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## **The Dark Geo-Cultural Heritage of Volcanoes: Combining Cultural and Geoheritage Perspectives for Mutual Benefit**

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### **Abstract**

It is now widely accepted that vulnerability is in part culturally and historically contingent. Similarly, geoheritage cannot be readily disentangled from cultural values and cultural heritage given that the assignment of value to a given geosite is conducted in the present and that many if not most geosites are also sites of culture-historical significance. Vice versa, most tangible cultural heritage also contains elements of geoheritage. To bridge these perspectives, we propose the notion of geo-cultural heritage; we argue that the viewpoints of geoheritage and of cultural heritage – here especially of dark heritage – can be brought together for mutual benefit. We begin by demonstrating through a bibliometric analysis that the two fields never were fully connected and that they remain disjointed. We highlight at the same time that cultural heritage generally leverages more public attention while the natural sciences arguably command greater attention with policy-makers. We then illustrate how geoheritage and dark cultural heritage can be brought together through four case studies of past volcanism and their complex human impacts. In concluding, we encourage heritage workers to be more fully interdisciplinary, to read more widely outside their own fields, and to disseminate their research more broadly for mutual benefits of preservation, risk reduction and valorisation.

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2  
3 **Keywords**

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5 geoheritage; cultural heritage; dark heritage; geotourism; dark tourism; social volcanology  
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8 **Introduction**  
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11 Geoheritage focuses on the diversity of minerals, rocks and fossils, as well as geomorphological features that  
12 illustrate the effects of present and past climate and environmental change (McBriar, 1995). The attribution of  
13 value to these geological features is based on the argument that they both constitute resources for science,  
14 education and tourism, and that they provide a sense of place tied to historical, cultural, aesthetic and religious  
15 values (Brocx and Semeniuk, 2007; Brocx, 2007). Related concepts such as geoconservation and geotourism  
16 extend the scope to the preservation of specific landforms (Wyatt and Moss, 1990; Blandin, 1992; Gibson *et al.*,  
17 1994; Withers and Horwitz, 1996) and the enhancement and use of a given geosite in touristic marketing  
18 (Stueve *et al.*, 2002). Importantly, geotourism also aims to raise awareness of the importance of geoheritage –  
19 officially recognised or not – and the dissemination of earth science knowledge (Dávid, 2004). A geotourist, it is  
20 argued, travels to gain increased awareness and knowledge of a given geosite or landform, learning about their  
21 natural characteristics and relations to human history, commerce, arts or crafts (Stueve *et al.*, 2002).  
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35 What should be evident from this brief sketch of geoheritage and related disciplinary fields is that they cannot  
36 readily be disconnected from cultural heritage because (a) the framing and valorisation of a given geosite is  
37 conducted within a specific contemporary cultural setting, and (b) the bulk of all recognised geosites directly  
38 relate to aspects of cultural heritage – even a cursory view at key publications such as the journal *Geoheritage*  
39 will illustrate as much. In this paper, we attempt to build bridges between the fields of geoheritage and cultural  
40 heritage. We see this as a pressing matter not just because both areas stand to make significant intellectual and  
41 practical gains from greater integration, but because thinking geological and cultural heritage together – we here  
42 propose the term geo-cultural heritage – articulates particularly well with research on natural hazards and risk  
43 reduction. It has long been pointed out that the impact of natural hazards are not in any straightforward nor  
44 natural, but emerge in the interaction of a given hazard with at-risk communities (O’Keefe *et al.*, 1976). Indeed,  
45 it is now widely accepted that vulnerability emerges within the context of a community’s history (García-  
46 Acosta, 2002; Bankoff, 2004), and that risk perception is largely culturally contingent. Hence, risk reduction  
47 also must be culturally sensitive (Mercer *et al.*, 2012). By this token, the emerging field of geoethics also  
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1 becomes relevant here as it is concerned with reflections on the values, appropriate behaviours and practices  
2 where human activities intersect the geosphere (IAPG, 2012; Peppoloni and Di Capua, 2012).  
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6 Our focus here is on volcanism and its coupled geological and cultural heritage (Németh *et al.*, 2017).  
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8 Approaches that tackle contemporary volcanism and its impact on human communities in culturally embedded  
9 ways has been termed ‘social volcanology’ (Donovan, 2010). Past volcanism has repeatedly affected human  
10 communities; the historical and archaeological remains of these interactions – the geological and cultural  
11 heritage – furnish the basis for a ‘paleo-social volcanology’ (Riede, 2018) that deploys such culturally specific  
12 and often highly valued heritage components in risk communication, education and debate (cf. Parkash, 2012;  
13 Neuberg, 2014; De Lucia, 2014; Riede *et al.*, 2016).  
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22 Volcanoes have provided human societies with a great number of benefits in terms of ready building materials  
23 and geothermal energy (Arnórsson *et al.*, 2015; Dehn and McNutt, 2015) as well as through soil improvement  
24 (Ugolini and Zasoski, 1979; James *et al.*, 2000; Delmelle *et al.*, 2015). Yet, volcanoes are also firmly associated  
25 with the awesome spectacles of their eruptions and the usually detrimental impacts these have on human  
26 communities. The trope of the destructive volcano is particularly strong in *popular* imagination (Pomeroy, 2008;  
27 Kozák and Cermák, 2010; Pyle, 2017). The study of such calamities and their tangible and intangible legacies  
28 has been termed ‘dark heritage’, and its use in tourism ‘dark tourism’ (Hooper and Lennon, 2017). While dark  
29 heritage and dark tourism focus on those aspects of history which are problematic, unwanted or unsavoury –  
30 classic examples of such sites are political prisons such as Alcatraz, Robben Island (Strange and Kempa, 2003)  
31 or Long Kesh (McAtackney, 2013), concentration camps and other war sites (Thomas *et al.*, 2016) or gruesome  
32 murders (Foley and Lennon, 1996) – they inadvertently exert a substantial pull on visitors (Kulcsar and Simon,  
33 2015). Importantly, cultural heritage practitioners have long since demonstrated that natural and cultural  
34 heritage are inseparable (e.g. Lowenthal, 2005) and that the valorisation of any given heritage feature is dynamic  
35 and often contested.  
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52 Cognisant of the significant entanglements of natural/geological and cultural heritage, we here propose the  
53 notion of geo-cultural heritage. We argue that the viewpoints of geoheritage and of cultural heritage – here  
54 especially of dark heritage – can be brought together for mutual benefit. Initial attempts of bringing these  
55 perspectives together have emerged in the literature (Erfurt-Cooper *et al.*, 2015), but we demonstrate through a  
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1 bibliometric analysis that the two fields remain largely disjointed. At the same time, we highlight the maturity of  
2 cultural heritage research and the pattern evident in site visitors that cultural rather than geological heritage  
3 generally leverages more public attention while acknowledging that the natural sciences command more policy-  
4 maker attention. We illustrate how geoheritage and dark cultural heritage can be brought together through four  
5 case studies of past volcanism and their complex human entanglements. In concluding, we encourage heritage  
6 workers to be more fully interdisciplinary, to read more widely outside their own fields, and to disseminate their  
7 research more broadly for mutual benefits of preservation, risk reduction and valorisation.  
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## 17 **Materials and Methods**

