

Impact case study (REF3)

Institution: University of Cambridge		
Unit of Assessment: UoA14		
Title of case study: <i>Into the Inferno</i> : Netflix film based on University of Cambridge research influences wide audiences and pioneers an innovative approach to science documentary filmmaking		
Period when the underpinning research was undertaken: 2000 to 2016		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Clive Oppenheimer	Professor of Volcanology	Oct 1994 to present
Period when the claimed impact occurred: April 2016 to 31 July 2020		
Is this case study continued from a case study submitted in 2014? N		
<p>1. Summary of the impact (indicative maximum 100 words)</p> <p>Since 2000, Professor Clive Oppenheimer's research has concerned volcanic hazards and processes; the long-range climatic and societal consequences of volcanism; the wider significance of volcanic resources and landscapes in prehistory; and studies of Mount Paektu volcano, in an unprecedented collaboration with geoscientists in the Democratic People's Republic of Korea (DPRK). The 2016 Netflix Original film, <i>Into the Inferno</i>, which he made with Werner Herzog, draws directly on this body of research. The film is available in nearly forty languages and distributed worldwide via Netflix's streaming video on demand platform. The film garnered five award nominations including 'Outstanding Science Documentary' (News and Documentary Emmy awards 2017) and 'Best Documentary Award' (Critic's Choice Documentary Awards, 2016), and its impacts include:</p> <ul style="list-style-type: none"> • Pioneering an innovative approach to science documentaries; • Increasing public understanding of volcanology; • Playing an instrumental role in Netflix's policy for open educational access; • Inspiring a new generation of science communicators. 		
<p>2. Underpinning research (indicative maximum 500 words)</p> <p>Volcanology interfaces with many disciplines beyond geology, including climatology, risk communication, archaeology and history. Much of Oppenheimer's research is situated at these disciplinary interfaces: he has worked with volcano observatories on new technologies for volcano monitoring and hazard assessment; with archaeologists to study procurement and exchange of obsidian in prehistory; and with tree ring specialists to date past eruptions and investigate their climatic impacts. The narrative, casting and locations of <i>Into the Inferno</i> are directly underpinned by Oppenheimer's research, carried out since 2000, as described below.</p> <p>Volcanic hazards and monitoring</p> <p>Oppenheimer's team in Cambridge pioneered the development of compact and low cost instrumentation for spectroscopic measurement of volcanic sulphur dioxide emissions [R1] (and the basis of Oppenheimer's impact case study in REF2014). In 2006, a prototype gas monitor was awarded a US patent (number 7,148,488: "Apparatus for measuring radiation and method of use"; five inventors including Oppenheimer). Scanning spectrometer networks building on this approach have since been installed worldwide on 42 volcanoes across five continents. The scientific and humanitarian significance of such monitoring was made clear during the 2010 eruption of the Javanese volcano, Merapi: in collaboration with Indonesian geohazards agencies the Cambridge team supported gas surveillance and data interpretation during the crisis. The observations suggested a large body of magma was intruding the volcano and provided critical information leading to evacuations of threatened communities. An estimated 10,000 to 20,000 lives were saved by the timely response [R2].</p>		

The large-scale climatic, societal and cultural consequences of volcanism

Oppenheimer's research into the long-range climatic and societal impacts of large volcanic eruptions involves evaluation of multiple lines of evidence (ice core chemistry, historical records, tree-ring chronologies, volcanology). Oppenheimer wrote an influential book on this forensic approach, *Eruptions that shook the world* [R3], which has contributed to more coordinated international efforts to identify large eruptions of the past and understand their climatic and societal effects, e.g., by the international network "Volcanic Impacts on Climate and Society" since 2015. Oppenheimer has researched and written on some of the most significant volcanic eruptions in history and prehistory. These include Iceland's largest eruption since settlement, that of Eldgjá in 939 CE. In [R4], Oppenheimer and colleagues securely date this event for the first time (from ice core and dendrochronological information) enabling a robust evaluation of its climatic and societal consequences in the Northern Hemisphere using tree-ring-based temperature reconstructions and medieval annals and chronicles. They also consider the medieval Icelandic poem *Völuspá* in which a seeress foretells the end of the pagan pantheon. The poem includes description of dramatic eruptive activity and attendant meteorological effects in an allusion to the fiery terminus of the gods, leading Oppenheimer and colleagues to suggest that the poem draws on first-hand experiences of the Eldgjá eruption. They argue further that this retrospection of harrowing volcanic events was intended to stimulate Iceland's Christianisation over the latter half of the tenth century.

