mining"', Bernstein, 2018.
- 17 German Flores and Alex Catalan, 'A Transition from a Large Open Pit into a Novel "Macroblock Variant" Block Caving Geometry at Chuquicamata Mine, Codelco Chile', *Journal of Rock Mechanics and Geotechnical Engineering* 11/3 (June 2019): pp. 549–61; Pablo Paredes, Tomas Leano Chlebnicek and Leopoldo Jauriat, 'Chuquicamata Underground Mine Design: The Simplification of the Ore Handling System of Lift 1', in *Proceedings of the Fourth International Symposium on Block and Sublevel Caving* (Australian Centre for Geomechanics, 2018), pp. 385–98.
- 18 Marian Radetzki, 'Seven Thousand Years in the Service of Humanity—the History of Copper, the Red Metal', *Resources Policy* 34/4 (December 2009).
- 19 Tim Worstall, 'The No Breakfast Fallacy: Why the Club of Rome Was Wrong about Us Running out of Resources', Adam Smith Institute, 2015.
- 20 Resources numbers from USGS. Annual consumption projections from Daniel Yergin et al., 'The Future of Copper', IHS Markit/S&P Global, 2022.
- 21 私の計算はCochilco（チリ銅委員会）のデータにもとづいている。チリの銅生産量（単位：千トン）は、2004年が5,413、2016年が5,533であり、また、銅鉱山の平均粗鉱品位（鉱石中に含まれる鉱物・金属の含有率）は、2004年が1.1パーセント、2016年が0.65パーセントだった。品位に関するデータは、
<https://www.cochilco.cl/Presentaciones%20Inglis/Chilean%20Copper%20Mining%20Co>

sts.pdf.

- 22 Jeff Doebrich, 'Copper – A Metal for the Ages', USGS, 2009.
- 23 Paul Gait, 'Metals & Mining: Copper and the Green Economy—Thoughts from Our Decarbonisation Conference', Bernstein, 2019.

12章

- 1 このセクションには、2018年にジャマイカのキングストンにある国際海底機構 (International Seabed Authority = ISA) を訪れた際の資料が含まれており、マイケル・ロッジ事務総長へのインタビューも含まれている。また、2018年にはチューリッヒを訪れ、2000年にロストシティを発見した科学者、グレッチェン・フルーグリーン氏にインタビューを行なった。プロジェクト・ウルトラに関する資料の多くは、2022年7月にブラム・マートン氏に行なったインタビューにもとづいている。
- 2 Cobalt: <http://pubs.usgs.gov/periodicals/mcs2022/mcs2022-cobalt.pdf>; nickel: <https://pubs.usgs.gov/periodicals/mcs2022/mcs2022-nickel>.
- 3 S. Petersen et al., 'News from the Seabed—Geological Characteristics and Resource Potential of Deep-Sea Mineral Resources', *Marine Policy* 70 (August 2016).
- 4 M. Hannington et al., 'The Abundance of Seafloor Massive Sulfide Deposits', *Geology* 39/12 (1 December 2011).

第五部 石油

13章

- 1 Thomas C. Barger, *Out in the Blue: Letters from Arabia 1937–1940* (Selwa Pr, 2000).
- 2 Daniel Yergin, *The Prize: The Epic Quest for Oil, Money & Power* (Simon & Schuster, 2012).
この章の大部分、とりわけ石油産業の歴史に関する箇所は、この素晴らしい著作に負うところが大きい。
- 3 Richard Rhodes, *Energy: A Human History* (Simon & Schuster, 2018).
- 4 Vaclav Smil, *Oil: A Beginner's Guide* (Oneworld, 2017).
- 5 <https://explorer.aapg.org/story/articleid/2185/elephant-hid-in-desert>.
- 6 Smil, *Oil*.
- 7 'BP Statistical Review of World Energy 2022', 2022, <https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html>.
- 8 E.A. Wrigley, *Energy and the English Industrial Revolution* (Cambridge University Press, 2010).
- 9 IEA World Energy Balances, accessed July 2022.
- 10 Maya Foa, 'Joe Biden Needs Saudi Oil But Must Not Ignore Its Human Rights Record', *Financial Times*, 13 July 2022.
- 11 Daniel Yergin, *The New Map: Energy, Climate, and the Clash of Nations* (Penguin, 2020); Gregory Zuckerman, *The Frackers: The Outrageous Inside Story of the New Energy Revolution* (Penguin, 2013).
- 12 'The father of fracking', *The Economist*, 3 August 2013, <https://www.economist.com/business/2013/08/03/the-father-of-fracking>.
- 13 'Biden Interrupted by Macron at G7, Told Saudis Are Near Oil Capacity Limit', *Newsweek*, 28 June 2022, <https://www.newsweek.com/biden-interrupted-macron-g7-told-saudis-oil-capacity-limit-1719747>.
- 14 John Tierney, 'Economic Optimism – Yes, I'll Take That Bet', *New York Times*, 28 December 2010, <https://www.nytimes.com/2010/12/28/science/28tierney.html>.