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19 In order to assess the current relations between the disciplinary fields of geoheritage, cultural heritage,  
20 geoconservation, geotourism, geoethics, dark tourism, and dark heritage, we have systematically collected key  
21 texts and interrogated their citation relations as a way of understanding whether and to what degree they overlap  
22 and interact. We subject these texts to a bibliometric citation analysis and visualise the results using network  
23 algorithms. In this way, we track patterns of knowledge production, use and the development of these  
24 disciplines in an evidence-based fashion (Hull, 1988; Hoffmann and Doucette, 2012). Previously, citation  
25 analysis has been used as a method of assessing research impact of individual publications (Nicolaisen, 2007;  
26 Sarli *et al.*, 2010); for gauging the extent of a given publication's influence on the literature; for tracking the  
27 advancement of knowledge with the inherent assumption that significant publications will demonstrate a high  
28 citation count (Wade, 1975; Lawani, 1977; Kostoff, 1998); to detect scientific collaboration; and to map  
29 knowledge transfer across domains (Ding *et al.*, 2014).  
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42 Citation analysis is an integral component of journal ranking criteria, and is best known as a tool to assess the  
43 impact of individual researchers and their institutions (Nightingale and Marshall, 2013). It has been shown that  
44 higher citation rates are due to articles (1) being written in English; (2) addressing generalist areas rather than  
45 specific disciplines; (3) providing reviews rather than original research; (4) representing cutting-edge research;  
46 (5) being longer rather than shorter; (6) addressing established rather than emerging disciplines; (7) appearing in  
47 ISI-indexed journals (Seglen, 1997); (8) pertaining to methodology; and lastly (9) by being jointly authored by  
48 international teams (Whitehouse, 2001). To measure an individual researcher's impact the h-index is used. This  
49 index calculates the highest number of articles published by the author that have the equivalent number of  
50 citations or above (Nightingale and Marshall, 2013). An h-index of three, for instance, shows that the author has  
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1 published three articles with a minimum of three citations each. This arguably enables citation performance and  
2 productivity to be compared and reduces the influence of few but highly cited articles (Nightingale and  
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4 Marshall, 2013).  
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9 To investigate citations in the seven disciplinary fields in focus here, we initially employed the *Publish or*  
10 *Perish* software (Harzing, 2007). The program was developed to mine academic citations from a variety of  
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12 online databases on the basis of the parameters chosen by the analyst, and to then provide the following metrics:  
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- 16 • total number of papers and total number of citations
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- 18 • average citations per paper, citations per author, papers per author, and citations per year
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- 20 • number of authors per paper
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- 22 • h-index
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- 24 • g-index
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- 26 • contemporary h-index
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29 The g-index aims to improve on the h-index by giving more weight to highly cited articles (Egghe, 2006), whilst  
30 the contemporary h-index aims to improve the original h-index by giving weight to more recent articles, thus  
31 rewarding academics who maintain a steady level of activity (Sidiropoulos *et al.*, 2006). Note that due to the  
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33 limitations inherent in the program, publications not written in English were excluded. Secondly, publications  
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35 with no citations were also excluded – these are, at any rate, unlikely to have had a lasting impact on the  
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37 disciplines in focus here.  
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45 Originally, citation data were harvested from three separate sources – Google Scholar<sup>®</sup>, Microsoft Academic<sup>®</sup>  
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47 and CrossRef<sup>®</sup> – but results were identical; subsequently, only Google Scholar<sup>®</sup> was used. Data in the following  
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49 categories were recorded: a general search for all published material within the seven disciplinary fields; the  
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51 total years of active publishing in each disciplinary field; the ten most highly cited papers in each disciplinary  
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53 field; the ten most prolific authors based on the number of publications; the ten most common journal  
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55 destinations where research in the seven disciplinary fields has been published; forward citation journal  
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57 destinations for the ten most highly cited papers and lastly; author overlap between disciplinary fields. Once  
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59 tabulated, patterns in these data are visualised using network analysis. Networks are efficient and elegant means  
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of visualising relations among the nodes – here individual papers, journals and disciplinary fields – and are regularly used to interrogate the historical developments of scientific research fields (Fanelli and Glänzel, 2013; Chappin and Ligtoet, 2014; Radev *et al.*, 2015). Several software solutions are available (for instance, <http://www.vosviewer.com/> or Sci2 - see Lewis and Alpi, 2017). Here, we employ the open-source *gephi* suite (<https://gephi.org/> - see Bastian *et al.*, 2009).

## Results

Table 1 summarizes the bibliometric findings of this citation analytical exercise. Several striking differences are extant between the disciplinary fields investigated. First, research within the domain of cultural heritage has been conducted the longest. This has unsurprisingly resulted in the highest total number of citations, although, interestingly, not in the highest total number of papers published overall. The definition of a specific geological heritage field and its derivatives geoconservation and geotourism occurred much later. At the same time, it appears that citation rates – both annually and annually by author – are considerably higher in the geological branch of the heritage domain indicating a rapid development and a high publication rate.

**Table 1** Summary of the citation analysis exercise for cultural heritage, dark heritage, dark tourism, geoheritage, geotourism, geoconservation, and geoethics. The overarching disciplinary fields of cultural and geological heritage are shaded in grey, but note that the term geotourism actually appears in the literature prior to the appearance of the term geoheritage.