The significance of volcanic resources and landscapes in prehistory

In collaboration with archaeologists and geochronologists, Oppenheimer has studied volcanic regions of Ethiopia, Eritrea and Yemen. This work has included a focus on obsidian procurement and exchange, highlighting one aspect of the significance of volcanoes for prehistoric human populations. In [R5], using argon isotopic measurements, Oppenheimer and colleagues establish the first chronology of key eruptive stages of Nabro volcano in Eritrea, spanning the past 400,000 years. The work highlights the entanglements of volcanoes and their eruptions with human paleoecology, suggesting further attention be paid to evaluating the significance of East African volcanic landscapes, eruptions and resources for understanding human behaviour in deep antiquity.

Collaboration in the DPRK

Oppenheimer's involvement in studies of Mount Paektu on the DPRK/China border dates back to 2011 following an invitation received from scientific authorities in Pyongyang. This initiated a sustained and ongoing engagement with colleagues from the State Academy of Sciences, Korean Earthquake Bureau, and universities in Pyongyang, with financial and other support from foundations, NGOs and government agencies in the US, China and UK. This lasting collaboration has been recognised as an example of science diplomacy between the West and DPRK at a time when conventional ties have been severely strained, and has led to the establishment, in 2020, of the Mount Paektu Research Centre. An example of the collaborative research [R6] presents analysis of recordings from the team's unprecedented seismometer deployment in the DPRK (supported by a loan from the UK Natural Environmental Research Council's Geophysical Equipment Facility). The work provides the first constraints on the crustal structure on the DPRK side of Mount Paektu and, indeed, for anywhere in the DPRK.

3. References to the research (indicative maximum of six references)

Research outputs R1, R2, R4, R5 and R6 were subject to standard international journal peer-review. Individual chapters of R3 were reviewed by experts in relevant fields.

R1 Galle, B., **Oppenheimer, C.**, Geyer, A., McGonigle, A.J., Edmonds, M. and Horrocks, L., 2003. A miniaturised ultraviolet spectrometer for remote sensing of SO₂ fluxes: a new tool for volcano surveillance. *Journal of Volcanology and Geothermal Research*, 119, 241–254. DOI: [10.1016/S0377-0273\(02\)00356-6](https://doi.org/10.1016/S0377-0273(02)00356-6)

R2 Surono, Jousset, P., Pallister, J., Boichu, M., Buongiorno, M.F., Budisantoso, A., Costa, F., Andreastuti, S., Prata, F., Schneider, D., Clarisse, L. and Humaida, H., Sumarti, S., Bignami, C., Griswold, J., Carn, S., **Oppenheimer, C.**, Lavigne, F., 2012. The 2010 explosive eruption

of Java's Merapi volcano—a '100-year' event. *Journal of volcanology and geothermal research*, 241, 121–135. DOI: [10.1016/j.jvolgeores.2012.06.018](https://doi.org/10.1016/j.jvolgeores.2012.06.018)

R3 Oppenheimer, C., 2011, *Eruptions that shook the world*, Cambridge University Press, 408 pp. DOI: [10.1017/CBO9780511978012](https://doi.org/10.1017/CBO9780511978012)

R4 Oppenheimer, C., Orchard, A., Stoffel, M., Newfield, T.P., Guillet, S., Corona, C., Sigl, M., Di Cosmo, N., Büntgen, U., 2018, The Eldgjá eruption: timing, long-range impacts and influence on the Christianisation of Iceland, *Climatic Change*, 147, 369–381. DOI: [10.1007/s10584-018-2171-9](https://doi.org/10.1007/s10584-018-2171-9)

R5 Oppenheimer, C., Khalidi, L., Gratuze, B., Iverson, N., Lane, C., Vidal, C., Sahle, Y., Blegen, N., Yohannes, E., Donovan, A., Goitom, B., Hammond, J.O.S., Keall, E., Ogubazghi, G., McIntosh, B., Büntgen, U., 2019. Risk and reward: explosive eruptions and obsidian lithic resource at Nabro volcano (Eritrea). *Quaternary Science Reviews*, 226, DOI: [10.1016/j.quascirev.2019.105995](https://doi.org/10.1016/j.quascirev.2019.105995)

R6 Kyong-Song, R., Hammond, J.O., Chol-Nam, K., Hyok, K., Yong-Gun, Y., Gil-Jong, P., Chong-Song, R., **Oppenheimer, C.**, Liu, K.W., Iacovino, K. and Kum-Ran, R., 2016. Evidence for partial melt in the crust beneath Mt. Paektu (Changbaishan), Democratic People's Republic of Korea and China. *Science advances*, 2(4), p.e1501513. DOI: [10.1126/sciadv.1501513](https://doi.org/10.1126/sciadv.1501513)