14章

- 1 本章の大部分、とりわけ石油精製のプロセスを解説しているところは、ウィリアム・レフラーによる比類なき名著『Petroleum Refining in Nontechnical Language』(PennWell、2020年)に大きく依拠している。
- 2 Anthony N. Stranges, 'The Conversion of Coal to Petroleum: Its German Roots', *Fuel Processing Technology* 16/3 (June 1987).
- 3 Rob West, 'Oil and War – Ten Conclusions from WWII', Thunder Said Energy, 3 March 2022, <https://thundersaidenergy.com/2022/03/03/oil-and-war-ten-conclusions-from-wwii/>; also Yergin, *The Prize*.
- 4 Yergin, *The Prize*; Anthony Stranges, 'Germany's Synthetic Fuel Industry, 1927–1945', in J.E. Lesch (ed.), *The German Chemical Industry in the Twentieth Century, vol. 18, Chemists and Chemistry*, (Springer, 2000).
- 5 Peter W. Becker, 'The Role of Synthetic Fuel in World War II Germany: Implications for Today?', *Air University Review*, July–August 1981.
- 6 'US Navy Technical Report 87-45–The Wesseling Synthetic Fuel Plant', http://www.fischer-tropsch.org/primary_documents/gvt_reports/USNAVY/usnavy-europe_toc.htm.
- 7 David Edgerton, 'Controlling Resources: Coal, Iron Ore and Oil in the Second World War', in Michael Geyer and Adam Tooze (eds), *The Cambridge History of the Second World War* (Cambridge University Press, 2015), pp. 122–48.
- 8 Rebecca Skloot, 'Houses of Butterflies', *PittMed*, Winter 2001; 'Looney Gas and Lead Poisoning – A Short, Sad History', *Wired*, 5 January 2001, <https://www.wired.com/2013/01/looney-gas-and-lead-poisoning-a-short-sad-history/>; William J. Kovarik, 'The Ethyl Controversy: How the News Media Set the Agenda for a Public Health Controversy over Leaded Gasoline, 1924–1926', thesis, University of Maryland, 1993, <https://drum.lib.umd.edu/handle/1903/16750>.

15章

- 1 Susan Freinkel, *Plastic: A Toxic Love Story* (Mariner, 2011).
- 2 *UN World Population Prospects 2022* (United Nations, 2022), <https://www.un.org/development/desa/pd/content/World-Population-Prospects-2022>; Frank Viviano, 'How the Netherlands Feeds the World', *National Geographic*, September 2017, <https://www.nationalgeographic.com/magazine/article/holland-agriculture-sustainable-farming>.
- 3 <https://www.producebluebook.com/2021/12/13/tomatoes-greenhouse-grown-grows/>.
- 4 William Alexander, 'Indoor Farming Is a “No-Brainer.” Except for the Carbon Footprint', *New York Times*, 21 June 2022, <https://www.nytimes.com/2022/06/21/opinion/environment/climate-change-greenhouses-drought-indoor-farming.html>.
- 5 Vaclav Smil, 'CrossTalk: The Tomato's Energy Footprint', *IEEE Spectrum* 58/3 (March 2021). Updated figures appear in Vaclav Smil, *How the World Really Works: A Scientist's Guide to Our Past, Present and Future* (Penguin, 2022).
- 6 Norton, *Ten Materials*.
- 7 'Polythene Comes of Age', *ICI Magazine*, September 1954.
- 8 E. Raymond Ellis, *Polythene Came from Cheshire* (E.R. Ellis, 2005).
- 9 Claudia Flavell-While, 'Dermot Manning and colleagues at ICI–Plastic Fantastic', *Chemical Engineer*, 1 November 2001, <https://www.thechemicalengineer.com/features/cewctw-dermot-manning-and-colleagues-at-ici-plastic-fantastic/>.
- 10 Norton, *Ten Materials*.
- 11 Freinkel, *Plastic*.
- 12 IEA, *The Future of Petrochemicals* (IEA, 2018).
- 13 Chris DeArmitt, *The Plastics Paradox: Facts for a Brighter Future* (Phantom

- Plastics,2020).
- 14 Jon Gertner, *The Idea Factory: Bell Labs and the Great Age of American Innovation* (Penguin, 2013).
 - 15 Alice A. Horton, ‘Plastic Pollution: When Do We Know Enough?’, *Journal of Hazardous Materials* 422 (January 2022); ‘Microplastics in household dust could promote antibiotic resistance’, *The Economist*, 10 November 2021, <https://www.economist.com/science-and-technology/microplastics-in-household-dust-could-promote-antibiotic-resistance/21806204>.
 - 16 IEA, *World Energy Outlook 2022* (IEA, 2022).

追記

- 1 ‘North Field: Sharing the Weight of the World?’, Thunder Said Energy, 28 July 2022, <https://thundersaidenergy.com/2022/07/28/north-field-sharing-the-weight-of-the-world/>.
- 2 Vaclav Smil, ‘What We Need to Know about the Pace of Decarbonization’, *Substantia* 3/2 (2919), Supplement 1: pp. 13–28.
- 3 Demand projections from Announced Pledges Scenarios in IEA World Economic Outlook 2022 (IEA, 2022), and from BP Energy Outlook 2023 Edition (BP, 2023).