Disciplinary field	N papers	N citations	Publication span	Citations/paper	Citations/author	Papers/author	Authors/paper	h-index	g-index
Cultural heritage	287	28552	1958-2016	99.48	18929.82	195.39	2.02	92	146
Dark heritage	83	5450	1981-2017	65.66	3719.99	62.5	1.58	20	73
Dark tourism	531	13039	1995-2018	24.56	9836.72	419.92	1.53	52	102
Geoheritage	385	2731	1993-2018	7.09	1591.27	214.32	2.53	23	37
Geoconservation	283	3957	1993-2017	13.98	3097.47	195.87	2.07	26	55
Geotourism	599	5946	1986-2018	9.93	3992.08	382.79	2.15	34	59
Geoethics	115	659	1996-2018	5.73	400.26	76.84	2.03	13	19

1 The ten most productive authors per field (Table 2) prove interesting, as the results do not directly correspond to  
 2 the most impactful paper as listed in Table 3. As is evident, several authors appear multiple times with different  
 3 highly-cited papers and some authors feature in multiple disciplinary field lists, albeit not across the divide  
 4 between cultural and geological heritage domains. This overlap between author productivity rankings and the  
 5 rankings of impactful publications hints at there being generally substantial overlap *within* the cultural and  
 6 geological heritage domains, but little to no overlap *between* them.  
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15 **Table 2** Summary of the ten most prolific authors based on the number of publications that have received  
 16 citations for cultural heritage, dark heritage, dark tourism, geoheritage, geoconservation, geotourism and  
 17 geoethics. N<sub>papers</sub> includes first- or sole-author publications as well as co-authored ones.  
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Disciplinary field	Author	N <sub>papers</sub>
Cultural heritage	Remondino F.	168
	Lourenco P.B.	113
	Bagilioni P.	101
	Hyvonen E.	90
	Timothy D.J.	87
	Sabbioni C.	76
	Ikeuchi K.	72
	Guidi G.	70
	Jokilehto J.	55
	Prott L.V.	53
Dark heritage	Biran A.	7
	McAttackney L.	6
	Poria Y.	5

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	Carr G.	3
	Hartmann R.	3
Dark tourism	Stone P.	56
	Korstanje M.	52
	Sharpley R.	33
	Foley M.	27
	Lennon J.J.	25
	Isaac R.	20
	Boyd S.	15
	Timothy D.J.	13
	Ashworth G.	13
	Dann G.	13
Geoheritage	Brilhá J.	40
	Reynard E.	33
	Semeniuk V.	32
	Komoo I.	28
	Németh K.	23
	Pelfini M.	23
	Hose T.A.	23
	Dowling R.K.	22
	Brocx M.	21
	Migon P.	20
Geoconservation	Brilhá J.	61
	Sharples C.	38
	Pereira D.	34
	Henriques M.	30
	Ruban D.A.	27
	Hose T.A.	26
	Alexandrowicz Z.	22
	Markovic S.	21

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	Burek C.	20
	Gordon J.E.	19
Geotourism	Hose T.A.	46
	Dowling R.K.	42
	Newsome D.	40
	Reynard E.	32
	Brilhá J.	32
	Ruban D.A.	25
	Vasiljevic D.	21
	Coratza P.	21
	Rodrigues J.	21
	Slomka T.	21
Geoethics	Peppoloni S.	30
	Di Capua G.	18
	Solarino S.	8
	Vasconcelos C.	7
	De Pascale F.	7
	Martínez-Frías J.	7
	Muto F.	6
	Bernardo M.	6
	Vasconcelos I.	5
	Torres J.	5

**Table 3** Summary of the ten most impactful publications based on the number of citations for cultural heritage, dark heritage, dark tourism, geoheritage, geoconservation, geotourism and geoethics.

<b>Disciplinary field</b>	<b>Author and Year</b>	<b>N<sub>citations</sub></b>
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1	Cultural heritage	Mckercher B. and Du Cros H. (2002) - Book	1439
2			
3		McIntosh A.J. and Prentice R.C. (1999) – <i>Annals of Tourism Research</i>	588
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6		Camuffo D. (2013) - Book	465
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9		Feilden B.M. and Jokilehto J. (1993) - Book	443
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12		Smith L. (2004) - Book	424
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15		Navrud S. and Ready R.C. (2002) - Book	410
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18		Sansoni G. et al. (2009) - Book	335
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21		Timothy D.J. (2011) - Book	318
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24		De la Torre M. and Thorsby D. (2002) - Book	307
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27		Kurin R. (2004) – <i>Museum International</i>	298
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30	Dark heritage	Biran A. et al. (2011) – <i>Annals of Tourism Research</i>	250
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32		Dann G.M.S. and Seaton A.V. (2001) – <i>Int. J. of Hospitality and Tourism</i>	239
33			
34		<i>Administration</i>	
35			
36		Hartmann R. (2014) – <i>Journal of Heritage Tourism</i>	80
37			
38		Seaton A.V. (2001) – <i>Int. J. of Hospitality and Tourism Administration</i>	43
39			
40		Graham B. and McDowell S. (2007) – <i>Cultural Geographies</i>	32
41			
42		McAttackney L. (2014) - Book	32
43			
44		O’Ballance E. (1981) - Book	31
45			
46		Van der Merwe C.D. (2014) – <i>Bulletin of Geography: Socio-economic Series</i>	16
47			
48		Frew E.A. (2012) – <i>International Journal of Heritage Studies</i>	15
49			
50		Henderson J.C. (2007) – <i>Journal of Heritage Tourism</i>	14
51			
52	Dark tourism	Lennon J.J. and Foley M. (2000) - Book	1103
53			
54		Stone P. and Sharpley R. (2008) – <i>Annals of Tourism Research</i>	554
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56		Stone P. (2006) - <i>Turizam</i>	549
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59		Seaton A.V. (1996) – <i>International Journal of Heritage Studies</i>	519
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	Strange C. and Kempa M. (2003) – <i>Annals of Tourism Research</i>	366
	Seaton A.V. (1999) – <i>Annals of Tourism Research</i>	337
	Sharpley R. and Stone P. (2009) - Book	320
	Foley M. and Lennon J.J. (1996) – <i>International Journal of Heritage Studies</i>	308
	Miles W.F.S. (2002) – <i>Annals of Tourism Research</i>	287
	Dann G.M.S. and Seaton A.V. (2001) – <i>Int. J. of Hospitality and Tourism Administration</i>	239
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Geoheritage	Reynard E. (2008) – <i>Geogr. Fis. Dinam. Quat.</i>	85
	dos Reis R.P. and Henriques M.H. (2009) - <i>Geoheritage</i>	81
	Panizza M. (2009) - <i>Geoheritage</i>	80
	Brocx M. and Semeniuk V. (2007) – <i>Journal of the Royal Society of Western Australia</i>	79
	de Lima F.F. et al. (2010) - <i>Geoheritage</i>	65
	Fassoulas C. et al. (2012) - <i>Geoheritage</i>	62
	Carcavilla L. et al. (2009) - <i>Geoheritage</i>	61
	Zhao T. and Zhao X. (2009) – <i>Acta Geoscientica Sinica</i>	57
	Wimbledon W.A.P. and Smith-Meyer S. (2012) - Book	56
	Gordon J.E. (2012) - <i>Geoheritage</i>	53
Geoconservation	Gray M. (2004) - Book	921
	Sharples C. (2002) – <i>Tasmanian Parks and Wildlife Service</i>	192
	Henriques M.H. et al. (2011) - <i>Geoheritage</i>	126
	Brilhá J. (2002) – <i>Environmental Conservation</i>	104
	Burek C.V. and Prosser C.D. (2008) - Book	92
	Sharples C. (1993) - Book	90
	Prosser C.D. et al. (2011) - Book	88
	Gray M. (2005) - <i>The George Wright Forum</i>	81
	Brocx M. and Semeniuk V. (2007) – <i>Journal of the Royal Society of Western Australia</i>	79
	Sharples C. (1995) - <i>Tasforests</i>	78
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Geotourism	Dowling R.K. and Newsome D. (2006) - Book	251