Research Funding

- **C. Oppenheimer**, Co-I, Multi-disciplinary monitoring, modelling and forecasting of volcanic hazard, EC 5th Framework Programme, 2001–2004, GBP100,000 to Cambridge. Funder reference: EVG1-CT-2000-00021
- M. Petraglia PI, **C. Oppenheimer** and H. Graf, co-Is: The Toba super-eruption and its impact on human populations and ecosystems, The Leverhulme Trust, 2007–2010, GBP198,392. Funder reference: F08622C.
- P. Jousset, PI, **C. Oppenheimer** and others, co-Is: Mitigate and assess risk from volcanic impact on terrain and human activities (MIAVITA), EC 7th Framework Programme, 2008–2012, EUR127,000 to Cambridge. Funder reference: 211393.
- **C. Oppenheimer**, PI: Mechanisms and implications of the 2011 eruption of Nabro volcano, Eritrea, NERC, 2011–2013, GBP64,958. Funder reference: NE/J012297/1.
- J. Hammond and **C. Oppenheimer**, co-PIs: Volcanological and Geophysical Research on Mt. Paektu, DPRK, The Richard Lounsbery Foundation, 2013–2016, USD215,000.
- **C. Oppenheimer**, PI: Nature and impacts of Middle Pleistocene volcanism in the Ethiopian Rift, The Leverhulme Trust, 2016–2021, GBP165,547. Funder reference: RPG-2016-218

4. Details of the impact (indicative maximum 750 words)

Oppenheimer met and first collaborated with the filmmaker Werner Herzog on Erebus volcano in Antarctica in 2006. Oppenheimer was carrying out field research with the US Antarctic Program and Herzog was filming *Encounters at the End of the World*. The collaboration on *Into the Inferno* came about through a shared vision to take scientific filmmaking in a new direction, inspired by Oppenheimer's book *Eruptions that shook the world*. This would involve making a documentary feature embracing and interweaving both the scientific and cultural understandings of volcanic phenomena. *Into the Inferno* was commissioned as a Netflix Original, and released in 2016 by Netflix (a platform with 195 million paid memberships in over 190 countries) [S1]. It has been translated into 37 languages. Audience data are unavailable for commercial reasons but the 670,000 views of the official trailer on Netflix's YouTube channel give a sense of its reach [S2].

The film premiered at the Toronto International Film Festival, and was also official selection at the Telluride Film Festival, DOC NYC, Rome Film Fest and the Cambridge Film Festival (all in 2016). Oppenheimer gave interviews and participated in Q&As at each venue, including with young filmmakers and high-school students. Oppenheimer introduced further screenings at the International Environmental Film Festival (Tenerife, 2017), Biografilm (Bologna, 2017), the Muestra de Cine de Lanzarote (inside a lava tunnel, 2018) and a public screening organised

by the University of Tübingen (2019). The film has been shown at other festivals, Herzog retrospectives and museums in the USA, Germany, Singapore, Hong Kong, Australia, Greece and Iceland. It received five award nominations including ‘Outstanding Science Documentary’ (News and Documentary Emmy awards 2017), and ‘Best Documentary award (TV/streaming)’ (Critic’s Choice Documentary Awards, 2016) [S3]. The film’s impact can be seen in its influence on diverse audiences. In pioneering an alternative approach to science documentary filmmaking, it has increased public understanding of the entanglements of nature and culture (with its reach extended thanks to Netflix’s policy on open educational access to documentaries) [S4]; and it has stimulated the science communication agenda for filmmakers.



Plate 1. Film crew on location in Vanuatu; scene from the film; screening in a lava tube.

Pioneering an alternative approach to science communication

What makes *Into the Inferno* innovative in science communication is its methodological development of form and content and the equal partnership of experienced filmmaker and geoscientist bringing both authenticity and artistry to the film: it is educational but not didactic; it is neither scripted nor storyboarded; it features conversations, not interviews; it is cinema not reportage. Filmmaker Werner Herzog describes his collaboration with Clive Oppenheimer as leading to a unique form of documentary filmmaking: “*It brings a new energy to films on science and to documentaries in general*” [S5]. International reviews of the film recognised its intention to depart from the conventional form of documentary factual. A reviewer in *Variety* wrote: “*Oppenheimer approaches the subject from a scientific background, determined to correct the tone of “doom and gloom” that so often accompanies nature docs about volcanoes*” [S6]. The *New York Times* review found that “*Despite [its] subject ... “Into the Inferno” is surprisingly buoyant, partly because of Mr. Oppenheimer... The movie was inspired by Mr. Oppenheimer’s 2011 book, “Eruptions That Shook the World” ... The film shares places with the book and narrows in on the impact of assorted eruptions... [Oppenheimer] becomes an emblem for scientific enquiry at its most accessible and exciting. He grounds the movie in science....*” [S6]. An interviewer describes how “*it’s like we’re with you on a journey of discovery as opposed to being on an expedition where you’re teaching us things. There’s a marvellous energy of unfolding in these films*” [S5].

