https://doi.org/10.5194/hgss-2021-22
Preprint. Discussion started: 22 December 2021

Open Access History of Geo- and Space Sciences Discussions

The international tephra research group 'Commission on Tephrochronology' and its activities – the first 60 years

David J. Lowe[1], Peter M. Abbott[2], Takehiko Suzuki[3], and Britta J.L. Jensen[4]

[1]School of Science/Te Aka Mātuatua, University of Waikato, Hamilton, New Zealand
[2]Climate and Environmental Physics, Physics Institute, and Oeschger Centre for Climate Change Research, University of Bern, Bern, Switzerland
[3]Department of Geography, Tokyo Metropolitan University, Tokyo, Japan
[4]Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton, Alberta, Canada

Correspondence: **David J. Lowe (david.lowe@waikato.ac.nz)**

https://doi.org/10.5194/hgss-2021-22
Preprint. Discussion started: 22 December 2021

Abstract. Modern tephra studies *per se* began almost 100 years ago (in the late 1920s) but the first collective of tephrochronologists, with a common purpose and nascent global outlook, was not formed until 7 September, 1961, in Warsaw, Poland. On that date, the inaugural 'Commission on Tephrochronology' (COT) was ratified under the aegis of the International Union for Quaternary Research (INQUA). COT's formation can be attributed largely to the leadership of Kunio Kobayashi of Japan, the commission's president for its first 12 years. We were motivated to record COT's heritage for posterity and also because the discipline of tephrochronology, including the study of cryptotephras, continues to grow globally at a significant rate. This is recognition of tephrochronology as both a unique correlational and age-equivalent dating method, and as a complementary method in other fields, such as volcanology, in which tephra research has been employed to develop eruption histories and hazards and to help understand volcano-climate interactions. In this article, we review the history of COT (which also functioned under other names, abbreviated as COTS, CEV, ICCT, COTAV, SCOTAV, INTAV) under the umbrella of INQUA for 53 of the last 60 years, or under IAVCEI (International Association of Volcanology and Chemistry of the Earth's Interior) for seven of the last 60 years, including since 2019. We describe the development of the commission and its subsequent activities that include organising nine specialist tephra-field meetings in seven different countries, numerous conference sessions or workshops, and generating tephra-themed issues of journals/books or specialist internet documents or websites. The commission began to prosper after 1987 when key changes occurred, and it has blossomed further, especially in the past decade or so as an entire new cohort of specialists has emerged alongside new analytical and dating techniques to become a vibrant global group today. We name 29 elected officers involved with COT since 1961 and their roles, and 15 honorary life members. We also document the aims of the commission and conclude by evaluating its legacies and current and future work.

Short summary. The Commission on Tephrochronology, formed in 1961, comprises global researchers who characterize, map, and date tephra (volcanic ash) layers and use them stratigraphically as linking and dating tools in geological, palaeoenvironmental, and archaeological research, and volcanology. We review the commission's history – its growth, leadership, and activities for 60 years that include hosting specialist meetings, symposia, and workshops, developing new analytical and dating methods and protocols, and encouraging ECRs.

https://doi.org/10.5194/hgss-2021-22
Preprint. Discussion started: 22 December 2021

This article is dedicated to the memory of Kunio Kobayashi, who led the founding of the Commission on Tephrochronology in 1961 and helped guide its earliest years

1 Introduction

The term 'tephra' (from Greek *τέφρα*, 'ash' or 'ashes') includes all the explosively-erupted, unconsolidated, fragmental or pyroclastic products – of any grain size including ash, lapilli, blocks and bombs (Wright et al., 1981) – from a volcanic eruption. 'Cryptotephras' are explosive volcanic-eruption derived ash-sized glass-shard and/or crystal concentrations that are preserved in sediments or soils but insufficiently numerous, or which comprise sparse grains too small, to be visible as a layer to the naked eye (Hunt, 1999a; Lowe, 2011a; Lane et al., 2017a). 'Tephrochronology' (*sensu stricto*) is a unique correlational and age-equivalent dating method that uses characterized tephra or cryptotephra deposits as isochronous, or time-parallel, layers to link or synchronise geological, palaeoenvironmental, or archaeological sequences or events, and to transfer and apply relative or numerical ages or dates to them where these are known (Lowe and Alloway, 2015). The correlation of deposits from site to site relies on matching the physical properties, mineralogical assemblages, and elemental 'fingerprints' (major, minor, or trace elements) of glass shards and/or crystals from the tephras/cryptotephras in combination with stratigraphic superpositioning and numerical age data (Abbott et al., 2020a; Hopkins et al., 2021a). A range of analytical methods and visual and statistical approaches can be used to help facilitate correlation (e.g., Lowe et al., 2017a; Bolton et al., 2020). Correlating dispersed tephra deposits, especially where well dated, back to their volcanic sources allows tephrochronological studies to provide information on the eruption frequency (i.e., eruption history) and geochemical evolution of volcanic regions and individual volcanoes (Abbott et al., 2020a), as well as informing volcanic hazard modelling and providing a means to help understand volcano-climate interactions, all within the realm of volcanology.

In this article we summarise and comment on the history of global collaboration by tephrochronologists, and associated researchers, that has taken place through activities of an international tephra-centred research group over the past 60 years. This group was first, and currently is, known as the 'Commission on Tephrochronology' but has had other guises over the years (Table 1). Such a summary is timely because the discipline of tephrochronology (and its burgeoning offspring, cryptotephrochronology) is growing from strength to strength, especially as tephrochronology has become one of the most versatile methods available to geoscientists, Quaternary scientists, and archaeologists that is potentially applicable over timescales spanning years to millions of years (Abbott et al., 2020a). Moreover, the method has the potential to correlate sequences over distances ranging from centimetres to thousands of kilometres, and the capability of linking and dating proximal, metre-thick deposits to diminutive distal layers comprising barely a handful of glass shards that have no visible expression (i.e., cryptotephras) (Hunt, 1999b; Abbott et al., 2020a). Applications of tephrochronology, chiefly for the Quaternary period, are equally varied and are becoming increasingly important in wide-ranging geochronological, palaeoenvironmental, and volcanological studies (Lowe, 2011a).

https://doi.org/10.5194/hgss-2021-22
Preprint. Discussion started: 22 December 2021

Table 1. Progression of names of the international tephra group associated with either INQUA[1] or IAVCEI[2]

2019-on	– Commission on Tephrochronology (COT) – IAVCEI
2007-2019	– International Focus Group on Tephrochronology and Volcanism (INTAV) – INQUA
2003-2007	– Subcommission on Tephrochronology and Volcanism (SCOTAV) – INQUA
1995-2003	– Commission on Tephrochronology and Volcanism (COTAV)[3] – INQUA
1991-1995	– Commission on Tephrochronology (COT) – INQUA
1987-1991	– Inter-congress Committee on Tephrochronology (ICCT) – INQUA
1982-1987	– Commission on Explosive Volcanism (CEV)[4], International Association of Volcanology and Chemistry of the Earth's Interior – IAVCEI
1961-1982	– Commission on Tephrochronology or Commission on Tephra (COT), International Union for Quaternary Research – INQUA

[1] For a history of INQUA (and Quaternary science), see Neustadt (1969), Porter (1999), and Smalley (2011)
[2] For a history of IAVCEI, see Cas (2019)
[3] According to Lowe (1995, 1996a), the commission from 1995 was initially Commission on Tephra Studies (COTS)
[4] COT was effectively merged with CEV in this period (CEV exists today alongside COT within IAVCEI). Note that CEV was initially called Working Group on Explosive Volcanism (see Sect. 3.3)

To date, however, information about the commission and its activities is scattered and sparse, and so we have assembled this review mainly because we recognised that such information, especially relating to the early years, was fast fading, and needed preserving for succeeding generations. We were also motivated by the especially strong support of commission members over the past decade, growing to well over 120 including increasing numbers of early-career researchers (ECRs), many now becoming proficient and experienced, as expressed at well-attended tephra meetings held in Kirishima, Japan (2010), Nagoya, Japan (2015), Portland, Oregon (2017), Moieciu de Sus, Romania (2018), and Dublin, Ireland (2019) (see Sect. 2). These modern practitioners wanted to maintain and enhance the active global collective the commission had now become.

In undertaking the review, we draw on our own and others' experience, various papers, and snippets from conference proceedings (where available) to provide a historical framework of the commission and some of its globally-focussed activities, mainly conferences or workshops, since its founding in 1961. We have included a variety of images to add colour to the narrative and to show a range of the people and activities involved in the events undertaken.

Apart from some key aspects relating specifically to the development of COT, largely we do not cover the development of the discipline and science of tephrochronology and its advances, which are reviewed extensively elsewhere (e.g., Thórarinsson, 1944, 1981; Westgate and Gorton, 1981; Froggatt and Lowe, 1990; Haflidason et al., 2000; Sarna-Wojcicki, 2000; Shane, 2000; Machida, 1991, 2002; Machida and Arai, 2003; Dugmore et al., 2004; Suzuki, 2007; Froese et al., 2008a; Larsen and Eiriksson, 2008; Lowe, 2008, 2011, 2014; Lowe et al., 2011a, 2017; Alloway et al., 2013; Riede and Thastrup, 2013; Smith et al., 2013; Davies et al., 2014; Lowe and Alloway, 2015; Davies, 2015; Ponomareva et al., 2015; Danišík et al., 2017; Lane et al., 2017a; Abbott et al., 2020a; Hopkins et al., 2021a; Lane and Woodward, 2022).

The rise of cryptotephra studies is remarkable and they have been very influential over the past three decades (see Sect. 3.3 and Lowe, 2008; Davies, 2015). Although beginning in Scandinavia in the 1950s and 1960s (with work by Christer Persson, e.g., 1966, 1971: Davies, 2015), then New Zealand in the mid-1970s and

https://doi.org/10.5194/hgss-2021-22
Preprint. Discussion started: 22 December 2021

early 1980s (Hopkins et al., 2021a), the new discipline of 'cryptotephrochronology' was propelled into the modern systematic era from 1990 by the publication of Andrew Dugmore's seminal UK-based paper of 1989 (Dugmore, 1989). The term 'cryptotephra', although introduced in 1999 (Hunt, 1999a), was first defined only in 2001 (Juvigné et al., 2001; Lowe and Hunt, 2001). The discipline has witnessed new or improved techniques and applications emerging to cater for the demanding, forensic-like requirements of such research (Davies, 2015; Ponomareva et al., 2015; Krüger and van den Bogaard, 2021). We list here examples referring to research on distal cryptotephra deposits, including wide-ranging applications, together with some recent papers on long sedimentary sequences containing cryptotephras (e.g., Turney, 1998; Hunt, 1999b; Hall and Pilcher, 2002; van den Bogaard and Schmincke, 2002; Davies et al., 2004; Gehrels et al., 2008; Lowe, 2008, 2011; Wastegård and Davies, 2009; Swindles et al., 2011, 2019; Wastegård and Boygle, 2012; Riede and Thastrup, 2013; Smith et al., 2013; Davies et al., 2014; Lane et al., 2014; Davies, 2015; Ponomareva et al., 2015; Abbott et al., 2018a, b, 2020a; Wulf et al., 2018; Albert et al., 2019; Leicher et al., 2019; Freundt et al., 2021; Kinder et al., 2021; Jensen et al., in press).

Numerous individuals have been involved with the commission. We record the names of those who have held positions as elected officers or who convened conferences or workshops on behalf of the tephra community. A number of individuals and their contributions to the discipline of tephrochronology have been reported in historical articles, special editorials, or obituaries (see Vucetich, 1982; Björnsson, 1983; Royal Geographical Society, 1983; Lowe, 1990a; Wilson, 2005; Self and Sparks, 2006; Tonkin et al., 2007; Froese et al., 2008b; Lowe et al., 2008a, 2015a, 2017b; Slate and Knott, 2008; Hunt, 2011; Moriwaki et al., 2011a; Suzuki et al., 2011; Benediktsson et al., 2012a; Steinthórsson, 1985, 2012; Alloway et al., 2013; Kile, 2013; Thomas and Lamothe, 2014; Plunkett et al., 2017; Lindqvist et al., 2019; Bunting et al., 2020; Hopkins et al., 2021a).