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	Hose T.A. (2006) - <i>Geotourism</i>	221
	Dowling R.K. (2011) - <i>Geoheritage</i>	180
	Newsome D. and Dowling R.K. - Book	166
	Zouros N. and McKeever P. (2004) - <i>Episodes</i>	162
	Farsani N.T. et al. (2011) – <i>International Journal of Tourism Research</i>	141
	Buckley R. (2003) – <i>Journal of Ecotourism</i>	125
	Hose T.A. (2008) – <i>Geological Society Special Publications</i>	118
	Dowling R.K. and Newsome D. (2010) - Book	117
	Dowling R.K. (2014) - Book	113
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Geoethics	Peppoloni S. and Di Capua G. (2012a) – <i>Annals of Geophysics</i>	37
	Cutchin M.P. (2002) – <i>Progress in Human Geography</i>	37
	Stoddard E.W. and Cornwell G.H. (2003) – <i>Liberal Education</i>	36
	Peppoloni S. and Di Capua G. (2015) - Book	27
	Martínez-Frías J. et al. (2011) - <i>Episodes</i>	24
	Cornwell G.H. and Stoddard E.W. (2006) – <i>Liberal Education</i>	24
	Matteucci R. et al. (2014) - <i>Episodes</i>	22
	Matteucci R. et al. (2012) – <i>Annals of Geophysics</i>	20
	Wyss M. and Peppoloni S. (2014) - Book	19
	Peppoloni S. and Di Capua G. (2012b) – <i>Annals of Geophysics</i>	16

It is noteworthy that the number of citations dramatically decreases past the first one or two top citations within most disciplinary fields. There is also a variance in the publication method: whilst the majority are within established journals – which, however, do not necessarily have a high impact factor and many may have limited accessibility – many key texts also are found within edited volumes or in monograph format. There is a general difference between the natural science and social sciences/humanities in terms of publication in journal vs book formats. This may at least partially explain the different speeds of publication within the fields examined here. Journal publication offers a more rapid turn-over as well as a much higher volume of individual publication in relation to the total amount of text produced.

Exploring the structure of the citation network between authors and research field (Fig. 1) visualises the lack of connectivity between geoheritage and cultural heritage. As expected, geoheritage, geotourism and geoconservation are greatly interconnected, and loosely connect with geoethics. Despite dark heritage being established longer, dark tourism has more published papers and citations, hence the larger circle. Only M. Shackley connects dark tourism and cultural heritage, having published one paper linking the two (Shackley, 2001).

**Fig. 1** Citation network of authors publishing in the seven disciplinary fields investigated. The green circles represent the different research fields where the size of the circle represents frequency of publications in the field. CH = cultural heritage, DH = dark heritage, GT = geotourism, GH = geoheritage, GC = geoconservation, DT = dark tourism, GE = geoethics. Red circles are individual authors' publications with citations.

Although there appears to be little overlap between authors across the cultural and geological heritage divide, there is substantially more contact when considering the destination journals chosen by these authors (Table 4). The network between destination journals and disciplinary field paints a more complex picture (Fig. 2). Again, we see similar closeness of geotourism, geoheritage, geoconservation and geoethics when compared to dark tourism and dark heritage. Yet, a handful of journals offer the opportunity of cross-linkage: The *Tourism Management* journal, *Journal of Heritage Studies* and the *International Journal of Heritage Studies* link cultural heritage to dark heritage and dark tourism, whilst the *Journal of Tourism Studies* and *Landscape Research* connects cultural heritage to geotourism. Interestingly, the *International Journal of Tourism Research* links cultural heritage with dark tourism, geotourism and geoethics.

**Table 4** Summary of the ten most favoured journal destinations based on the number of papers for cultural heritage, dark heritage, dark tourism, geoheritage, geotourism, geoconservation and geoethics.