第六部 リチウム

16章

- 1 Seth Fletcher, *Bottled Lightning: Superbatteries, Electric Cars, and the New Lithium Economy* (Hill & Wang, 2011).
- 2 IEA, *Net Zero by 2050 – A Roadmap for the Global Energy Sector* (IEA, 2021).
- 3 <https://www.nobelprize.org/prizes/chemistry/2019/whittingham/facts/>.
- 4 Jarod C. Kelly et al., ‘Energy, Greenhouse Gas, and Water Life Cycle Analysis of Lithium Carbonate and Lithium Hydroxide Monohydrate from Brine and Ore Resources and Their Use in Lithium Ion Battery Cathodes and Lithium Ion Batteries’, *Resources, Conservation and Recycling* 174 (November 2021), <https://doi.org/10.1016/j.resconrec.2021.105762>.
- 5 Jorge S. Gutierrez et al., ‘Climate Change and Lithium Mining Influence Flamingo Abundance in the Lithium Triangle’, *Proceedings of the Royal Society B: Biological Sciences* 289/1970 (9 March 2022).

17章

- 1 Stanford Energy, ‘Sustainable Supply Chain for Batteries | Straubel, Mikolajczak, & Urtel | StorageX Symposium’, 2020, <https://www.youtube.com/watch?v=FQoyFAGELnE>.
- 2 ‘Lithium Ion Battery Gigafactory Assessment’, Benchmark Mineral Intelligence, June 2022.
- 3 IEA, *Role of Critical Minerals*.
- 4 G. James Herrera and Frank Gottron, ‘National Stockpiles: Background and Issues for Congress’, Congressional Research Service ‘In Focus’ report, 15 June 2020; Maiya Clark, ‘Revitalizing the National Defense Stockpile for an Era of Great-Power Competition’, The Heritage Foundation, 4 January 2022.
- 5 Ana Swanson, ‘Biden Invokes Cold War Statute to Boost Critical Mineral Supply’, *New York Times*, 31 March 2022, <https://www.nytimes.com/2022/03/31/business/economy/biden-minerals-defense-production-act.html>; battery costs: <https://about.bnef.com/blog/battery-pack-prices-cited-below-100-kwh-for-the-first-time-in-2020-while-market-average-sits-at-137-kwh/>.

18章

- 1 Neil Munshi, 'Belgium's reckoning with a brutal history in Congo', *Financial Times*, 13 November 2020, <https://www.ft.com/content/a17b87ec-207d-4aa7-a839-8e17153bcf51>.
- 2 USGS, *Mineral Commodity Summaries 2022* (US Geological Survey, 2022).
- 3 John Higginson, *A Working Class in the Making: Belgian Colonial Labor Policy, Private Enterprise, and the African Mineworker, 1907–1951* (University of Wisconsin Press, 1989).
- 4 'Managing impact in Hoboken', Umicore, 17 March 2021, <https://www.umicore.com/en/newsroom/news/managing-impact-in-hoboken/>.
- 5 T.E. Graedel et al., *Recycling Rates of Metals: A Status Report* (United Nations Environment Programme, 2011).
- 6 IEA, *World Energy Outlook 2022*.

結び

- 1 J. Doyne Farmer and François Lafond, 'How Predictable Is Technological Progress?', *Research Policy* 45/3 (1 April 2016): pp. 647–65.
- 2 Data collected by John C. McCallum, <https://jemit.net/index.htm>.
- 3 Azeem Azhar, *Exponential: Order and Chaos in an Age of Accelerating Technology* (Cornerstone Digital, 2021).
- 4 Smil, 'What We Need to Know'.
- 5 UK historical electricity generation data: <https://www.gov.uk/government/statistical-data-sets/historical-electricity-data>.
- 6 Data from the International Energy Agency.
- 7 Mark P. Mills, 'The Hard Math of Minerals', *Issues in Science and Technology*, 27 January 2022, <https://issues.org/environmental-economic-costs-minerals-solar-wind-batteries-mills/copper> data from Gait, 'Copper and the GreenEconomy'; prediction about future copper demand from *The Future of Copper: Will the looming supply gap short-circuit the energy transition?* (IHS Market/S&P Global, 2022).
- 8 Smil, *How the World Really Works*.
- 9 Zoltan Pozsar, 'War and Industrial Policy', Credit Suisse, 24 August 2022.
- 10 Diane Coyle, *GDP: A Brief but Affectionate History* (Princeton University Press, 2015); Pozsar, 'War and Industrial Policy'.
- 11 一般的なパナマックス型のコンテナ船は5,000TEU（コンテナ）強を積載でき、これは重量にしておよそ7万トンに相当する。それに対し、イギリス商船隊全体の総積載量は6万8,000トンであった。
Yuval Noah Harari, 'Lessons from a Year of Covid', (フィナンシャル・タイムズ紙、2021年2月26日)
- 12 Smil, *How the World Really Works*, p.51; Gait, 'Why Isn't the Price of Copper US\$24,000/t'.