2 Formation and development of COT as an international specialist tephra research group and its activities

2.1 Formation of COT in 1961

The Commission on Tephrochronology (COT), today hosted within IAVCEI, is the current incarnation of a series of international tephra-related research groups whose history as a collective can be traced back to 7 September, 1961 (Table 1). The formation of the commission was initiated at a meeting of the National Committee of Quaternary Research, Science Council of Japan, in Tokyo on 6 February, 1961. Attendants agreed that a proposal to form a commission on tephrochronology should be developed and presented at the forthcoming VIth Congress of the International Union for Quaternary Research (INQUA) being held in Warsaw, Poland, in September that year. Kunio Kobayashi (Fig. 1), Masao Minato, and Sohei Kaizuka were appointed to develop one (Kobayashi, 1965).

https://doi.org/10.5194/hgss-2021-22
Preprint. Discussion started: 22 December 2021

Open Access
History of Geo- and Space Sciences
Discussions

小 林 国 夫 先 生
〈遺影は１９７８年１０月１２日撮影〉

Figure 1. Professor Kunio Kobayashi (19 February, 1918–19 June, 1979), driving force and founding president of COT. Photo taken 12 October, 1978 (from Committee for Publishing of Selected Papers by Professor Kunio Kobayashi, 1990).

The Japanese trio prepared the proposal and, before the Warsaw Congress, mailed it to those engaged in tephrochronological studies in various volcanic regions of the world and to the congress Secretariat. The Secretariat copied part of the proposal, along with a list of publications on tephra studies provided by the Kanto Loam Research Group of Japan, for distribution to conference participants. The pre-congress proposal to form a COT within INQUA was as follows (Kobayashi, 1965, p. 782):

> "Aims of the Commission: To advance the progress to the method [i.e., to develop the method] of tephrochronology and Quaternary researches based on tephrochronology.
>
> Means of achieving these aims: 1. Gathering and exchange of information on tephrochronological studies in various countries; 2. Report on the results of studies at the next INQUA congress.
>
> Proposed by Masao Minato (Hokkaido University), Kunio Kobayashi (Shinshu University), Sohei Kaizuka (Tokyo Metropolitan University)."

https://doi.org/10.5194/hgss-2021-22
Preprint. Discussion started: 22 December 2021

At the Warsaw Congress, the three proposers and others convened on 6 September, 1961, to formulate a resolution to present to the General Assembly. Despite all the preparatory work, it seems the process was by no means plain sailing. On arrival in Warsaw, Kobayashi had scanned the list of scientists coming to the congress and discovered to his consternation that no tephra specialists were attending (other than from Japan). However, Terah ('Ted') L. Smiley, a dendrochronologist from Tucson, USA, helped Kobayashi garner support from various delegates from a wide range of disciplines (which, on reflection, may have ultimately been to Kobayashi's advantage) including Väinö Auer, a pioneering tephrochronologist from Finland who had worked in South America from 1928 (e.g., Auer, 1965), Neville Moar, a New Zealand palynologist who was well aware of the growing importance of tephra studies (e.g., Moar, 1961), André Cailleux, a French glacial geologist, and Carl Troll, a German geographer (Kobayashi, 1962, p. 129).

The full resolution as presented to the General Assembly is recorded below (Kobayashi, 1962, p. 130, slightly edited):

> "[A] session of the proposed Commission on Tephrochronology was held yesterday afternoon. The significance of studies on volcanic ash layers as a key [means] of correlation of events in the Quaternary was [described] by the chairman and [the] establishment of a commission to promote the international co-operation of this matter was discussed. As a result of discussion, [and] considering the significance of investigation to clarify the sequence of events in … Quaternary volcanic activities, and also considering eolian Quaternary volcanic ash layers to be useful as a key [method for] correlation of … Quaternary formations, geomorphic surfaces and so on, the following persons cited below agreed to propose the foundation of the Commission on Tephrochronology in INQUA.
>
> They ask the General Assembly to agree [to] the foundation of a new commission and appoint Prof. Kobayashi as the organizer [chair/president] of the commission. The [president] should arrange the organization of the Commission on Tephrochronology till the following Congress of INQUA 1965 and report the activities of the commission after this congress."

The resolution was signed by E.H. Muller (USA), N.T. Moar (New Zealand), Ladislav Bánesz (Czechoslovakia), F. Mancincini (Italy), H.D. Kahlke (Germany), P. Bellair (France), T.L. Smiley (USA), T. Yoshikawa (Japan), and Shoji Horie (Japan) (Kobayashi, 1962, p. 130). The following day on 7 September, 1961, it was adopted by the General Assembly of INQUA with Kobayashi declared the commission's founding president (Kobayashi, 1962, 1965) (see Sect. 3 below).

We note here that Neustadt (1969, p. 90) referred to the commission (which was the eighth to be formed in INQUA's history) as the "Commission pour la téphrochronologie", i.e., Commission *for* rather than *on* tephrochronology. However, we prefer 'on' as reported by Kobayashi (1962, 1965), and COT forms a mellifluous acronym. Also, it seems that Kobayashi was the sole officer (president) within COT from 1961 to 1969. By the start of the 1969 Paris Congress, two other commissions in INQUA similarly comprised just a president, but the remaining seven commissions had either two or three officers (Neustadt, 1969).

Interestingly, prior to the Warsaw resolution, Kobayashi had received a letter of support for the commission from Sigurdur Thórarinsson, regarded by many as the founder of the science of tephrochronology (Steinthórsson, 2012), and IAVCEI awards a medal in Thórarinsson's honour. Thórarinsson emphasised that the term 'tephrochronology' rather than 'ash' should be used in the commission's name. In his letter of 1961, Thórarinsson defined tephrochronology as "chronology based on the study of the successive deposits of fragmental volcanic products" (Thórarinsson, 1965, p. 785). This definition relates to the original sense (*sensu stricto*) of the term tephrochronology – essentially as proposed by Thórarinsson (1944, 1954) and as outlined in the introduction – namely, the use of tephra layers as isochrons to connect or correlate sequences, and to transfer relative or numerical ages to such sequences where the tephras have been identified and dated. In recent times, however, the term 'tephrochronology' has been used more broadly to encompass all aspects of tephra studies (including correlating and dating via tephrochronology), and this wider sense (*sensu lato* of Lowe and Hunt, 2001) is preferable in denominating the commission. Thórarinsson also noted that he would "gladly accept a membership in such a commission" and he suggested four other possible members (V. Auer, H. Straka, J. Frechen, and R. Wilcox), who (with Thórarinsson) may or may not have been elected as foundation members.

2.2 Hosting of commission by INQUA or IAVCEI since 1961

For most of the time since 1961, the commission has been hosted under the umbrella of INQUA (Table 1), but with the creation of the new COT in 2019, the collective is now hosted by IAVCEI, where the group was temporarily housed between 1982 and 1987. The penultimate incarnation, INTAV, was formed in 2007 as an International Focus Group (IFG) within the newly-formed Stratigraphy and Chronology Commission (SACCOM) of INQUA (Table 1). INTAV operated under the INTREPID projects I and II (2009–2015, 'Enhancing tephrochronology as a global research tool') and then the EXTRAS project (2015–2019, 'EXTending TephRAS as a global geoscientific research tool stratigraphically, spatially, analytically, and temporally within the Quaternary') (e.g., Lowe, 2013, 2015, 2018a).

Most recently, discussions at the 'Tephra Hunt' meeting in Romania in 2018 led to a near-unanimous decision to form a new commission (COT) within the IAVCEI framework rather than INQUA. The rationale for change is outlined in Lowe et al. (2018), and some of the difficulties of INQUA's complex and cumbersome structure were expressed by Ashworth (2018). The main reason for switching to IAVCEI was that the global tephra community very strongly indicated that it wanted to remain part of a formal and, critically, *ongoing* global collective of tephra specialists as a stand-alone entity. This stand-alone status was available within IAVCEI (and as a commission would be a potential recipient of funding from that parent body) but not within INQUA. It would also allow for regular meetings at *specialist tephra conferences or workshops* rather than being specialists taking part within conferences for other disciplines (important though such multi-disciplinary meetings are). In INQUA, the original commissions (such as COT) had been replaced by subcommissions in 2003 at the Reno INQUA Congress, and then removed entirely because five much broader, over-arching commissions (including SACCOM) were formed in 2007 at the Cairns INQUA Congress. These new commissions adopted a project-based approach rather than relying on the small individual commissions, some of which were inactive, to initiate and undertake projects involving IFGs

https://doi.org/10.5194/hgss-2021-22
Preprint. Discussion started: 22 December 2021

including INTAV. But such focus groups had a limited shelf-life, normally two inter-congress periods (i.e., eight years) at most, after which they were to end, although INTAV managed to persist, somewhat aberrantly, for 12 years.

2.3 Specialist stand-alone tephra-centred conferences hosted by COT (or equivalent) since 1964, and outputs

Nine international specialist tephra field conferences, led by 23 convenors in total and attracting between 37 and 92 participants, have been organised in seven different countries around the globe since 1964 (Table 2). Three of the nine meetings have been held in Japan. In terms of the entire 60-year history, the number of meetings has doubled in the last 30 years, with six meetings taking place since 1991 (i.e., approximately every five years on average). The average number of participants at each meeting is 58. The field conferences are exceptionally important because they not only facilitate an opportunity for the presentation and discussion of the latest advances in tephra studies or their application, but also they provide exceptional insight into the geological, palaeoenvironmental, and archaeological history of a specific region encompassing the conference location (Davies and Alloway, 2006). Furthermore, Lowe et al. (2018, p. 1) noted that “one of the joys of science, and tephrochronology and volcanic studies in particular, is the opportunity to meet like-minded colleagues and keen students in the field where formalities and reserve seem to dissipate in the face of shared interests, friendly discussions at the outcrop, and in meeting new people and cultures whilst being graciously hosted in new countries.” In addition, the conferences provide opportunities and critical support (including mentoring) and inspiration for ECRs including PhD students.

2.3.1. Tokyo, Japan, 1964

Referred to normally as ‘inter-congress’ or ‘inter-INQUA’ conferences because of their occurrence between the four-yearly, full-congress meetings of INQUA, the first stand-alone tephra meeting of COT took place in Tokyo, Japan, from 26–29 November, 1964. Including field excursions to see Asama volcano and sites in Tokyo (Ikuta, Chitose, Todoroki) (Fig. 2), the meeting attracted 50 participants, seven from beyond Japan including Sigurdur Thórarinsson (Iceland) and dendrochronologist Paul E. Damon (USA), along with Hiroshi Machida (Japan) attending his first COT meeting, who appears to be COT’s longest standing member, 57 years, as at November, 2021. Seven presentations were made (Neustadt, 1969).