Disciplinary field	Journal	N <sub>papers</sub> with forward citations
Cultural heritage	<i>Journal of Cultural Heritage</i>	130
	<i>International Journal of Heritage Studies</i>	96

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	<i>International Journal of Cultural Property</i>	61
	<i>Museum International</i>	51
	<i>Journal of Heritage Tourism</i>	26
	<i>Conservation and Management of Archaeological Sites</i>	21
	<i>Journal of Cultural Heritage Management and Sustainable Development</i>	20
	<i>Tourism Management</i>	16
	<i>City, Culture and Society</i>	7
	<i>Annals of Tourism Research</i>	6
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Dark heritage	<i>International Journal of Heritage Studies</i>	12
	<i>Journal of Heritage Studies</i>	12
	<i>Journal of Heritage Tourism</i>	10
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Dark tourism	<i>Annals of Tourism Research</i>	61
	<i>Tourism Management</i>	49
	<i>Issues in Tourism</i>	35
	<i>Journal of Heritage Tourism</i>	35
	<i>Current Issues in Tourism</i>	33
	<i>Journal of Tourism and Cultural Change</i>	31
	<i>Tourist Studies</i>	24
	<i>International Journal of Heritage Studies</i>	23
	<i>International Journal of Tourism Research</i>	21
	<i>Tourism Recreation Research</i>	18
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Geoheritage	<i>Geoheritage</i>	307
	<i>Acta Geologica</i>	32
	<i>Quaternary International</i>	24
	<i>Geojournal of Tourism and Geosites</i>	21
	<i>Sustainability</i>	14
	<i>International Journal of Geoheritage</i>	5
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Geoconservation	<i>Geoheritage</i>	177
	<i>Proceedings of the Geologists' Association</i>	55
	<i>Quaternary International</i>	26
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1	Geotourism	<i>Geoheritage</i>	204
2		<i>Geotourism</i>	167
3		<i>Geological Society</i>	120
4		<i>Journal of Tourism</i>	41
5		<i>Geojournal of Tourism and Geosites</i>	31
6		<i>Acta Geoturistica</i>	24
7		<i>Acta Geographica</i>	22
8		<i>Quaternary International</i>	20
9		<i>Journal of Ecotourism</i>	15
10		<i>Tourism Management Perspectives</i>	12
11	Geoethics	<i>Annals of Geophysics</i>	26
12		<i>Geological Society</i>	18
13		<i>Engineering Geology for Society and Territory</i>	7
14		<i>Geoethics: ethical challenges (book)</i>	6
15		<i>Episodes</i>	6
16		<i>EGU General Assembly</i>	6

**Fig. 2** Citation network of journals and the seven research fields investigated. The green circles represent the different research fields, the size of the circles represents frequency of publications in the field. CH = cultural heritage, DH = dark heritage, GT = geotourism, GH = geoheritage, GC = geoconservation, DT = dark tourism, GE = geoethics. Red circles are individual journals.

Again, it is evident that the choices made by authors active within the respective fields are rather limited. Furthermore, the range of chosen journal destinations is more exclusive within some of the fields investigated: dark heritage and geoconservation research appears in only three journals respectively (*International Journal of Heritage Studies; Journal of Heritage Studies; Journal of Heritage Tourism*), geoheritage typically appears in five journals (*Acta Geologica; Quaternary International; Geojournal of Tourism and Geosites; Sustainability and International Journal of Geoheritage*) besides *Geoheritage*, whilst geoethics work appears in four journals (*Annals of Geophysics; Geological Society; Engineering Geology for Society and Territory; Episodes*) and as abstracts as

1 part of the EGU General Assembly. This trend continues in forward citations: Cultural heritage destinations  
2 include cultural/heritage, environmental and economics; dark heritage also is found within cultural/heritage  
3 journals but also in geography-related journals. Both geotourism and geoheritage forward citation destinations  
4 are within geography and geology journals. Geoconservation is also targeted at geography and geology  
5 destinations, as well as ecology and conservation. Lastly, dark tourism research is targeted at heritage and  
6 general humanities journals. One interesting and surprising finding is, however, that each field (except for  
7 geoethics) has forward citation destinations in tourism-related journals.  
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## 17 **Discussion**

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20 The results of our bibliometric analysis and visualisation show that the broad disciplinary fields of cultural and  
21 geological heritage are largely disconnected. A lack of citation across these disciplinary domains and their sub-  
22 fields indicates that there is little shared literature and likely little common ground in terms of terminology,  
23 theory and method. Importantly, the field of cultural heritage has the longest research and publication pedigree,  
24 and cultural heritage figures prominently in the funding programs of major agencies (e.g. the EU's  
25 Horizon2020). Furthermore, the statistics available for many countries indicate that museums of cultural history  
26 are among the major attractions for tourists and locals alike (<http://www.egmus.eu/>). Museums are increasingly  
27 active in relation to questions of sustainability, biodiversity and climate change (Cameron and Neilson, 2015;  
28 Rees, 2017), although museums of cultural history have not yet fully grasped that chance (Jackson *et al.*, 2017;  
29 Jackson *et al.*, 2018), despite the fact that the entanglement of our knowledge about past environmental change  
30 and hazards in relation to culture history can be said to afford not only learning opportunities (Riede *et al.*,  
31 2016b) but also certain ethical obligations (Riede *et al.*, 2016a). Aligning geoheritage closer with cultural  
32 heritage would open this remarkable public interface to the concerns of geoconservation, sustainability and  
33 vulnerability. At the same time, it has been shown repeatedly that the humanities and social sciences remain  
34 side-lined in major efforts such as the Intergovernmental Panel on Climate Change's (IPCC) reports (Hulme,  
35 2011; Corbera *et al.*, 2016). A closer alliance between cultural and geological heritage practitioners could thus  
36 not only increase public but also policy-maker impact.  
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58 Mindful of these results and in an effort to support our argument that investigations of volcanic geoheritage –  
59 and geoheritage in general – can draw benefits from joint attention from both geoheritage and cultural heritage  
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1 perspectives, we now briefly illustrate how such a geo-cultural heritage perspective could take form. We focus  
2 on four volcanic eruption/landforms (Soufrière Hills Volcano, La Soufrière, Vesuvius and the Laacher See) in  
3 order to show how both active and dormant volcanoes and their different cultural and geological heritage  
4 components can be brought into play. In this effort, we focus specifically on aspects of dark heritage, i.e. aspects  
5 of these geosites that place themselves in the “tense intermediary zone between voyeurism and social justice”  
6 (Robb, 2009: 58)  
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### 10 *Soufrière Hills Volcano, Montserrat*

