Figure S1. Events sequence Tantalum

Event Number	Time	Event description
1	1954	Tantalum Capacitor Invented: Tantalum capacitors were developed in the 1950s, offering advantages in size and stability, leading to their widespread adoption in electronics.
2	Late 1950s	US Buys 6800 Tons of Tantalum for Strategic Reasons: In the 1960s, the U.S. government purchased large amounts of tantalum to ensure a stable supply of this critical metal for military and industrial purposes.
3	1960s	Increasing Use of Tantalum in Consumer Electronics: As consumer electronics became more prevalent, tantalum capacitors were increasingly used due to their small size and reliability, especially in devices like radios, calculators, and later, computers.
4	1961 and 1966	First Instances of Price Spike of Tantalum Due to Increasing Use in Consumer Electronics: The growing demand for tantalum in consumer electronics, caused its price to rise due to the limited supply of the metal.
5	1971	Use of Tantalum Capacitor in HP Calculator: Hewlett-Packard's use of tantalum capacitors in its calculators in the 1970s marked an early example of tantalum's importance in portable consumer electronics.
6	1970s	Increasing Number of Capacitor Plants Were Set Up: To meet the rising demand for tantalum capacitors, numerous capacitor plants were built worldwide during the 1970s and 1980s.
7	1978- 1980	Further Price Spike of Tantalum: Tantalum prices spiked again in the late 1970s and early 1980s as demand from the electronics industry outpaced supply, creating significant market pressure.
8	1980	Large Tantalum Inventories Built Up During the Price Spike Period: Companies stockpiled tantalum during the price spikes of the early 1980s, anticipating continued high demand, but the oversupply eventually led to a price correction.
9	1982	Tin Crash, Reduced Tin Slag as Coltan Source: The "tin crash" in the 1980s led to a reduction in the availability of tin slag, a key source of coltan (tantalum ore). This decrease in supply pushed the market to explore alternative sources of tantalum.
10	1980s	Diffusion into Consumer Electronics Continues Leading to Increased Demand: The increasing use of tantalum capacitors in consumer electronics, driven by mobile phones and personal computers, further fueled the demand for tantalum. However, limited supply continued to put pressure on prices.
11	1980s	Price Spike Move Away from Tantalum: Due to the volatility of tantalum prices, companies started seeking alternatives to tantalum capacitors in the early 1990s. This shift marked the beginning of a trend toward exploring substitute materials for capacitors.
12	1980s	Development of Substitutes: During the 1990s, research into alternative capacitor materials began in earnest. Manufacturers focused on developing cheaper, more stable alternatives to tantalum, such as aluminum and ceramic capacitors.
13	1980s	Exploration of Other Sources: As the price of tantalum continued to fluctuate, companies and governments began to explore new sources of tantalum. This included mining operations in regions like Africa, where coltan deposits were discovered.
14	1995	Trade in Coltan from Congo: The 1990s saw an increase in the trade of coltan from the Democratic Republic of Congo (DRC). This created a new supply chain for tantalum, though it also sparked concerns over conflict mineral trade.
15	1999-2000	Dotcom Bubble: The late 1990s saw the dotcom bubble, with a surge in demand for electronics to support the growth of the internet. This fueled a significant rise in the need for tantalum capacitors, driving up demand and prices.
16	1999	Price Spike in Coltan Due to Dotcom Bubble: The dotcom boom led to a sharp increase in the demand for coltan, causing a price spike. Mobile phone companies, in particular, overestimated consumption growth, leading to overstocking and eventual market instability.
17	2000	In 2000, Mobile Telephone Companies Had Overly Optimistic Consumption Growth Forecasts: As mobile phones became more widespread, companies projected unsustainable growth in demand. This resulted in an overstock of tantalum concentrate, which contributed to a price crash in the early 2000s.
18	1998-2003	War in DRC: The late 1990s and early 2000s saw ongoing conflict in the DRC, with various armed groups fighting over the country's mineral resources, including coltan. This conflict further complicated the already unstable tantalum supply chain.
19	2003	UN Reports MNC Role in Looting: United Nations reports in the early 2000s uncovered the involvement of multinational corporations (MNCs) in the looting of coltan in the DRC. This revelation brought global attention to the ethical concerns surrounding conflict minerals.