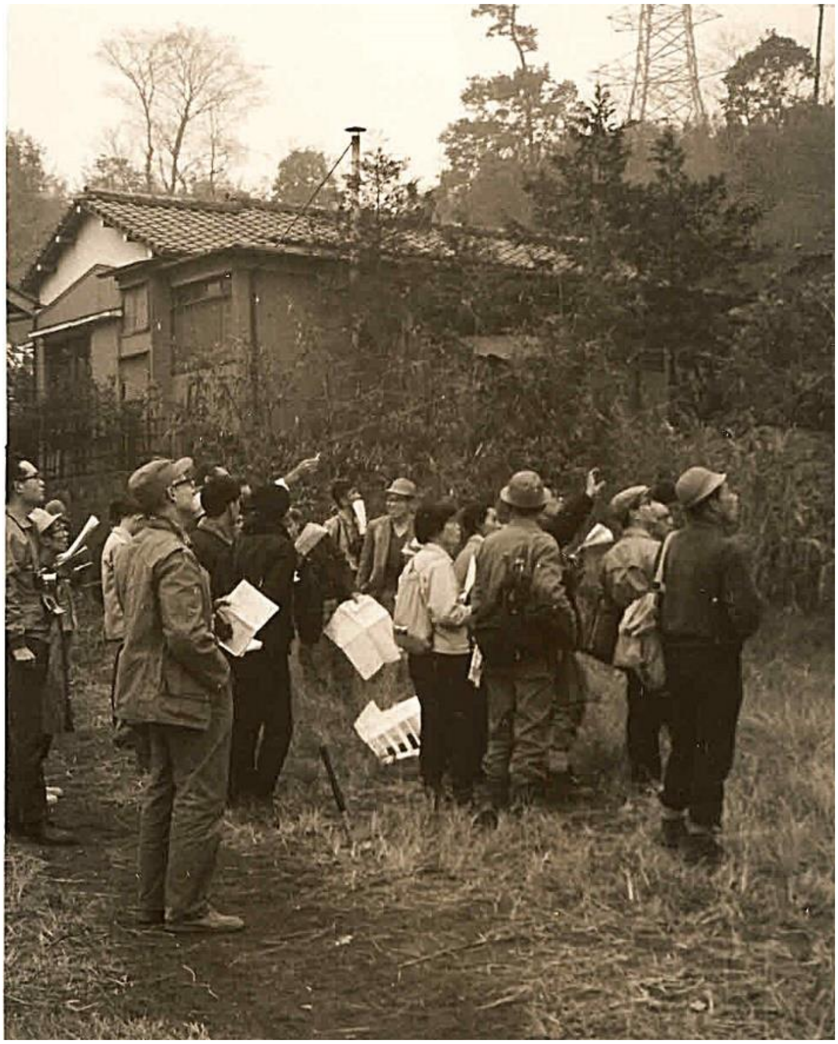

Figure 2. Field trip at Ikuta during the first COT meeting in Tokyo, November 1964 (from Suzuki et al., 2011, p. 8).

https://doi.org/10.5194/hgss-2021-22
Preprint. Discussion started: 22 December 2021

History of Geo- and Space Sciences Discussions

Table 2. List of international inter-INQUA tephra-centred field meetings of COT, ICCT, COTAV, SCOTAV, or INTAV (excludes sessions/symposia associated with quadrennial INQUA/IAVCEI congresses or other conferences or workshops)*

2018 – Tephra Hunt in Transylvania, Moieciu de Sus, Romania (24 June–1 July, 92 participants)[1]
Convenors: Daniel Veres, Ulrich Hambach

2010 – Active Tephra in Kyushu, Kirishima, Japan (9–17 May, 76 participants)[2]
Convenors: Takaaki Fukuoka, Hiroshi Moriwaki, Takehiko Suzuki

2005 – Tephra Rush in Yukon, Dawson City, Canada (31 July–8 August, 41 participants)[3]
Convenors: Duane Froese, John Westgate (with Brent Alloway)

1998 – Tephrochronology and Co-existence of Humans and Volcanoes (Inter-INQUA and Inter-IUSPP), Brives-Charensac (Haute-Loire), France (24 August–1 September, 53 participants)[4]
Convenors: Étienne Juvigné, Jean-Paul Raynal

1994 – Tephrochronology-Loess studies-Paleopedology, Hamilton, New Zealand (7–17 February, 62 participants)[5]
Convenor: David Lowe

1993 – Climatic Impact of Explosive Volcanism (PAGES/INQUA-COT Workshop), Meiji University, Chiyoda-ku, Tokyo, Japan (1–5 December, 37 participants)[6]
Convenors: Hiroshi Machida, James (Jim) Begét

1990 – Mammoth Hot Springs, Yellowstone National Park, USA (17–26 June, 53 participants)[7]
Convenors: John Westgate, Nancy Naeser, Bill Hackett

1980 – Tephra Studies as a Tool in Quaternary Research, Laugarvatn (and Reykjavík), Iceland (18–29 June, 60 participants)[8]
Convenors: Stephen Sparks, Stephen Self, Guðrún Larsen (with Sigurdur Thórarinsson)

1964 – Tephra Field Meeting of COT (inaugural meeting), Tokyo, Japan (26–29 November, 50 participants)
Convenors: Kunio Kobayashi, Sohei Kaizuka, Takeshi Matsui

---

*For abbreviations see Table 1. Special volumes/issues arising from the meetings are as follows: 1, Abbott et al. (2020b); 2, Lowe et al. (2011b); 3, Froese et al. (2008c); 4, Juvigné and Raynal (2001b); 5, Lowe (1996c); 6, Begét et al. (1996); 7, Westgate et al. (1992b); 8, Self and Sparks (1981c)

At the 1964 Tokyo COT meeting, the decision was taken to develop and publish a world bibliography of Quaternary tephrochronology (Westgate, 1974). The agreement was reinforced at the 1965 INQUA Congress in late August/early September at Boulder, USA, at a COT session that included representatives from institutions in ten counties (Neustadt, 1969). Kunio Kobayashi and Roald (‘Fryx’) Fryxell handled the project initially and then John Westgate took over on his election as secretary of COT at the INQUA Congress in Paris in 1969. Westgate had first become involved with COT at the 1965 INQUA Congress in Boulder, and has thus been a member for 56 years as at November, 2021. An ambitious deadline for completing the book’s compilation was set for December, 1971 (Steen-McIntyre, 1971). Substantial grants to COT provided by INQUA and other funders in the early 1970s enabled the volume, entitled *World Bibliography and Index of Quaternary Tephrochronology*, to be published by Westgate and Gold (1974), ten years after it was first mooted (Kaizuka, 1974). Amongst a treasure trove of wide-ranging information, the volume contains an update by Thórarinsson (1974) on the terms ‘tephra’ and ‘tephrochronology’ twenty or thirty years on, respectively, from the definitions he wrote in 1954 and 1944. In 1973, Thórarinsson, an influential ‘formal member’ of COT at the time (later an honorary president of the commission from 1977–1982), was successfully persuaded at the 1973 INQUA Congress in Christchurch, New Zealand, that the term ‘tephra’ be broadened to include unconsolidated pyroclastic flow deposits (non-welded ignimbrites) (Cole et al., 1972;

https://doi.org/10.5194/hgss-2021-22
Preprint. Discussion started: 22 December 2021

Howorth, 1975; Thórarinsson, 1981). Although endorsed by COT, this amplification was considered by some to have ruined the use of the word 'tephra' (*sensu stricto*), and there are still tephrochronologists who do not use the wider meaning (*sensu lato*) of the word (Vince Neall personal communication, 2017). Even though Thórarinsson's (1954) definition did not specifically exclude flow deposits, Neall (1972, p. 510) argued that because pyroclastic flow deposits 'flow from a crater during an eruption' they should not be considered 'tephra' and hence should be classified separately as 'flow deposits'. Nevertheless, by 1973–74, the term 'tephra' (*sensu lato*) was no longer restricted to fall deposits because it had been recognised that ignimbrites could be partly or entirely non-welded and unconsolidated (Ross and Smith, 1961; Sparks et al., 1973; Froggatt and Lowe, 1990). Furthermore, it was argued by Thórarinsson (1974), who had used the term 'tephra flow' to describe a small pyroclastic flow descending from the slopes of Mt. Lamington in an eruption in 1951, and also for the non-welded uppermost layer of the Thorsmörk ignimbrite in Iceland (Thórarinsson, 1969), that such deposits, strictly, were 'airborne' in their emplacement (e.g., see Lube et al., 2019). However, the term 'air-fall' is now rarely used, with tephra-fall/fallout, or ash-fall/fallout if appropriate, typically employed instead (Cole et al., 1972; Schmid, 1981; Lowe and Hunt, 2001; Lowe, 2008).

2.3.2. Laugarvatn and Reykjavík, Iceland, 1980

The next specialist tephra conference, in June, 1980, took place 16 years after the 1964 Tokyo meeting. Held in Laugarvatn and Reykjavík, Iceland, it was supported by the NATO Advanced Studies Institute and COT (Self and Sparks, 1981a, b) (Fig. 3).

Figure 3. (Left) Logo for the Icelandic INQUA-COT tephra meeting in June 1980 that was designed by Sue Selkirk (Arizona State University) (Self and Sparks, 1981a), depicting the distribution of the historic silicic tephra, H$_1$, erupted from Hekla in 1104 AD, the outermost isopach being 2 mm (isopach map based on Larsen and Thórarinsson, 1977, p. 29, although it had been originally mapped by Thórarinsson in 1939: Steinthórsson, 2012, p. 5). **(Right)** Some participants in the field in Iceland during the meeting. Figure centre-

https://doi.org/10.5194/hgss-2021-22
Preprint. Discussion started: 22 December 2021

front with blue jacket is Sigurdur Thórarinsson; just behind him (with sample bag) is (Sir) Stephen Sparks. Photo: Malcolm Buck.

At this Iceland meeting, it is striking that Self and Sparks (1981a, p. xii), closely following Thórarinsson (1974, p. xviii), defined 'tephra' (*sensu lato*) as "a collective term for all airborne pyroclasts, including both air-fall and pyroclastic flow material", pointing out that "this usage complements rather than replaces terms such as ignimbrite, welded tuff, pumice, etc., that are used to designate specific types of tephra produced by distinctive types of eruption". Also, as evident on the conference logo image in Fig. 3, they referred to the Commission on 'Tephra', rather than 'Tephrochronology', presumably because the latter term was seen to be somewhat restricted in its original sense (use of tephra layers as a correlational and age-equivalent dating tool) so that potential volcanological interpretations and applications appeared to be downplayed. Later, advent of the names Commission, or Subcommission, on Tephrochronology and Volcanism – i.e., COTAV or SCOTAV in 1995 and 2003, respectively (Table 1) – made 'volcanology' an explicit function of the commission. However, as noted previously, today's more holistic usage of 'tephrochronology' (*sensu lato*), encompassing all aspects of tephra studies including volcanology, now negates this argument and obviates the need to include 'volcanism' in the modern commission's name (Lowe and Hunt, 2001; Lowe, 2008). (Also, COT, being sponsored by IAVCEI, has an obvious volcanological connection.)

2.3.3. Mammoth Hot Springs, USA, 1990

The tephra meeting in 1990 in Mammoth Hot Springs (Yellowstone National Park), Wyoming, USA, was next, the first of what might be deemed a 'golden decade' in which four specialist tephra conferences were held (Table 2). The meeting in Mammoth, under the ICCT banner, comprised around 53 participants, the majority from the USA but with representatives also from Canada, Japan, New Zealand, Australia, Belgium, Tanzania, Ethiopia, and the UK (Fig. 4). Some scientists from the USSR and several other countries were unable to attend because of financial limitations or (in the case of the Soviets) a lack of flights at that tumultuous time (Lowe, 1990b).

Figure 4. (Upper) Participants of the ICCT tephra meeting held in Mammoth Hot Springs, Yellowstone National Park, USA, June, 1990. Photo: anonymous. **(Lower)** Participants in the field on 4 December, 1993, near Haruna volcano, northern Kanto, Japan, during the PAGES/INQUA-COT workshop on the climatic impact of explosive volcanism. Photo: anonymous. Names of the participants in this photo are listed in Appendix A.

Presentations featured a notable array of new dating techniques for tephra components such as isothermal-plateau fission-track dating (ITPFT) of glass, single-crystal laser fusion analysis using $^{40}Ar/^{39}Ar$, luminescence dating, and high-precision radiocarbon (^{14}C)-dating using liquid scintillation spectrometry. In addition, reports from ICCT working groups were presented, including one to standardise the characterization of tephra deposits, the role of tephra in land-sea correlation, and the development of a catalogue of widespread Quaternary tephras. Five days were spent in the field (six or seven counting the days travelling overland to and from Mammoth), two being in the Yellowstone Park region of the Yellowstone Plateau Volcanic Field, and three on a post-conference tour looking mainly at Yellowstone tephra localities, Quaternary deposits and, occasionally, soils and paleosols in northern Yellowstone National Park and the northern Bighorn Basin, Wyoming (Lowe, 1990b).