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12 Soufrière Hills Volcano, on the Lesser Antilles island of Montserrat has been periodically erupting since 1995  
13 (Sword-Daniels *et al.*, 2014), and with geological evidence that similar activity occurred just before first  
14 European settlements in 1632 (Smith *et al.*, 2007). Archaeological evidence shows that there were Saladoid  
15 (Amerindian) coastal sites (Reid, 2009) (an indigenous cultural group that inhabited Venezuela and the  
16 Caribbean from 500 BCE to 545 CE) and pre-Arawak occupation between 4000-2500 BP (Cherry *et al.*, 2012).  
17 In the Lesser Antilles, the Arawak were then displaced by the Kalinago, who also inhabited Montserrat (Lalubie,  
18 2013) from approximately 1200 CE. It is unknown what became of the Kalinago, and it was not until 1632, that  
19 the first Irish Catholic settlers colonised the island, to escape Protestant intolerance at the neighbouring island of  
20 St. Kitts and, later, from Virginia (Russell, 2015). It is contested whether they brought with them the law of the  
21 Kingdom of Ireland, which differed from the Kingdom of England law (Roberts-Wray, 1966). After the English  
22 seized Montserrat in 1667, Irish indentured servants and African slaves were imported, displacing small holding  
23 Irish farms and replacing them with larger plantations (Russell, 2015). The most curious cultural heritage aspect  
24 of the island may be St. Patrick’s Day, which embraces the Irish-African creole society. Whilst it was originally  
25 celebrated by the Irish, a failed slave revolt took place on the 17<sup>th</sup> March 1768 (Fergus, 1996), and for future  
26 generations captivated the imaginations of the creole society to the point that the failed rebellion was  
27 incorporated into the festivities, which attracts tourists the world over (see:  
28 <https://www.irishcentral.com/roots/montserrat-irish-st-patricks-day>). Through the continued development of the  
29 creole society, the festival’s meaning has changed throughout the island’s colonial history: from  
30 postcolonialism, left-wing politics, the Black Power movement, the role of the Roman Catholic church, and  
31 since the eruption of 1995, altered spatial dimensions of the festival’s home and as a gathering-point of the  
32 diaspora that were displaced by Soufrière Hills (McAtackney *et al.*, 2014).  
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1 The volcanic island's most prominent development issue has been the abandonment, following the 1995  
2 eruption, of over 50 settlements in the south of the island, where a permanent exclusion zone of Soufrière Hills  
3 Volcano is in effect (Fig. 3).  
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9 **Fig. 3** Aerial photograph of Plymouth and the surrounding area buried by the 25<sup>th</sup> June 1997 pyroclastic  
10 density currents. By Lally Brown, June 1997.  
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17 Consequently, development is currently restricted to the north of the island, where new settlements are slowly  
18 being developed, and as of last year tour guides have been training for accompanied tours of the outskirts of  
19 Plymouth (Skinner, 2018). The inhabitants of Montserrat are on their way to exploiting its dark tourism related  
20 to past human impacts and contemporary risks. The Soufrière Hills eruptions are well-investigated  
21 volcanologically and the remains from its most recent eruptions offer touristic and research opportunities today.  
22 Yet, they also reflect a more troublesome legacy of colonial rule (e.g. Charvériat, 2000; Spence *et al.*, 2007;  
23 Kelman and Mather, 2008; Donovan *et al.*, 2014; Barclay *et al.*, 2015).  
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31 The recent history of the island epitomises issues of colonial rule and how contemporary world systems fell into  
32 place. It is a history of marginalised groups (e.g. Mlambo, 2006; McGrattan, 2010; Montero, 2011; Boyle, 2011)  
33 and a history that can be linked to issues of social justice (Wolf, 1990) and of contemporary environmental  
34 concerns (Lewis and Maslin, 2015). The destruction of the capital Plymouth is akin to the destruction of St.  
35 Pierre, Martinique by Mont Pelée in 1902 (Fig. 4), which had far-reaching effects in terms of early disaster  
36 medialisation (Kverndokk, 2015). St. Pierre has been nicknamed the “Pompeii of the Caribbean” (Janssens and  
37 O’Keefe, 2010) and Plymouth, too, has been described as: a “modern-day Pompeii in the Caribbean” (Bachelor,  
38 2014). But the trope of Pompeii is itself contested and some Eurocentric short-hand for a moment frozen in time  
39 (Holmberg, 2013). Both capitals are dark heritage sites, due to the large cultural, socioeconomic, and political  
40 sites also being sites of human trauma and the destruction of the built environment, that almost mirror the  
41 settlements destroyed by the 79 CE eruption of Vesuvius, in that pyroclastic density currents essentially buried  
42 the surrounding landscape. Visiting these deserted places is very much dark tourism for those from the outside,  
43 while the land is being reclaimed in an ad hoc fashion by those who in fact live there (Skinner, 2018). Both  
44 places carry an inheritance of loss, to use Holmberg's (2013) term. With due tact, respect and professional  
45 conduct, this inheritance – this geo-cultural heritage – could be turned into powerful generators of income and  
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1 insight. Here, the community archaeology approach – a branch of archaeology concerned with inclusion,  
2 participation, education and interaction rather than a one-way conferral of knowledge (Ryzewski and Cherry,  
3 2012) – could leverage cultural heritage to focus also on the intimately related topics of social justice and  
4 vulnerability.  
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14 **Fig. 4** (A) Photograph of abandoned Plymouth, and (B) the rebuilt Statue of Mary in St. Pierre, Martinique.  
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16 By (A) Lally Brown, 1996 and (B) D. Morvan, 2006.  
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#### 22 *La Soufrière, St. Vincent and the Grenadines*