20	2006	House of Commons ID Inquiry: In response to growing concerns over conflict minerals, the UK House of Commons launched an inquiry into the sourcing of tantalum and other minerals. The investigation aimed to uncover the role of international trade in perpetuating the conflict in the DRC.
21	2006-2009	Continued Civil Scrutiny of Conflict Minerals: Activists and human rights organizations continued to scrutinize the trade in conflict minerals, demanding greater accountability from corporations. This pressure led to calls for supply chain transparency.
22	2009	Fairphone Social Movement Demands to OEMs Regarding Conflict Minerals: Fairphone, a company focused on ethical sourcing, led a social movement advocating for transparency in the sourcing of conflict minerals. Their goal was to push original equipment manufacturers (OEMs) to avoid sourcing minerals tied to conflict.
23	2010	US Dodd-Frank Act Requires Companies to Avoid Conflict Minerals: The Dodd-Frank Act, passed in 2010, included provisions requiring companies to disclose whether they sourced conflict minerals, including tantalum, from the DRC. This regulation aimed to reduce the funding of armed groups through mineral trade.
24	2011	OECD Guidelines on Conflict Minerals: The Organisation for Economic Co-operation and Development (OECD) introduced guidelines to help companies responsibly source minerals. These guidelines aimed to address the ethical and legal challenges associated with conflict minerals.
25	2013 onwards	Fairphone Movement: The Fairphone movement gained momentum in the 2010s, focusing on promoting ethical and sustainable electronics. Fairphone emphasized fair labor practices and the use of conflict-free minerals in its products.
26	2013	Crowdfunding to Produce a Fairphone: In 2013, Fairphone launched a successful crowdfunding campaign to produce an ethically sourced smartphone. This marked a significant milestone in the ethical electronics movement, demonstrating consumer demand for conflict-free products.
27	2013	Market Launch of Fairphone: In 2013, Fairphone launched its first product, a smartphone designed with ethical sourcing and sustainable production in mind. The launch was seen as a major step toward challenging the status quo of electronics manufacturing.
28	2015	Fairphone Receives an Award on Fastest Growing Tech Startup: In recognition of its innovative approach to sustainable technology, Fairphone received an award as one of the fastest-growing tech startups. This highlighted the increasing importance of ethics and sustainability in the tech industry.
29	2014-2020	EU Regulation Development: In the mid-2010s, the European Union began developing regulations aimed at addressing the issue of conflict minerals. These rules required companies to ensure that their supply chains were free of minerals sourced from conflict zones like the DRC.
30	2021	EU Rules Come into Force: In 2021, the EU's conflict minerals regulation came into force, requiring EU companies to conduct due diligence and ensure that their supply chains for minerals like tantalum were free of conflict and human rights abuses.

Event Number	Year	Description
1	1970	The 1973 oil crisis led governments to invest in alternative energy storage research, including lithium-ion battery development.
2	1973	Exxon researchers discovered lithium intercalation in titanium disulfide, laying the foundation for rechargeable lithium batteries.
3	1976	Sony, Asahi Kasei, and Toshiba intensified lithium-ion R&D, focusing on higher energy density and safer materials.
4	1977	Scientists achieved stable lithium-ion intercalation in graphite, which became the standard anode material for lithium-ion batteries.
5	1980	John Goodenough developed lithium cobalt oxide ($LiCoO_2$) as a cathode, significantly increasing battery performance and stability.
6	1990	Akira Yoshino created the first practical lithium-ion battery prototype using a carbon anode, making it safer for commercial use.
7	1991	Sony introduced the first commercial lithium-ion battery, revolutionizing portable electronics with longer-lasting rechargeable batteries.
8	1992	Panasonic, Asahi Kasei, and Sanyo scaled up lithium-ion battery production for camcorders, driving mass-market adoption.
9	1993	Toshiba and NEC launched lithium-ion batteries for early mobile phones, improving battery life and portability.
10	1994	Sony expanded lithium-ion battery production for use in laptops and digital cameras, cementing its industry dominance.
11	1994	Asahi Kasei and Panasonic improved lithium-ion energy density, leading to widespread adoption across consumer electronics.
12	1996	Cost reductions and improvements by Sony, Toshiba, and Panasonic made lithium-ion batteries the industry standard worldwide.
13	2005	Apple and Dell transitioned to lithium-ion batteries across their devices, significantly increasing global demand.