A conspicuous outcome of the Mammoth conference was the publication of the first of a number of proceedings in the journal *Quaternary International*, which was founded in 1987 and is owned by INQUA (and therefore returns a profit to the union to help fund its activities) (Catto, 2019). The Mammoth conference special issue, entitled straightforwardly as 'Tephrochronology: stratigraphic applications of tephra' and comprising 27 scientific papers, was an early double-volume of the journal (Westgate et al., 1992a, b).

2.3.4. Tokyo, Japan, 1993

The Tokyo meeting in 1993, co-sponsored by the Past Global Changes (PAGES) Core Project of the International Geosphere-Biosphere Programme (Oldfield, 1998) and INQUA's COT, was the first to be designated as a field conference *and workshop* because it focussed on a specific theme, namely the impact of volcanism on climate. As well as spending time in the field (Fig. 4) and in oral presentations, the 37 participants (representing institutions in six countries) were therefore involved in break-out sessions in four *ad hoc* working groups:

- Modelling studies, ice cores, frozen ground, historic, and non-biologic records
- Tree-rings, palynology, corals (biologic records)
- Volcanology and climate components
- Tephrochronology.

Their task was to answer a series of topical questions and to synthesise ideas and data. A final discussion session led to a series of recommendations that were published in a report by Begét et al. (1996).

2.3.5. Hamilton, New Zealand, 1994

The meeting in Hamilton, on New Zealand's North Island, in February, 1994, as well as being the first in the Southern Hemisphere, was noteworthy in being the first to be held under the INQUA banner that involved three commissions – tephrochronology, loess studies, and paleopedology. The conference included a special symposium, the 'C.G. Vucetich Symposium on Tephrostratigraphy and Tephrochronology in New Zealand'. The 62 participants (including 12 students) from institutions in 12 countries (Fig. 5) spent two days in the field during the conference and a group of 35 took part in the five-day post-conference North Island field trip (Lowe, 1994b). Along with the field guides, the proceedings took up three slender but contiguous volumes of *Quaternary International* and comprised 27 scientific papers (Lowe, 1996b, c).

https://doi.org/10.5194/hgss-2021-22
Preprint. Discussion started: 22 December 2021

Figure 5. **(Upper)** Participants in the integrative triple-discipline (tephra-loess-paleosols) meeting at University of Waikato, Hamilton, New Zealand, photographed on 8 February, 1994. Photo: Ross Clayton (University of Waikato). Names of the participants in this photo are listed in Appendix A. **(Lower)** (*Left*) Front page of flyer prepared prior to the meeting in New Zealand. (*Middle*) Brad Pillans exposing buried soil horizons (paleosols) formed on early Holocene, Taupo volcano-derived rhyolitic tephras overlying steeply dipping reworked Oruanui eruptives deposited into a temporary lake, Lake Taupo forest area, central North Island (stop 7 on day-one of five-day post-conference field trip, 13 February; Wilson, 1994). (*Right*) Colin Wilson explaining the stratigraphy of mid-Holocene Taupo-derived eruptives (~5.4–4.5 cal ka) with intervening soil horizons near southern Lake Taupo (stop 11). Photos: David Lowe.

2.3.6. Brives-Charenac, France, 1998

The meeting held in Brives-Charenac in the Haute-Loire region of southern France from 24-29 August, 1998, with 53 participants from institutions in 11 countries, successfully brought together tephrochronology and volcanism (as represented by COT) and their relationship to humans in antiquity (Fig. 6). The latter aspect was represented by Commission 31, 'Humans and Active Volcanoes during History and Prehistory', of the International Union of Prehistoric and Protohistoric Sciences (IUSPP) (Table 2).

https://doi.org/10.5194/hgss-2021-22
Preprint. Discussion started: 22 December 2021

Figure 6. **(Upper)** Participants in the tephra meeting held in Brives-Charenac, France, in August, 1998. Photo: Jean-Paul Raynal. **(Lower)** (*Left*) Part of cover page for programme/abstracts volume of the meeting, The COT logo – a three-armed bubble-junction (cuspate) glass shard with an electron probe (or laser) beam spot on it – was designed by Paul van den Bogaard (Germany). (*Right*) After COT became INTAV in 2007, cartographer Betty-Ann Kamp (University of Waikato) updated the logo in 2008 to this now-familiar form.

By this time, a logo for the commission had been developed by Paul van den Bogaard (Fig. 6), possibly in anticipation of the tephra-based field trip to the Eifel Volcanic Field he co-led prior to the Berlin INQUA Congress held in August, 1995 (Lowe, 1995). The Brives-Charenac conference was followed by a three-day post-conference field trip across the Massif Central volcanic fields. Although it had been originally planned that the conference proceedings would appear in the journal *Quaternaire*, the large number of papers accepted, 27 in total, rendered that option impractical. Remarkably, a new journal, *Les Dossiers de l'Archaéo-Logis*, was established in which all the papers were eventually published (Juvigné and Raynal, 2001a, b).

2.3.7. Dawson City, Canada, 2005

Seven years passed before the spectacular 2005 'Tephra Rush' meeting, now under the banner of SCOTAV, was held in Dawson City, Yukon Territory, Canada (Fig. 7; Alloway et al., 2005). The meeting, comprising 41 participants from institutions in 11 countries (Table 2), began with an evening public lecture in Whitehorse by

https://doi.org/10.5194/hgss-2021-22
Preprint. Discussion started: 22 December 2021

volcanologist and author Grant Heiken, thereby helping to enhance public dissemination of tephra-based research (one of the aims of the commission: see Sect. 4 below). Heiken explored the different human perceptions of volcanoes and the risks of living in the shadow of a volcano. A second public lecture was given during the conference by Paul Matheus on the topic of Beringian mammals. A one-day field trip from Whitehorse to Dawson took place on 1 August, 2005 (Fig. 7), and two days were spent in the Klondike Goldfields during the conference itself (Davies and Alloway, 2006).

Figure 7. (Upper) Participants in the 2005 'Tephra Rush' meeting on 3 August, 2005, in Dawson City, Yukon Territory, Canada (from Froese et al., 2008a, p. 2). Photo: Brent Alloway. Names of the participants in this photo are listed in Appendix A**. (Lower)** John Westgate (with megaphone) and Duane Froese on 1

https://doi.org/10.5194/hgss-2021-22
Preprint. Discussion started: 22 December 2021

August, 2005, explaining the stratigraphy, chronology, composition, and distribution of the AD 833–850 White River Ash (eastern lobe) on the pre-conference trip from Whitehorse to Dawson (Froese et al., 2005). The eruption was coincident with the transition in southern Yukon from atlatl and throwing dart technology to adoption of bow and arrow, which were likely present a few hundred years earlier in southern Alaska. Possibly a proto-Athapaskan population inhabiting the region was strongly affected by the ecological impacts of the volcanic eruption and migrated, at least temporarily, from the thick tephra-fall region to encounter this technology (Davies and Alloway, 2006). Diminutive forms of the same White River ash were recognised by Jensen et al. (2014) as a cryptotephra in Greenland and northern Europe (where it is dated AD 846–848), the first record of the 'transatlantic distribution' of an eruptive. Photo: Brent Alloway.

The subsequent special issue of *Quaternary International*, edited by Froese et al. (2008c), comprised 20 scientific articles based on presentations at Dawson, as well as from a special session of the annual Geological Society of America conference (held in Salt Lake City in October, 2005) entitled 'Advances and Applications of Tephrochronology and Tephrostratigraphy: in Honor of Andrei M. Sarna-Wojcicki'. The special issue by Froese et al. (2008c) was the first by the commission to specifically honour in its title two of the biggest names in tephrochronology, John Westgate and Andrei Sarna-Wojcicki (Froese et al., 2008b; Slate and Knott, 2008).

2.3.8. Kirishima City, Japan, 2010

In 2010, the commission returned to Japan where a meeting was held in Kirishima City in southern Kyushu from 9–17 May, 2010, this time under the INTAV banner. One reason for the meeting to be hosted in Japan was to expose the emerging cohort of cryptotephra specialists (who tended to work only on sparse shards from mainly distal or ultra-distal locations) to proximal pyroclastic and volcanic deposits as a way of broadening their experience and understanding. The conference was held during a lull in the 2010 eruptions of Eyjafjallajökull in Iceland, with the latter's on-and-off behaviour (Gudmundsson et al., 2010; Davies et al., 2010) creating opportunities for considerable press interest in the meeting (including local TV coverage of a special public session on the Icelandic eruptions and impacts, with presentations by Chris Hayward, Siwan Davies, and Thor Thordarson) and some headaches for travel arrangements (Holt and Lowe, 2010). Of the 76 participants in attendance from institutions in 12 countries, a substantial proportion (25) comprised students. At the start of the conference, two consecutive public lectures to an audience of around 800 in Kirishima City Hall were given by David Lowe ('Connecting with our past: using tephras and archaeology to date the Polynesian settlement of Aotearoa/New Zealand'), Lowe's talk being translated into Japanese whilst he spoke, and Hiroshi Machida ('Widespread tephras originating from Kagoshima occurring in northeast Asia and adjacent seas').

New work on the tephrostratigraphic record of ice cores was presented as well as new protocols involving electron probe microanalysis (EPMA), and laser-ablation inductively-coupled plasma mass spectrometry (LA-ICP-MS) analysis, of glass shards considerably smaller than previously attainable (~5 and ~10 μm in diameter, respectively). The revolutionary rise of Bayesian age-depth modelling, which has helped

https://doi.org/10.5194/hgss-2021-22
Preprint. Discussion started: 22 December 2021

to dramatically improve age frameworks for tephras and cryptotephras, was also reported (e.g., Blockley et al., 2007; Lowe et al., 2008b; Bronk Ramsey et al., 2015a; Blaauw et al., 2018).

An influential letter was written during the conference by the COT president and secretary on behalf of INTAV to the Secretariat of the Japan Geopark Committee. Signed by more than 50 conference participants, the letter supported the application by Kirishima City for the Kirishima volcano system ('Kirishima Mountains') to become an accepted member of Geoparks Japan as Kirishima Geopark. The park was successfully certified later that year.

The meeting also featured two days in the field, on the first of which participants witnessed several small eruptions of Sakurajima (Fig. 8). A three-day post-conference field trip across Kyushu was held as well, and included visits to Unzen volcano, Aso caldera, and Kuju and Yufu-Tsurumi volcanoes. Unusually, participants on the post-conference trip were given a small refund at the end, such was the efficiency of the leaders.

Figure 8. **(Upper)** Participants of the 'Active Tephra' meeting held in Kirishima in May, 2010, in the field on Kyushu, Japan. Sakurajima volcano (just visible in the background) erupted later that day during the trip (see below) (from Lowe et al., 2011a, p. 2). Photo: Koji Okumura. **(Lower)** (*Left*) Thick coastal exposure of Aira tephra formation (erupted ~ 30 cal ka from Aira caldera) near Fumoto on the eastern coast of Kagoshima Bay and visited 13 May, 2010. Initial deposits comprise plinian fall deposits (Osumi pumice) overlain by thin stratified (intra-plinian) pyroclastic flow deposits (Tarumizu ignimbrite) and then by thick, mainly non-welded ignimbrite, Ito ignimbrite (bulk volume >450 km^3). Ito ignimbrite is coeval with a widespread co-ignimbrite ash, first recognised in 1976, named Aira-Tanzawa ash (Aira-Tn) (Machida and Arai, 2003). Photo: David Lowe. (*Middle*) Small vulcanian eruption from active Showa crater (Minamidake crater), Sakurajima volcano,

one of two witnessed just a few minutes after participants arrived at the stop (12 May, 2010). Such impressive 'organisation' was greatly admired by all! Photo: David Lowe. (*Right*) Participants examining Holocene tephras and humic buried soil horizons at Tenjindan archaeological site of Joman era on Osumi Peninsula near Kagoshima Bay, southern Kyushu, on the mid-conference field trip (13 May). The bright yellowish-orange tephra about 1.2 m below the land surface is Kikai-Akahoya tephra aged ~7.3 cal ka. Artefact locations are marked with tags in the foreground (Moriwaki and Lowe, 2010). Photo: David Lowe.