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24 La Soufrière Volcano, on the main island of St. Vincent, is one of the most active volcanoes in the Lesser  
25 Antilles Volcanic Arc (Robertson, 1995), last erupting explosively in 1979 and with effusive lava dome growth  
26 until 1984 (Robertson, 2005). The small island state shares much history and many contemporary challenges  
27 Montserrat and other similar island in the region (Briguglio, 1995). Currently, research draws on the past two  
28 eruptions of 1979 and 1902-1903 to educate, to prepare for the future and for capacity building – through an  
29 annual volcano awareness week that coincides with the 1979 eruption commemoration where school children  
30 and the wider public are imparted knowledge of the volcano in a semi-formal setting (Fig. 5).  
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42 **Fig. 5** School children learning about volcanoes and La Soufrière during the 2016 Volcano Awareness Week.  
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44 By Jazmin Scarlett, April 2016.  
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50 Besides the physical presence of the active volcano, and extinct volcanic centres forming a central axial range of  
51 mountains (Robertson, 2005), various outcrops exist that offer outstanding examples of volcanic island  
52 processes. Various popular eco-tourism routes criss-cross the mountain range, rainforests and bays (SVG  
53 Tourism Authority, 2009) (Fig. 6) and, Amerindian petroglyphs are present across the island, which are likewise  
54 a source of tourism income that have been submitted for consideration as cultural heritage sites (UNESCO,  
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2018a) (Fig. 6). It would not only be possible to integrate these routes with a narrative of the geology of the island but to integrate community-led research into the exploration of these prehistoric landscape features.

**Fig. 6** (A) The La Soufrière Nature Trail, and (B) a petroglyph of St. Vincent and the Grenadines. By (A) Jazmin Scarlett, April 2016 and (B) Megan Walker, 2017.

St. Vincent and the Grenadines have a complex colonial history, which has contributed to both ethnic and religious diversity in the present (e.g. Brathwaite, 1971; Bolland, 1998; Shepherd and Richards, 2002; Finneran, 2013). This history has not been a happy one and encapsulates many aspects of the emergence of contemporary world systems as well as the emergence of our contemporary environmental quandaries (Lewis and Maslin, 2015). Yet, the history of slavery and colonialism has been embraced and exploited as a form of dark heritage on other Caribbean islands, in the southern United States and in West Africa (e.g. Dann and Seaton, 2001; Mowatt and Chancellor, 2011; Tunbridge and Ashworth, 2017). Weaving narratives of volcanic unrest and human impact together with narratives of colonialism, resistance, migration, social and environmental justice may yet be for the benefit – also in terms of tourism-generated income – for all involved.

### *Vesuvius, Italy*

The cities of Pompeii and Herculaneum are known the world over and are, in fact, prime examples of dark heritage. Their discovery was integral to the development of research fields such as archaeology, just as research on Vesuvius has been integral in the development of volcanology – so much so that the very term Pompeii has become a common and more often than not misleading idiom for some site – tephra-covered or not – frozen in time (cf. Holmberg, 2013). Pompeii does offer unprecedented insights into the life of the Romans (Beard, 2008) and has long inspired art, theatre and film (Pomeroy, 2008; Sigurdsson, 2015). The volcano looming over the city of Naples and the world famous casts of agonisingly dying animal and human inhabitants of this ancient city adds its element of titillation (Kulcsar and Simon, 2015) together making Pompeii into a tremendously attractive site for visitors (Fig. 7). In 2014, nearly 2.5 million visitors came to Pompeii (Culture, 2014). In 2017, this number has risen to over 3.4 million and many more see the various exhibitions staged about Pompeii in museums around the world (e.g. at the British Museum in 2013, see

1 [http://www.britishmuseum.org/whats\\_on/exhibitions/pompeii\\_and\\_herculaneum.aspx](http://www.britishmuseum.org/whats_on/exhibitions/pompeii_and_herculaneum.aspx)). In contrast, only about 1  
2 million visitors came to the Vesuvius National Park in 2004 (Erfurt-Cooper, 2010a) and just over 4 million in  
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4 2017 (<http://www.pompeiiisites.org/Sezione.jsp?titolo=Dati+Visitatori&idSezione=9>). While these figures  
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6 derive from different years, they clearly support and reflect the general trend, already alluded to above, that  
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8 institutions of cultural heritage such as museums or sites of culture history or art, attract substantially more  
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10 visitors than their natural history counterparts (Istat, 2016).

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15 **Fig. 7** (A) A classic image of Vesuvius that forefronts the cultural heritage in the form of Pompeii,  
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17 deliberately chosen from Wikipedia (Morn the Gorn - Own work, CC BY-SA 3.0,  
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19 <https://commons.wikimedia.org/w/index.php?curid=7919520>), and (B) a film poster of one of the many  
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21 productions of the *Last Days of Pompeii*, going back to the painting of the same title by [Karl Bryullov](#) from  
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32 There is little doubt that much effective outreach about risk, vulnerability and coupled geological and cultural  
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34 heritage is already going on at Pompeii. It is not, however, strongly visible in the literature and rarely framed as  
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36 such. Given, however, just how many people – locals and tourists alike – are at risk from renewed eruption at  
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38 Vesuvius (Zuccaro *et al.*, 2008; Scandone *et al.*, 2015), effective risk communication is a high priority. There is  
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40 great awareness of this need and ethical obligation to communicate these risks (Solana *et al.*, 2008; De Lucia,  
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42 2014) and including elements of cultural framings of risk and response (Everson, 2012; Chester *et al.*, 2015)  
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44 may assist in these endeavours.