14	2005	Basel Convention discussions highlighted lithium-ion battery waste as an emerging environmental issue due to rising e-waste.
15	2006	Governments and industry stakeholders initiated early discussions on lithium-ion battery recycling and disposal regulations.
16	2006	Apple, Dell, and Sony issued mass recalls of lithium-ion batteries over fire risks, prompting stricter safety standards.
17	2006	International regulatory bodies introduced new safety testing standards to prevent overheating and explosion risks in batteries.
18	2007	The EU's Renewable Energy Directive (2009/28/EC) encouraged large-scale lithium-ion battery storage for renewable energy.
19	2008	Governments introduced EV subsidies and incentives, significantly increasing demand for lithium-ion battery production.
20	2009	Research expanded into solid-state batteries and lithium-iron-phosphate (LFP) as alternatives to cobalt-heavy lithium-ion batteries.
21	2009	Tesla, Nissan, and BMW announced large-scale EV production plans, further driving lithium-ion battery demand.
22	2010	The European Battery Alliance (EBA) was launched to develop a secure and sustainable lithium-ion battery supply chain.
23	2011	The IEA reported growing demand-supply imbalances in lithium-ion battery materials due to increasing EV adoption.
24	2012	The European Parliament raised concerns about lithium-ion battery disposal, prompting calls for stricter recycling regulations.
25	2013	The EU and U.S. increased funding for R&D on battery recycling technologies to recover lithium, cobalt, and nickel.
26	2014	Amnesty International exposed child labor in cobalt mining in the Democratic Republic of the Congo (DRC), sparking global backlash.
27	2015	Tesla, Samsung, and Apple faced mounting pressure to ensure ethical sourcing of cobalt in their battery supply chains.
28	2016	The OECD introduced due diligence guidelines for responsible sourcing of lithium and cobalt to mitigate human rights violations.
29	2017	The Responsible Cobalt Initiative (RCI) was launched to improve ethical sourcing and traceability in the global cobalt supply chain.
30	2018	The European Commission introduced stricter regulations on lithium and cobalt sourcing under the Raw Materials Initiative.
31	2018	The EU Conflict Minerals Regulation (2017/821) came into effect to address human rights issues in the battery supply chain.
32	2019	The European Green Deal included policies promoting sustainable lithium-ion battery production and responsible raw material sourcing.
33	2019	The EU Battery Regulation (2020) introduced stricter sustainability standards, including carbon footprint limits and recycling mandates.
34	2019	Major battery manufacturers invested in closed-loop recycling systems to recover critical materials from used lithium-ion batteries.
35	2019	The International Energy Agency (IEA) warned about potential lithium and cobalt supply chain disruptions impacting EV production.
36	2020	Advances in battery technology, including solid-state batteries, promised safer, higher-energy-density alternatives to lithium-ion.
37	2020	The EU proposed the Battery Passport initiative to improve traceability and sustainability of materials in the supply chain.
38	2020	The European Raw Materials Alliance (ERMA) was launched to secure the lithium and rare earth supply chains.
39	2020	Second-life EV battery repurposing for grid storage gained momentum, reducing waste and extending battery lifespans.
40	2020	The U.S. launched the National Blueprint for Lithium Batteries to enhance domestic battery supply chains and manufacturing.
41	2020	The European Commission approved funding for next-generation lithium-ion battery research under the Horizon Europe program.
42	2020	The European Battery Innovation IPCEI (Important Project of Common European Interest) launched to accelerate sustainable battery R&D.
43	2022 onwards	Formal efforts towards developing the battery passport framework. This digital passport system tracks lithium and other critical materials in batteries, ensuring transparency and sustainability from raw material extraction to recycling. The framework aligns with the EU Green Deal and Circular Economy goals.
44	2023	Batteries Regulation (Regulation (EU) 2023/1542) was passed in August 2023. The regulation enforces sustainability, carbon footprint tracking, and ethical sourcing of lithium and other materials. It sets mandatory recycled material targets for lithium by 2031.
45	2023 onwards	Following the push for traceability and sustainability, UN 38.3 transport standards were updated in 2023 to include new safety testing and packaging rules for lithium batteries.
46	2023	The US government enforced IRA critical mineral requirements in 2023. To qualify for EV tax credits, at least 40% of lithium in batteries must come from US allies or domestic sources (increasing to 80% by 2027).

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Figure S3. Event sequence cobalt