The conference proceedings, published in *Quaternary International* and comprising a record 31 scientific papers (Lowe et al., 2011b), were dedicated to the memory of Shinji Nagaoka (Moriwaki et al., 2011a). The then editor-in-chief for *Quaternary International*, Norm Catto, described the papers from the Kirishima meeting as part of an "outstanding *QI* volume" and "one of the most commonly downloaded through the Elsevier website" (Norm Catto personal communication, 2013). The volume paid specific tribute to the leading researcher of his generation in Japan, Hiroshi Machida. Of him, Suzuki et al. (2011, p. 6) stated: "Perhaps more than any other geoscientist from Japan, Hiroshi carried the insights and advances of tephra studies and their application in palaeoenvironmental and archaeological research, landscape processes, and volcanology and hazard analysis, to the outside world through a succession of papers and books written in English and through conference presentations". Machida followed initially in the large footprints of Kunio Kobayashi, who, as well as founding COT, had a similarly compelling, outward-looking role in the 1960s and early 1970s through his development of methods to characterize tephras both in the field and petrographically, and by publishing papers in English to widen their impact (e.g., Kobayashi and Shimuzu, 1962; Momose et al., 1968; Kobayashi, 1969, 1972). Kobayashi also encouraged scientists from countries other than Japan to become involved in promoting tephra studies, including through appointment to COT's executive committee (John Westgate personal communication, 2021).

2.3.9. Moieciu de Sus, Romania, 2018

There was an eight-year period before the next tephra meeting, the 'Tephra Hunt in Transylvania' conference held (under the auspices of INTAV) in the Cheile Gradistei Fundata Resort near Moieciu de Sus and set in the dramatic landscapes of the south Carpathian Mountains of Romania. Prior to this meeting, the INTAV committee members for some years had been working on holding a meeting in Chile and Argentina, but changes in circumstances for key personnel meant that it had to be shelved in 2016. The Transylvania meeting, with a theme of 'Crossing new frontiers', is the largest tephra meeting of the commission held thus far (Table 2): 92 participants from institutions in 21 countries attended, including 22 students (17 of whom were undertaking PhDs) (Lowe, 2018b). With nearly 100 attending, around double the number of countries normally represented, and the robust mix of senior, experienced, and emerging researchers, this meeting might be considered a 'coming of age' for INTAV. It included four days in the field – a one-day mid-conference trip that took in a memorable visit to Bran Castle and a three-day post-conference trip with 32 participants – as well as a public lecture where the complex geological setting of the region was introduced by Ioan Seghedi. A workshop for several dozen participants on Bayesian age modelling was led by Maarten Blaauw (Fig. 9).

https://doi.org/10.5194/hgss-2021-22
Preprint. Discussion started: 22 December 2021

Figure 9. (Upper) Participants of the Transylvanian 'Tephra Hunt' conference in the Perșani volcanic field on 26 June, 2018, in the southern Carpathians, Romania, during the mid-conference field trip (from Abbott et al. 2020a, p. 2). Photo: Pierre Oesterle. **(Lower)** (*Left*) A distal occurrence of Y5 tephra, about 0.6 m thick, associated with the Campanian Ignimbrite eruption c. 39–40 ka of the Campi Flegrei field (Italy), within loess on the Wallachian plains in southeast Romania near the Buzău River. Dan Veres is directly alongside the darker, slightly pinkish, fine-grained Y5 tephra deposit. Photo: David Lowe. (*Right*) Maarten Blaauw (far right) leading a Bayesian age-modelling workshop during the conference on 27 June, 2018. Such workshops (on various topics) have been a feature of a number of tephra meetings, in some cases the main focus (e.g., Tokyo, 1993; Portland, 2014 and 2017). Photo: David Lowe.

Faithfully following the commission's enduring and important philosophy, only one session of oral papers was run during the Romanian conference (i.e., no parallel sessions were held) so that all participants could see all the talks and thereby support ECRs as well as taking in keynote and other oral presentations. In addition, the organisers placed equal value on poster papers, with all posters being displayed for the entirety of the conference, and they were featured in stand-alone poster presentation sessions. The special volume of ensuing papers, published as a double issue of the *Journal of Quaternary Science* (Abbott et al., 2020b), includes 27 scientific articles and was entitled 'Crossing new frontiers: extending tephrochronology as a global geoscientific research tool'. The volume was dedicated to the memory of Richard Payne (Abbott et al., 2020a; Bunting et al., 2020).

2.4 Other activities of COT

As well as the nine stand-alone, specialist tephra meetings described above, tephrochronologists of COT have been active since the 1960s in convening and running tephra-focussed sessions or symposia, or leading field trips, in association with various commissions or full congresses of INQUA or IAVCEI (e.g., Smith, 1986; Eden and Furkert, 1988; Saito et al., 2016; Lane et al., 2017b; Hopkins et al., 2021a; Scott, 2021), or in conjunction with PAGES (Past Global Changes) (e.g., Hall and Alloway, 2004) or other organisations such as the International Geological Congress (IGC) or the National Science Foundation (NSF) of USA.

COT members have also been heavily involved in a range of projects including the highly successful INTIMATE Project (which was launched for the North Atlantic region at the 1995 Berlin INQUA Congress) in which tephrochronology has played a pivotal role (e.g., Davies et al., 2002, 2012; Turney et al., 2004a, b; Alloway et al., 2007; Lowe et al., 2008b; Lowe et al., 2008; Moriwaki et al., 2011b; Barrell et al., 2013; Blockley et al., 2014). In addition, studies on tephras or cryptotephras have featured at numerous national or regional meetings or specialist workshops (e.g., Smalley, 1980; Howorth et al., 1981; Suzuki and Nakamura, 2005; Dugmore et al., 2011; Benediktsson et al., 2012a; Austin et al., 2014a). Some of these meetings were built around multi-disciplinary projects such as SMART (Synchronising Marine And ice-core Records using Tephrochronology), which was one of the first systematic projects investigating the cryptotephra record preserved within North Atlantic marine deposits (Austin et al., 2014b), and the RESET project (RESponse of humans to abrupt Environmental Transitions) (Lowe et al., 2015).

Examples (not comprehensive) pertaining mainly to INQUA congresses, or specific commissions where field trips and sessions (symposia) involving aspects of tephrochronology were featured, include the following:

- 1965 INQUA Congress in Boulder (tephra session/s; field trips in Pacific Northwest, central-south Alaska) (Neustadt, 1969)
- 1969 INQUA Congress in Paris (tephra session/s; field trip in Massif Central) (Neustadt, 1969)
- 1973 INQUA Congress in Christchurch (tephra session/s; field trips in western North Island, central North Island) (Fairbridge, 1974)
- 1977 INQUA Congress in Birmingham (tephra session/s)
- 1986 IAVCEI International Volcanological Congress in Auckland-Hamilton-Rotorua (sessions on explosive volcanism, tephrochronology; field trips in North Island, e.g., Houghton and Wilson, 1986)
- 1987 New Zealand conference, Western Pacific Working Group of INQUA Loess Commission (field trip including North Island, e.g., Smalley and O'Hara-Dhand, 2010)
- 1987 INQUA Congress Ottawa (tephra session; advent of ICCT)
- 1990, 1992, 1994 Biennial UK Tephra Meetings in Edinburgh (1990), Belfast (1992), and Cheltenham (1994) (e.g., Hunt, 1999a)
- 1991 INQUA Congress in Beijing (tephra session/s)

- 1992 IGC Tephra and volcanological meeting, Mt Tateyama, Japan
- 1995 INQUA Congress in Berlin (tephra session/s; field trip in Eifel Volcanic Field)
- 1999 INQUA Congress in Durban (tephra session/s; formalising link between S/COTAV and INTIMATE Project; e.g., Turney et al., 2004a)
- 2000 4th International INTIMATE Workshop, INQUA Palaeoclimate Commission and COTAV, Kangerlussuaq, Greenland (e.g., Turney et al., 2004b)
- 2003 INQUA Congress in Reno (tephra session/s; launch of Australasian INTIMATE Project, e.g., Shulmeister et al., 2006)
- 2005 NSF Revealing Hominid Origins Initiative, International Tephra Working Group Workshop, Santa Fe, New Mexico (WoldeGabriel et al., 2005)
- 2007 INQUA Congress in Cairns (tephra sessions; field trip in Atherton Tablelands)
- 2011 INQUA Congress in Bern (tephra sessions)
- 2012 Tephra and Archaeology – Chronological, Ecological and Cultural Dimensions Symposium, Annual Meeting of European Association of Archaeologists, Helsinki
- 2015 INQUA Congress in Nagoya (tephra sessions; numerous field trips)
- 2017 IAVCEI Scientific Assembly in Portland, Oregon ('Best Practices' tephra workshop)
- 2019 INQUA Congress in Dublin (tephra sessions) (see Sect. 7 below)
- 2021 American Geophysical Union AGU21 Fall Meeting (tephra session).

3 Officers of COT and their roles, members, key periods in COT's development, and funding since 2007

3.1 Officers of COT

Until the Nagoya INQUA Congress in 2015, the commission committees (also called executives) usually comprised three officers elected to serve the needs of COT: a president, vice-president, and secretary (Table 3). A total of 29 different people have filled the committee roles over the past 60 years, representing nine countries. Twenty-two officers have represented just four countries: UK (8 officers), New Zealand (5), USA (5), and Japan (4). Around half (14) of the officers have served eight years or more, the longest serving being Kunio Kobayashi (12 years), Takehiko Suzuki (12 years), and David Lowe (16 years).

https://doi.org/10.5194/hgss-2021-22
Preprint. Discussion started: 22 December 2021

Table 3. List of officers of COT/S, CEV, ICCT, COTAV, SCOTAV, or INTAV*.

Inter-congress period	Name[1]	President	Vice-president (VP)	VP	VP	Past–president (PP)	VP (ECR rep)
2019-on[2]	COT (IAVCEI)	Britta Jensen (CA)[3]	Peter Abbott (CH)	Ian Matthews (UK)	Paul Albert (UK)	Takehiko Suzuki (JP)	Jenni Hopkins (NZ)
		President	**VP**	**VP**	**VP**	**PP**	
2015-2019	INTAV	Takehiko Suzuki (JP)	Britta Jensen (CA)	Peter Abbott (UK)	Victoria Smith (UK) + Siwan Davies (UK)	David Lowe[4] (NZ)	
		President	**VP**	**Secretary**			
2011-2015	INTAV	David Lowe (NZ)	Takehiko Suzuki (JP)	Victoria Smith (UK)			
2007-2011	INTAV	Siwan Davies (UK)	Phil Shane (NZ)	David Lowe (NZ)			
2003-2007	SCOTAV	Chris Turney (AU)	Siwan Davies (UK)	Brent Alloway (NZ)			
1999-2003	COTAV	Etienne Juvigné (BE)	Valerie Hall (UK)	Chris Turney (UK)			
1995-1999	COTAV/ COTS	James Begét （US）	Etienne Juvigné (BE)	Valerie Hall (UK)			
1991-1995	COT	Hiroshi Machida (JP)	James Begét (US)	David Lowe (NZ)			
1987-1991	ICCT	John Westgate (CA)	Hiroshi Machida (JP)	Paul van den Bogaard (DE)			
1982-1987	CEV (IAVCEI)	Bruce Houghton (NZ)[5] Grant Heiken (US)		Colin Wilson (NZ) Wolf Elston (US) Stephen Self (US)			
1977-1982	COT	Stephen Sparks (UK)[5]		Stephen Self (US)			
1973-1977	COT	Dragoslav Ninkovitch (US)	Yoshio Katsui (JP)	Colin Vucetich (NZ)			
1969-1973	COT	Kunio Kobayashi (JP)	(?) Sohei Kaizuka (JP)	John Westgate (CA)			
1965-1969	COT	Kunio Kobayashi (JP)[6]					
1961-1965	COT	Kunio Kobayashi (JP)[6]					