The result of this new approach to scientific documentaries is a deep connection and emotional engagement with viewers. For example, an emergency doctor from the USA wrote: “*Thank you so tremendously much for your remarkable film with Werner Herzog, Into the Inferno. It is spectacularly beautiful, informative, and engaging. However, what prompted me to write to you is how struck I was by your compassion. You were so deliberate to highlight and respect the work of others, a rare and special trait. I hope to emulate it*” [S7].

Increasing public understanding of volcanology and nature/culture entanglements

The intention of the film is not just to explain the science around volcanoes, but also their ‘magic’ – their cultural, social and cosmological significance around the world. Oppenheimer is contacted on a frequent basis by students, school children and members of the public who have watched the film and describe their intention to study further or use their knowledge gained. Students in the US have been shown the film as a component of seminar classes. High-school students from Colorado were invited to a free screening of the film during the Telluride Film Festival (2016). One wrote: “*... I have an interest in geology and archaeology and the film... made me even more excited to study in college. ...I was enthralled by the connections between cultures and volcanoes.*” [S8]. The website Common Sense Media (a leading non-profit organisation providing education and advocacy for parents) identifies the film as ‘highly

recommended' for older children: '*With the extraordinary Clive Oppenheimer as guide, this film is science at its most accessible.*' [S9].

Playing an Instrumental role in Netflix's educational screening policy

The impact of *Into the Inferno* extends beyond its immediate influence on audiences. As a result of Oppenheimer's request to screen the film at conferences (a public screening, during the 2017 Scientific Assembly of the International Association of Volcanology and Chemistry of the Earth's Interior in Portland, Oregon), it played an instrumental role in initiating Netflix's policy for open educational access to documentaries [S4]. This policy, which came into effect shortly after the release of the film, now grants permission for free screenings of films marked as educational documentaries in the classroom, community groups, book clubs, etc. [S10]. *Into the Inferno* is part of a group of films (including Oscar-winning films and shorts on topics as diverse as slavery, the prison system, the war in Syria, poaching, trafficking and sexual assault) granted this status by Netflix as they "speak to our users in a meaningful way" [S10;S11]. This not only recognises Netflix's view of the value of the film and its increasing educational influence, it highlights the ongoing impact of *Into the Inferno* in opening educational access to this important body of work.

Inspiring a new generation of science communicators

In 'Better Science through Storytelling', an article in the International Documentary Association magazine, the organisers of the CPH conference (an industry-facing workshop in Copenhagen) explained their choice of high-profile speakers and the invitation of Clive Oppenheimer: "*In particular, we wanted to spotlight the more artistic and humanistic approaches to science storytelling*" [S12]. This approach has inspired the next generation of science communicators. A PhD student from Indonesia explains:

"I am originally from Indonesia, from Bogor – the city at the foot of Mt. Gede-Pangrango ... The movie shows me (and the world) how fascinating the volcanoes around the world are. Also, thank you very much for showing Sinabung and Merapi, and the stories around them, to the world. Your work has inspired me to involve in science communication because it's one of the ways to make people or general public to be aware of volcanic hazard. I visited some volcanoes in Indonesia and it's always amaze me how people who lives near volcanoes interact with them, in every different way at each volcano." [S7].

A UK Geosciences student describes: "*During the third year on my undergraduate degree and whilst reading for a Masters degree in Geophysical Hazards I discovered your book Eruptions that Shook the World and watched Into the Inferno. Since discovering your work I have been inspired to push and challenge myself, the science of volcanology and most importantly devise effective ways to communicate the science*". [S7].

5. Sources to corroborate the impact (indicative maximum of 10 references)

[S1] Netflix [subscriptions](#) and [geographical spread](#).

[S2] [Official trailer](#) for *Into the Inferno* on the Netflix YouTube channel. It has been viewed over 670,000 times.

[S3] Award nominations for *Into the Inferno*: [Emmy Outstanding Science Documentary Award](#) and [Critics Choice Documentary Award](#).

[S4] Confirmation of role of *Into the Inferno* in educational screening policy

[S5] Transcript of interview with Werner Herzog and Clive Oppenheimer, 2020, moderated by Julia Steele. See pages 6 and 7 of PDF.

[S6] Compiled film reviews of *Into the Inferno*. See pages 25 and 27 of PDF for quotations.

[S7] Compilation of unsolicited emails received by Professor Oppenheimer in relation to the film

[S8] Unsolicited letter from high-school students from Colorado (received September 15th 2016) who attended a free screening of *Into the Inferno* during the Telluride Film Festival that month

[S9] [Common Sense Media](#) review of *Into the Inferno*.

[S10] Netflix '[Grant of Permission for Educational Screenings](#)'

[S11] [Newspaper article](#) describing Netflix's educational public access policy

[S12] [International Documentary Association article](#) describing the CPH Annual Conference