#### 45 46 47 48 49 *Laacher See, Germany*

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52 The eruption of the Laacher See volcano, part of the Eifel volcanic zone located in present-day Germany,  
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54 around 12900 years ago was the last major volcanic event in continental Europe, lasting up to several months, it  
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56 devastated the immediate surroundings (Schmincke *et al.*, 1999; Schmincke, 2006). Its eruption sequence and  
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58 associated processes such as the formation and subsequent collapse of a dam on the nearby river Rhine are well  
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60 investigated (Park and Schmincke, 2009). Indeed, recent research motivated by a concern about the eruptions  
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1 impact on human communities at the time has highlighted the extent of the tephra fallout from the eruption  
2 (Riede *et al.*, 2011) and the likely impacts of this eruption on animals, plants and people living in Europe at the  
3 time (Riede, 2008; Riede, 2016; Riede, 2017a; Riede, 2017b). The Eifel is a recognised UNESCO Geopark (see  
4 <https://www.geopark-vulkaneifel.de/en/>), the Laacher See a beautiful recreational area (Fig. 8), and much  
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6 vigorous outreach focusing on the regions rich geo-cultural heritage – Roman and Medieval mining,  
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8 underground beer storage and contemporary industry (Custodis, 1994; Kremer, 1995) – is going on (Erfurt-  
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10 Cooper, 2010).  
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18 **Fig. 8** A drone photo of the Laacher See caldera. By Florian Sauer, May 2018.  
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20 We note, however, that much of this outreach circumvents issues of past human impacts (Bitschene and  
21 Schüller, 2011; Bitschene, 2015) and hence underutilises the opportunity of putting issues of vulnerability and  
22 resilience to debate, and underutilises the touristic appeal of the eruption’s dark heritage. While unlikely in the  
23 near future, any potential reawakening of this volcano would likely result in major infrastructure costs (Leder *et*  
24 *al.*, 2017) or even secondary technological disasters with not merely local effects but reverberations across  
25 Europe (Fig. 9). Moreover, and perhaps more usefully still, the Laacher See can be used as a case study for  
26 seriously thinking through the societal consequences and responses to events of this magnitude and to do so in a  
27 manner that is historically informed by what we know of past impacts (Donovan and Oppenheimer, 2016;  
28 Riede, 2017a). A strategic and balanced inclusion of the Laacher See’s dark heritage would likely further  
29 increase the region’s and the eruption event’s appeal and hence lift the reach of any associated educational  
30 initiatives up on a supra-regional scale.  
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46 **Fig. 9** The location of the Laacher See and proximal (<50 km), medial (50-500 km) and distal (500-1000 km)  
47 hazard zones, following Thorarinsson (1979), in relationship to (A) European population density and (B) major  
48 power plants.  
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## 55 **Conclusion**

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58 Volcanoes and their landforms are natural features but are also commonly deeply entangled with human history,  
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60 culture and society. Culture history and cultural heritage are a resource on which people anywhere draw for  
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1 identity formation and for social capital. The UN Millennium Ecosystem Assessment (2005), for instance,  
2 classified *cultural services* as a form of ecosystem service, essential for sustainability and well-being (Hølleland  
3 *et al.*, 2017). Cultural services cover ten aspects: 1) cultural diversity, 2) spiritual and religious values, 3)  
4 knowledge systems, 4) educational values, 5) inspiration, 6) aesthetic values, 7) social relations, 8) sense of  
5 place, 9) cultural heritage values, and 10) recreation and ecotourism (Fig. 10).  
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13 **Fig. 10** The categories of cultural ecosystem services as defined by the UN Millennium Ecosystem  
14 Assessment. After Hølleland *et al.* (2017).  
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21 Cultural ecosystem services were determined to be nonmaterial benefits that people obtain from ecosystems  
22 through recreation and aesthetic experiences, spiritual enrichment, reflection and cognitive development.  
23 Cultural heritage values are described as "...many societies place high value on the maintenance of either  
24 historically important landscapes (cultural landscapes) or culturally significant species" (Millennium Ecosystem  
25 Assessment, 2003, pg. 59). From the perspective of volcanology, volcanoes and their associated landforms can  
26 almost always be slotted into all ten of the subcategories of cultural services. Assessments of volcanic risk,  
27 vulnerability, resilience, and their translations into hazard maps and warning messages all require cultural  
28 understanding. Cultural values and perceptions provide saliency to specific hazards through a specific and  
29 culturally variable prioritisation of threats (Cutter *et al.*, 2008).  
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42 Historical data – geological, archival and archaeological – of past eruptions can be fed into building community  
43 resilience through education and knowledge systems, participatory research (for instance, geo-archaeological), a  
44 deep sense of place, tourism, spirituality and religion, social relations, aesthetic values, recreation, and  
45 ecotourism. Accepting the entanglement of geological and cultural heritage, we have here proposed the notion  
46 of geo-cultural heritage and have presented some initial suggestions for how certain aspects of cultural heritage  
47 can usefully be blended with aspects of geological heritage. Seen against the background of our citation  
48 analysis, we also argue for increased interdisciplinarity. Cultural heritage professionals have developed  
49 countless ways of engaging local communities in the context of, for instance, community archaeology projects  
50 (Moshenska and Dhanjal, 2011; Moshenska *et al.*, 2011; Fernández *et al.*, 2017). Cultural heritage sites almost  
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1 universally tell stories of past human-environment relations (Rockman, 2015; Hambrecht and Rockman, 2017)  
2 and from here it is but a small step to thinking volcanic hazards together with cultural heritage and cultural  
3 history – a trend that is in fact already on-going (Cronin and Cashman, 2007; Cashman and Cronin, 2008;  
4 Cashman and Giordano, 2008; Németh and Cronin, 2009).  
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8 Millions of visitors are attracted by the wonders of volcanoes and volcanic landforms every year (Erfurt-Cooper  
9 and Cooper, 2010; Erfurt-Cooper *et al.*, 2015; Jones and Ohsawa, 2016; Németh *et al.*, 2017). Their popular  
10 appeal is substantial. Yet, we have argued here, this appeal can be enhanced further through a strategic alliance  
11 between geoheritage and cultural heritage researchers and managers. Several points stand out clearly. First and  
12 foremost, cultural heritage attractions tend to command greater attention and hence generate more income, jobs  
13 and attention. Cultural heritage professionals have developed, over the many years since the establishment of  
14 this field of research, numerous approaches to understanding and managing such sites and their attendant issues.  
15 Importantly, heritage is often contested and a robust handling of any heritage feature – geological or otherwise –  
16 must be attuned to the potential for diverging viewpoints and value assignments. This is also at the core of dark  
17 heritage, where problematic or uncomfortable sites actually generate great visitor appeal and hence present  
18 themselves as particularly powerful places of engagement. Here, we have merely touched upon how issues of  
19 colonialism, slavery, vulnerability and resilience can be woven into the narratives about particular eruptions.  
20 Breaking down the increasingly artificial boundaries between natural/geological and cultural/historical heritage  
21 can be achieved through wider reading and publication – we have provided lists of the most important authors,  
22 articles and journals – and more interdisciplinary collaboration across the domains of geological and cultural  
23 heritage. Resulting outreach efforts can be brought into effect through, for instance, museums or local interest  
24 groups that provide uniquely suitable platforms for such engagements. Such interdisciplinarity would, we argue,  
25 be to the mutual benefit of both domains.  
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