* For abbreviations see Table 1. Gaps indicate non appointment
[1] Affiliated with INQUA except where noted (with IAVCEI)
[2] Interim committee to support the transition to IAVCEI
[3] CA, Canada; NZ, New Zealand; JP, Japan; IS, Iceland; CH, Switzerland; BE, Belgium; DE, Germany; UK, United Kingdom; US, United States of America
[4] David Lowe has been emeritus advisor to the committee since 2019
[5] IAVCEI commissions at this time comprised two officers. Sigurdur Thórarinsson held an honorary president role in COT from 1977–82 (Self and Sparks, 1981a; Elston and Heiken, 1984)
[6] Up until 1969, the COT executive evidently comprised only a president

There has been ongoing support for COT through elected officers since the 1990s as new generations have emerged, including from the increasing numbers of cryptotephra specialists. However, it must be said that to join the commission as an officer does entail dedication and, at times, intense bursts of work – such as developing, promoting, organising, and enacting specialist field conferences or tephra symposia at the INQUA congresses. Within IAVCEI, it is an expectation that normally a meeting is held by commissions within each inter-congress period, i.e., roughly every four years. As well as organising these meetings, officers of the commissions have hosted business meetings for commission members, acquired funding (see Sect. 3.4 below), developed and hosted websites, and, as editors, typically led the publication of articles following conferences in proceedings comprising special collective issues of journals or books.

https://doi.org/10.5194/hgss-2021-22
Preprint. Discussion started: 22 December 2021

History of Geo- and Space Sciences Discussions
Open Access

In 2015, the INTAV committee was expanded to five officers: a president, an immediate past-president, and three vice-presidents (Table 3). Partly this move was recognition that in the age of the internet a secretarial role had become less pivotal, but the main reasons were to:

- enhance the general functioning capability of the committee to reflect a rapidly growing membership
- to help spread the increasing load relating to the acquisition of funding and associated compliance
- to develop capacity to cope with workload in the 2015–19 inter-congress period of simultaneously co-organising the tephra meeting in Romania (2018) and the multiple tephra sessions planned for the Dublin INQUA congress (2019)
- to provide editing support to the local organising committee to publish the 2018 conference-related special issue (Abbott et al., 2020b)
- to widen the geographic representation and to include cryptotephra specialists
- maintain experience while concomitantly encouraging ECR-members and improving gender balance.

3.2 Members

Until the early- to mid-2000s, membership of the commission under INQUA protocol was somewhat complex with several categories including officers, formal members, honorary members, and corresponding members, the last representing by far the bulk of the membership. Formal members, usually respected specialists or allied practitioners (such as palynologists or volcanologists) who applied tephrochronology closely to their research, were limited in number – for example, just six were listed for the 1965–69 period (Neustadt, 1969, p. 90) and nine were elected at the Christchurch INQUA Congress in 1973 (Kaizuka, 1974, p. 80). (Honorary members are discussed below in Sect. 5.)

From around 2002, membership was simplified and email lists of members were developed, amalgamating formal and corresponding members into a single email group (see also Sect. 6). The process began with the advent of the 'TEPHRA' group of JISCMail (a national academic mailing list service in the UK) on 4 March, 2002, which was set up by Chris Turney (based in Queen's University, Belfast, at the time). The purpose was to facilitate discussion around tephra issues as tephrochronology (involving cryptotephras) began expanding in the UK and beyond. Membership was then widened by Siwan Davies on 11 November, 2005, following a tephra workshop in Swansea in April, 2005, to include SCOTAV members globally, the aim being "to provide an important [international] forum for increased interaction and discussion amongst those involved with tephra studies." Thus, JISCMail (Tephra) became the default membership list for SCOTAV and INTAV after 2007 (Lowe, 2008). When issues or queries required membership input or voting, members were notified via JISCMail. Today, under IAVCEI rules, members must formally sign up to COT within IAVCEI, and pay a membership fee (which include a reduced-fee option for ECRs).

https://doi.org/10.5194/hgss-2021-22
Preprint. Discussion started: 22 December 2021

Open Access History of Geo- and Space Sciences Discussions

3.3 Key periods and circumstances in the development of COT

After the 1980 Iceland meeting, the need for COT was questioned. Some considered that COT "had reached its goals of communicating the utility of tephrochronology and tephra studies to the scientific community" (chiefly with publication of Westgate and Gold, 1974, and Self and Sparks, 1981) (Elston and Heiken, 1984). Realization that research on explosive volcanism was rapidly expanding at this time led the secretary of COT to propose (in December, 1982) that some members of the commission could serve as a nucleus for a proposed Working Group (WG) on Explosive Volcanism within IAVCEI. A proposal for such a working group was submitted to the IAVCEI Secretariat at the International Union of Geodesy and Geophysics (IUGG) meeting in Hamburg in August, 1983. The IAVCEI Executive Committee officially approved adoption of the WG at the Hamburg meeting (Elston and Heiken, 1984; Schmincke, 1989, p. 234), and Grant Heiken was appointed president and Stephen Self secretary. Self was replaced in 1984 by Wolfgang ('Wolf') Elston. Sometime after, the WG was renamed the Commission on Explosive Volcanism (CEV). Bruce Houghton (president) and Colin Wilson (secretary) led the CEV from 1986 following their pre-eminent roles in the highly successful IAVCEI International Volcanological Congress (centenary of 1886 Tarawera eruption) held in New Zealand in February, 1986 (Schmincke, 1989). Retirements or passing of some of the early protagonists of COT may have had an impact on this shift from INQUA to IAVCEI in the early 1980s. It seems possible also that the long hiatus since the first COT meeting in 1964 could have been another catalyst for change.

In 1987, however, at the INQUA Congress at Ottawa, several persons, especially those from Japan, expressed the view that the needs of tephrochronologists were not being met under IAVCEI. It was decided at this meeting to make a request to the INQUA Executive Committee for reinstatement of COT. John Westgate convened a meeting at the conclusion of the tephra symposium in Ottawa and prepared a document justifying this wish. He presented it to the INQUA Executive Committee the next day. The executive decided to reinstate this group but under the title 'Inter-Congress Committee on Tephrochronology' (ICCT). There would be a trial period of inter-congress length and a decision to elevate to a full commission would be made at the next INQUA Congress. Looking back, it might seem this was a bit harsh, but a more objective view is that COT's first quarter of a century might be characterized as somewhat below par with only two field meetings (1964, 1980), albeit tempered with a strong presence by COT at the INQUA Congress in Christchurch (1973) and publication of Westgate and Gold (1974) and Self and Sparks (1981). In any event, the formation of ICCT in 1987 can be seen as a turning point for COT: the election of a full complement of officers in 1987 under Westgate's leadership, the successful tephra meeting in Mammoth in 1990, and the subsequent volume of ensuing papers (including the new tephra characterization protocols of Froggatt, 1992) edited by Westgate et al. (1992b), collectively demonstrated a renewed and strong commitment by ICCT and enabled COT to be restored as a formal commission of INQUA in Beijing in 1991 (Lowe, 1996a).

The momentum was maintained with the PAGES-COT 'Climatic impact of volcanism' meeting held in Japan in December, 1993, the triple-discipline meeting held only a few months later in New Zealand in

Open Access History of Geo- and Space Sciences Discussions

February, 1994, and the meeting held in France in July-August, 1998 (Table 2). At the same time, cryptotephra studies of the modern era (noted earlier) were advancing at pace (e.g., Pilcher and Hall, 1992, 1996; Merkt et al., 1993; van den Bogaard et al. 1994; Pilcher et al., 1995; Dugmore et al., 1996) and so a new cohort of graduate students (working on cryptotephra) was training in parallel to the more traditional graduates developing skills and expertise relating to visible tephra and associated deposits in volcanic countries (Froese et al., 2008a). It is also noteworthy that, following on from Froggatt's (1992) recommendations, John Hunt and Peter Hill undertook in the 1990s the first interlaboratory comparison exercise involving EPMA, targeting data quality, testing glass standards (including Lipari obsidian), and evaluating reproducibility (Hunt and Hill, 1993, 1996, 2001; Hunt et al., 1998).

The 2010 Active Tephra meeting in Kirishima, Japan, may thus be viewed as another turning point for COT, described as a 'step-change' in tephrochronology by Lowe et al. (2011a), because by then, or soon after, many cryptotephra specialists were graduating, some taking up research and/or lecturing positions, and therefore helping to develop new directions for research including in the marine environment and in ice cores. Thus an increasingly global outlook began to accelerate from around that time (Davies, 2015; Lane et al., 2017a).

We mentioned earlier that new dating techniques were reported at the 1990 Mammoth meeting, and also Bayesian age modelling (built around ever-improving ^{14}C-calibration curves and other age data, most recently including zircon double dating) was featured at the 2010 Kirishima meeting. These techniques, alongside improving and new analytical techniques for glass shards, especially involving EPMA and LA-ICP-MS that were developing through the 1990s and the 2000s, provided further drive to enable tephra and cryptotephra studies to flourish (e.g., Westgate et al., 1994; Hunt et al., 1998; Pearce et al., 1999, 2011, 2014; Platz et al., 2007; Kuehn et al., 2011; Hayward, 2012; Pearce, 2014; Tomlinson et al., 2015; Danišík et al., 2020). In particular, the need to date glass shards in distal or ultra-distal settings, where inappropriate or no mineral grains were present, helped lead to the critical development of the IPTFT method. Moreover, the requirement to be able to analyse very small glass shards accurately (such as in ultra-distal ice cores) led to the development of improved probe and LA-ICP-MS methods in cryptotephra studies (Alloway et al., 2013; Lowe et al., 2017a).

Thus by the time the most recent commission meetings were held in 2015 (Nagoya, Japan), 2017 (Portland, USA), 2018 (Moieciu de Sus, Romania), and 2019 (Dublin, Ireland), the contributions of participants in the discipline were wide ranging and detailed, i.e., the new research had both breadth and depth. A survey undertaken of commission members in 2017 (as part of an EXTRAS funding application to INQUA) showed that ECRs and PhD students made up a healthy 39% of respondents, balanced by 53% of established or senior scientists (along with 8% of researchers associated with developing countries). Creditably, female tephrochronologists amounted to 39% of respondents at that time (cf. male 61%). We speculate that this gender imbalance may have tilted further towards an even more equitable status since the survey in 2017.

3.4 Funding acquired by INTAV since 2007 and its expenditure

The commission officers have always had to bid for funding, primarily from INQUA and also from PAGES. Funding and in-kind support have also been acquired from numerous geo-institutes, universities, city councils, and private companies relating to the hosting of events in various cities or countries. These funds have been used to support specialist meetings and/or for publishing special COT-endorsed volumes, such as Westgate and Gold (1974), or conference proceedings such as Juvigné and Raynal (2001b). Since 2007, support from INQUA, especially through successive presidents of SACCOM until 2018, has been greatly appreciated, particularly financial support (approximately €35,000 in total from 2009–2018) that mainly helped ECRs attend the international field conferences and specialist (tephra skills) workshops as follows:

- full tephra field meeting in Kirishima, Japan in May, 2010 (supported also by PAGES: Lowe, 2011b)
- Bayesian age-modelling workshop in San Miguel de Allende, Mexico, led by Maarten Blaauw in August, 2010 (supported also by PAGES: Blaauw et al., 2011)
- INTAV/TIQS Tephra in Quaternary Science workshop on the Eyjafjallajökull eruption of Iceland in Edinburgh, UK, led by Andrew Dugmore in May, 2011 (Dugmore et al., 2011)
- two tephra workshops in Portland, USA, in August, 2014, and August, 2017 (Kuehn et al., 2014; Bursik et al., 2017) (https://vhub.org/search/?terms=tephra+workshops) (see Sect. 7.1 below)
- full tephra field meeting in Moieciu de Sus, Romania, in June-July, 2018 (Karátson et al., 2018).

Considerable efforts have been needed to justify the continuation of the focus group (INTAV) to INQUA in the form of annual reports, bidding for and reporting on the INTREPID and EXTRAS projects; as a condition of funding, reports were also required for *Quaternary Perspectives*, the INQUA newsletter (e.g., Lowe, 2013, 2015, 2018a, b). With this past support and long history with INQUA, the decision to move the commission to IAVCEI was not taken lightly. However, the increased burden of maintaining some version of COT within INQUA, the continual need to justify its existence annually, and the loss of a structural model within which it could exist as a coherent, ongoing group (noted earlier) ultimately led to this decision. Additionally, the move to IAVCEI in 2019 was to allow for stability and a more predictable workload for the executive. It is emphasised that cooperation and involvement in quadrennial INQUA congresses are not precluded. Unfortunately, the rapid emergence of COVID-19 in 2020, and its commensurate impacts, have severely limited planning and future activities with the next specialist tephra meeting, originally planned for 2020/2021, being indefinitely delayed. A tephra symposium and other activities planned for the next IAVCEI Scientific Assembly, ostensibly being held in Rotorua, New Zealand, in late January/early February, 2023 (Scott, 2021), are also uncertain.

https://doi.org/10.5194/hgss-2021-22
Preprint. Discussion started: 22 December 2021

History of Geo- and Space Sciences Discussions
Open Access

4 Aims of COT – then and now

Prior to the 1961 Warsaw INQUA Congress, Kunio Kobayashi's pre-congress proposal for a COT included several broad aims, namely to develop tephrochronology and apply it to Quaternary research and to meet to report and discuss findings from different countries (as noted in Sect. 2.1). After the conference, he expanded on these aims, key aspects being to advance the principles of tephrochronology as well as methodology, to develop a global inventory (with regional maps) of the distribution of tephras including in the oceans, and to determine the numerical ages of tephras (Neustadt, 1969, p. 90). It is of interest that Kobayashi (1965, p. 786), after discussions in person with Prof. Josef Frechen, a tephrochronologist in Germany, compiled a list with several more potential objectives, some presciently, including:

- study of widely distributed tephra deposits, such as thin ash layers in the Greenland ice sheet and in marine sediments, derived from very explosive, large-volume eruptions
- developing microscopic methods to try to recognise the existence of tephra materials "even if they are in least [sparse] amounts"
- developing diagnostic petrographic and palaeomagnetic features on lavas to provide a basis for correlating related (co-magmatic) tephras
- undertaking weathering studies on glass and associated clay minerals and hence evaluating potential environments of deposition
- holding regular workshops/conferences to discuss ideas and compare findings.

Although the aim of COT can now be expanded to include a re-awakened focus on volcanic studies (although these have remained an important aspect in currently/recently active volcanic countries such as New Zealand, Iceland, Indonesia, Chile, USA, and Japan, e.g., Crandell and Mullineaux, 1978; Heiken and Wohletz, 1987; Lowe, 1988; Machida, 1991, 2002; Begét et al., 1994; Pilcher et al., 1995; Lowe et al., 2002; Smith et al., 2005; Waitt and Begét, 2009; Óladóttir et al., 2012; Tatsumi and Suzuki-Kamata, 2014; Cashman and Rush, 2020; Pearce et al., 2020; Romero et al., 2021), the means to achieve this aim broadly remain the same.

In general terms, the aim is to improve or develop new methods and protocols of tephrochronology (spanning field, analytical, geochronological, and digital/internet realms) to support and facilitate wide-ranging Quaternary research initiatives ranging from paleoenvironmental reconstruction to archaeology and paleoanthropology, as well as geochronological and volcanological applications. In addition, enhancing the global capability of tephrochronology for future research by training and mentoring emerging researchers remains paramount within the aims of the modern-day (post-2019) COT (Lowe et al., 2018).

The seven objectives of the (now-completed) EXTRAS project provide a useful summary of the current major aims of COT in greater detail. We have added a new objective, number 5 listed below, along with several relevant supporting references:

https://doi.org/10.5194/hgss-2021-22
Preprint. Discussion started: 22 December 2021

1. To evaluate and apply new and emerging technologies to identify and map proximal-to-distal, and ultra-distal, tephra and cryptotephra deposits, and to establish their spatial and stratigraphic interrelationships to facilitate their use as chronostratigraphic units (including within loess, ice, and other sedimentary deposits, and in soils/paleosols) and as a basis for documenting and enhancing volcanic eruption histories;
2. To develop and evaluate new and emerging methods to characterize tephra and cryptotephra constituents mineralogically and geochemically (including isotopically) using formalised protocols that enhance data quality and quantity;
3. To develop improved age models for tephra and cryptotephra deposits, including via Bayesian modelling, and hence improve existing age models for key volcanic, palaeoclimatic, archaeological, sedimentary and other sequences using tephra and cryptotephras as appropriate;
4. To evaluate and develop objective ways of correlating tephra and cryptotephra deposits from place to place using statistical techniques and numerical measures of probability of correlation;
5. Recognising and mapping transformed tephra deposits (i.e., that have undergone morphological changes such as reworking, dislocation, or bioturbation) and hence evaluating new ways of reconstructing past environments using information provided by such transformations (e.g., Dugmore and Newton, 2012; Cutler et al., 2016; Blong et al., 2017; Dugmore et al., 2020; Thompson et al., 2021);
6. To develop regional and ultimately global databases of high-quality mineral, geochemical, and other data (stratigraphic, chronologic, spatial, bibliometric) for tephra and cryptotephra deposits;
7. To maintain and enhance the global capability of tephrochronology for future research through mentoring and training of emerging researchers (ECRs) in the discipline;
8. To improve education to the wider community (outreach) about tephrochronology and its application and relevance.

5 Life membership awards

During the ICCT period (1987−1991), one of the initiatives was to recognize more clearly those individuals who had made exceptional contributions to the discipline of tephrochronology. Ray Wilcox was the first member so elected at this time (John Westgate personal communication, 2021), recorded as an ‘honorary member’. A simplification of membership categories in the early 2000s (Sect. 3.2) then led to the development (by David Lowe) of the ‘honorary life member’ award (replacing ‘honorary member’), and Ray Wilcox and Colin Vucetich were the first two recipients. Another 13 recipients have been awarded honorary life membership since 2007, all under INTAV (Table 4). The 15 life members in total represent institutions in eight countries.

https://doi.org/10.5194/hgss-2021-22
Preprint. Discussion started: 22 December 2021

Table 4. Honorary life members of COT or INTAV and the year of their award

James Begét (USA) – 2015
Andrew Dugmore (UK) – 2014
Siwan Davies (UK) – 2019
Valerie Hall (UK) (1946-2016) – 2011
John Hunt (UK) – 2011
Étienne Juvigné (Belgium) – 2007
Guðrún Larsen (Iceland) – 2018
David Lowe (New Zealand) – 2018
Hiroshi Machida (Japan) – 2007
Hiroshi Moriwaki (Japan) – 2015
Vera Ponomareva (Russia) – 2014
Andrei Sarna-Wojcicki (USA) – 2007
Colin Vucetich (New Zealand) (1918-2007) – pre-2007
John Westgate (Canada) – 2007
Ray Wilcox (USA) (1912-2012) – pre-2007

For the record, the life membership certificate (Fig. 10), designed by Betty-Ann Kamp, shows a schematic eruption plume representation based on the eruption of Mt Ruapehu stratovolcano (New Zealand) around 1230 h on 18 June, 1996 (see Lowe, 2011a, p. 108).

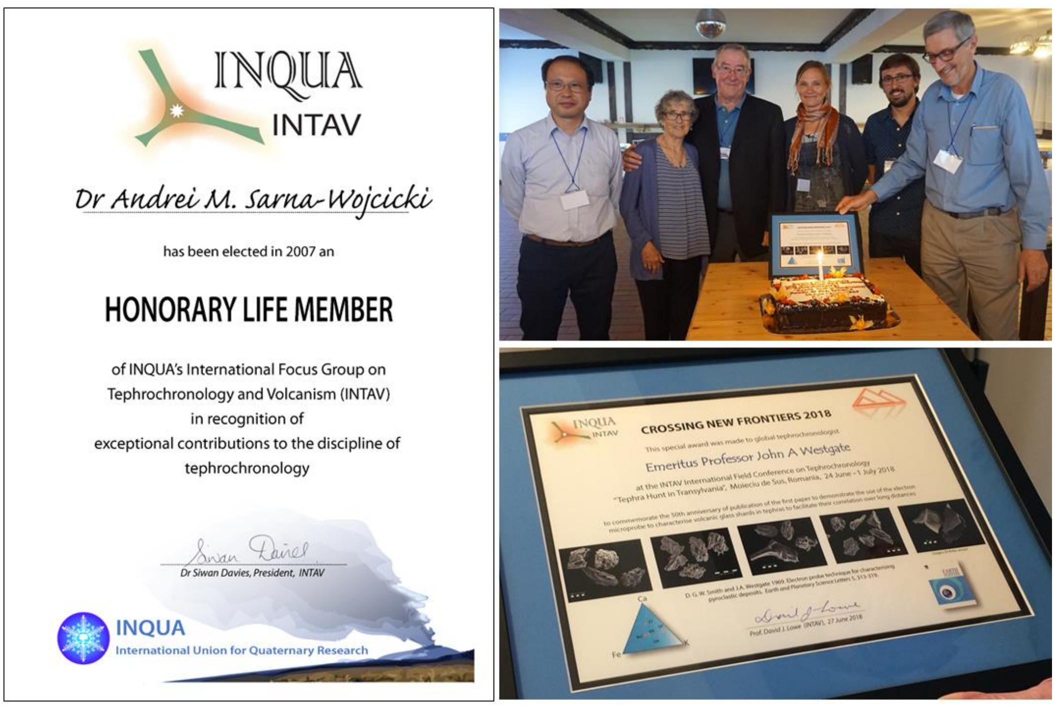

Figure 10 (Left). Example of a life member certificate of INTAV. **(Right)** (*Upper*) Special cake and unique certificate prepared for the 'Tephra Hunt' conference dinner (27 June, 2018) to commemorate the 50th anniversary of the publication of John Westgate's pioneering paper on EPMA analysis of glass shards (Smith and Westgate, 1969). From left, Takehiko Suzuki, Cora and John Westgate, Britta Jensen, Peter Abbott, and

Open Access History of Geo- and Space Sciences Discussions

David Lowe. Photo: anonymous. (*Lower*) Close-up view of the commemorative certificate presented to John Westgate. The scanning electron microscope images of glass shards (provided by Britta Jensen) represent the North American tephras that Westgate analysed in undertaking this early seminal research (see Froese et al., 2008b). Photo: David Lowe.

6 Communicating within COT and beyond

Communication amongst members was originally by irregular newsletter, probably the most recent paper copies being physically posted from 1991–94 (Machida and, Lowe 1991; Lowe, 1992, 1994a). As described earlier in Sect. 3.2 on membership, the 'TEPHRA' group of JISCMail (https://www.jiscmail.ac.uk/cgi-bin/webadmin?A0=TEPHRA) was initiated by Chris Turney in 2002 and then broadened to global coverage by Siwan Davies in 2005 "for increased interaction and discussion amongst those involved with tephra studies." That development, significantly, sparked a furious discussion about the terms 'microtephra' versus 'cryptotephra', kicked off by comments from John Lowe on 13 November, 2005. This email system is still being used today by members of COT (e.g., advertising PhD scholarships, forthcoming meetings, etc.). The archives have in fact been extraordinarily helpful in allowing us to provide some dates for events, names of people, etc., otherwise probably lost forever.

JISCMail TEPHRA works alongside a Facebook page (https://www.facebook.com/IAVCEICOT/) that was set up by Peter Abbott on 19 August, 2015 (following discussion at the Nagoya INQUA Congress earlier that month), and a Twitter feed (https://twitter.com/IAVCEI_COT). A tephrochronology website has been in place since about 2002 (under SCOTAV), originally being established by Chris Turney (then at Queen's University, Belfast, UK). It was subsequently hosted by Phil Shane (University of Auckland) from September 2008 to November 2011 (under INTAV), then by Victoria Smith (University of Oxford) until March 2017, and by Takehiko Suzuki (Tokyo Metropolitan University) from March 2017 until 2021. A new COT website, to be hosted by IAVCEI (cot.iavceivolcano.org), is being developed and is to be launched in the near future.

7 Legacies and future

Key legacies from the pre-2019 commission that will be continued by the current COT include the organisation of regular stand-alone international tephra conferences – approximately every four years – that combine conference and field elements, together with workshops on specific topics and/or the development of certain skills. In addition, COT will continue convening sessions/symposia at large-scale meetings, such as the IAVCEI scientific assemblies (e.g., tephra skills workshop held in Portland in 2017) and INQUA congresses (e.g., two sessions on tephra studies were held in Dublin in 2019, together generating the largest number of papers of any group at that congress: Fig. 11), supporting smaller meetings and workshops, and reporting the results of tephrochronological studies in special issues of journals or books or specialist interactive websites.

https://doi.org/10.5194/hgss-2021-22
Preprint. Discussion started: 22 December 2021

Commission-supported or endorsed methodological research projects, such as those conducted by Froggatt (1992), Turney et al. (1994b), Hunt and Hill (1996), Suzuki (1996), Hunt et al. (1998), Kuehn et al. (2011), Pearce et al. (2014), and Suzuki et al. (2014), remain a high priority and we will continue to provide support for tephra-focused projects that require input from the community, as exemplified below in Sect. 7.1.

Figure 11. (Upper) (*Left*) Large audiences, reflecting the new vibrancy of INTAV/COT, were a feature of the two tephra sessions at the Dublin INQUA Congress in July, 2019. Photo: David Lowe. (*Right*) Takehiko Suzuki (INTAV president) presenting Siwan Davies with honorary life membership. **(Lower)** (*Left*) INTAV's last executive committee (2015–2019), photographed on 30 July, 2019, during the INTAV business meeting at the Dublin congress. From left, Peter Abbott, Siwan Davies (seconded to committee in August 2017), Britta Jensen, Victoria Smith (who resigned in February 2017 after ~5 years of service), Takehiko Suzuki, and David Lowe. Photo: anonymous. (*Right*) Tephrochronologists and volcanologists enjoying the special tephra dinner in Dublin. Photo: David Lowe.

7.1 Current projects and future initiatives

Two key projects that are currently being undertaken with the endorsement of COT are as follows:

(1) *The development of 'best practices' protocols and databases* for undertaking all aspects of tephra studies, a project that began in 2014 (Kuehn et al., 2014). Initially led by Steve Kuehn, Marcus Bursik, Solène Pouget, Kristi Wallace, and Andrei Kurbatov, many others have now been involved in the project as well. Best practices recommendation spreadsheets were updated this year to version 3 (Abbott et al., 2021),

https://doi.org/10.5194/hgss-2021-22
Preprint. Discussion started: 22 December 2021

and a manuscript which describes them has been revised and re-submitted for publication (Wallace et al., in review). Since mid-2020, there is support for tephra in the StraboSpot field app (https://strabospot.org) and a tephra-specific help file (https://strabospot.org/files/StraboSpotTephraHelp.pdf). Staff of the Alaska Volcano Observatory of US Geological Survey have used the protocols now for two field seasons. A new tephra community portal was developed in 2021 in collaboration with the EarthChem data repository (https://earthchem.org/communities/tephra/), and this has templates for submitting sample information, analytical method information, and geochemical data. Recently updated examples of a 'best practice dataset', based on (i) Summer Lake and (ii) June Lake tephras and their analyses, are available at Kuehn and Hostetler (2020) and Kuehn and Lyon (2020), respectively (see also Kuehn et al., 2021; Wallace et al., 2021). Steve Kuehn has 22 electron microprobe analysis method descriptors published with DOIs at EarthChem as the first of their kind using the new method-reporting format (Kuehn, 2021a, b).

(2) *A microbeam trace-element characterization project of tephra reference material*, led by Nick Pearce, John Westgate, and Brent Alloway. This project involves analyzing trace elements in glass shards from four carefully selected tephra-derived glass samples (A-D) using a range of analytical techniques including LA-ICP-MS, ion probe, isotopic analyses, mini-bulk methods, etc. More than 30 analytical labs are involved in the project.

Within project (1), the further development of regional, thence global, databases is a priority because incomplete data are tending to limit correlation efficacy, especially as 'exotic' cryptotephras are now being increasingly discovered many thousands of kilometres away from source as ultra-distal deposits (e.g., Lane et al., 2017a; Lowe et al., 2017a; van der Bilt et al., 2017; Abbott et al., 2020a; Krüger and van den Bogaard, 2021; Jensen et al., in press). The growing need for developing modern tephra databases was emphasised in discussions on JISCMail in 2006, including contemporary comments from Chris Turney and Simon Blockley, although 'Tephrabase', first made available in June, 1995, represents one of the earliest scientific databases to be made available on the web (Newton et al., 1997, 2007) (see https://www.tephrabase.org/). Some further examples of databases of various types include those of Preece et al. (2011), Riede et al. (2011), Bronk Ramsey et al. (2015b), Gudmundsdóttir et al. (2016), Cameron et al. (2019), Meara et al. (2020), Portnyagin et al. (2020), and Hopkins et al. (2021b). Connecting such databases to larger, more comprehensive setups is exemplified in New Zealand by the availability of analytical and other data in Hopkins et al. (2021b): data are provided as Excel files in open access supplementary materials, in GNS Science's (national database) Pet Lab (https://pet.gns.cri.nz), and as a file submission on EarthChem (https://doi.org/10.26022/IEDA/111724) (Hopkins et al., 202b).

The 'best practices' group has taken things even further towards a global or 'next generation' system using both SESAR (www.geosamples.org) to generate unique, persistent global digital indices (IGSNs) for tephra samples, and EarthChem (https://earthchem.org/) on the tephra portal (noted above). SESAR provides access to IGSNs for samples, specimens, and related sampling features from the natural environment (https://www.igsn.org/). Registration with IGSN allows samples to be unambiguously cited and linked to data and publications, and tracked through labs and repositories, making samples 'findable, accessible, interoperable, and reusable' (FAIR). SESAR develops and operates digital tools and infrastructure for researchers, institutions, and sample facilities to store and openly share information about their samples. IGSNs can resister field sites and cores as well as samples. In the longer term, the vision is for everything to be connected. Hence, someone in the near future could undertake a geochemical search and, from there, find all related data and information from the labs for potentially correlative samples, all of the related publications, the researchers who did the work, and everything including the original field sites (Steve Kuehn personal communication, 2021).

Another recent development from the volcanological community is the comprehensive VOLCORE (Volcanic Core Records) database (Mahony et al., 2020). Although not strictly a COT initiative, it is nonetheless a very important advance for tephrochronologists and volcanologists alike, hence is documented here. VOLCORE comprises a collection of 34,696 visible tephra (volcanic ash and lithological or grain size variations) occurrences reported in the initial reports volumes of all of the Deep Sea Drilling Project (DSDP; 1966–1983), the Ocean Drilling Program (ODP; 1983–2003), the Integrated Ocean Drilling Program (IODP; 2003–2013), and the International Ocean Discovery Program (IODP; 2013–present) up to and including IODP Expedition 381. Data include the depth below sea floor, tephra thickness, location, and any reported comments. The authors report that an approximate age was estimated for most (29,493) of the tephra layers using published age-depth models, and that VOLCORE can be used as a starting point for studies of tephrochronology, volcanology, geochemistry, studies of sediment transport, and palaeoclimatology (Mahony et al., 2020).

8 Conclusions

Although modern tephra studies effectively began globally in the late 1920s, and the terms 'tephra' and 'tephrochronology' were resurrected and coined, respectively, by Thórarinsson in 1944, the advent of a portmanteau group catering for tephrochronologists globally did not exist until 7 September, 1961. On that day, the Commission on Tephrochronology was born within INQUA, thanks largely to the very substantial efforts of Kunio Kobayashi, along with those of Masao Minato and Sohei Kaizuka, backed by the National Committee of Quaternary Research of Japan, and various supporters including Thórarinsson and others. In this article we have traced COT's development, including both waxing and waning phases, for the past 60 years in what is the first review of the commission and its activities, our aim being to preserve, document, and comment on important historical information and events. In preparing the review, we felt a substantial obligation to inform succeeding generations because many of the commission members, especially ECRs, have shown a strong commitment for COT's continuation as a vigorous stand-alone international research group.

https://doi.org/10.5194/hgss-2021-22
Preprint. Discussion started: 22 December 2021

A critical turning point in COT's fortunes is identified as taking place in 1987, after which the commission began to flourish. The 'Active Tephra' meeting in southern Japan in 2010 was another key point in COT's development, as new dating methods and analytical techniques were being developed, or had been achieved, and many of the ECRs (including students) from around that time started to become – or had become – leaders in the discipline. Now with strong numbers of members globally and expertise encompassing a much wider range of countries than previously, and a high proportion of ECRs working alongside a mix of experienced mid-career and senior practitioners, the commission might be seen as attaining close to its full potential in the past decade, most notably in the three meetings held since 2017. Support and enthusiasm for the discipline of tephrochronology has never been stronger. Renewed linkages with the volcanological community – unequivocal now that IAVCEI is the commission's sponsor – alongside the Quaternary paleoenvironmental, archaeological, and geochronological communities, are also important.

We have documented and illustrated the nine inter-INQUA specialist tephra field meetings, each averaging nearly 60 participants, which have taken place in seven different countries, along with other activities including key involvement of tephrochronologists in projects such as INTIMATE, RESET, or SMART, the organisation of tephra sessions or symposia at full congresses of INQUA, or in conjunction with various commissions (e.g., Loess, Palaeoclimate, Paleopedology), and specialist workshops facilitated and/or run by COT. We have also listed the commission's outputs of highly-cited special journal issues or books or specialist websites. The commission has been led by 29 officers in total, representing nine countries, and many have served eight years or more on COT. Fifteen recipients representing eight countries have been awarded honorary life membership.

It is perhaps ironical that at recent meetings a majority (or close to it) of participants has comprised those studying cryptotephras in countries without active, or even recently active, volcanism. Nevertheless, the continuing rise and impact of research by members of COT, both in volcanic and non-volcanic countries, including increasing proportions of ECRs and female tephrochronologists, ensure an exciting, enlightened, and, perhaps equally importantly, collegial and warm-hearted future for all tephrochronologists in advancing the discipline.

Author contributions. DJL and PMA wrote the initial draft with support from TS and BJLJ who contributed valuable information and editing. All authors contributed to the final paper.

Competing interests. The authors declare that there is no conflict of interest.

Acknowledgments. We are very grateful to John Westgate, Steve Kuehn, Hiroshi Machida, Colin Wilson, Marcus Bursik, Jean-Paul Raynal, Paul van den Bogaard, John Hunt, Steve Self, Sir Stephen (Steve) Sparks, Vince Neall, Nick Pearce, Ray Cas, Hans-Ulrich Schmincke, Bruce Houghton, Mizuo Machida, Etienne Juvigné, and Maria McGuire for their help in this compilation. We acknowledge and thank all those who have helped with COT and its development and activities and associated scientific advances over the past 60 years, and for the wonderful attendant companionship enjoyed by participants in the commission's activities. The paper is an output of COT of the International Association of Volcanism and Chemistry of the Earth's Interior (IAVCEI).

References

Abbott, P.M., Griggs, A.J., Bourne, A.J., and Davies, S.M.: Tracing marine cryptotephras in the North Atlantic during the last glacial period: protocols for identification, characterisation and evaluating depositional controls. Marine Geology 401, 81–97, 2018a.

Abbott, P.M., Griggs, A.J., Bourne, A., Chapman, M.R., and Davies, S.: Tracing marine cryptotephras in the North Atlantic during the last glacial period: improving the North Atlantic marine tephra framework. Quaternary Science Reviews 189, 169–186, 2018b

Abbott, P.M., Jensen, B.J.L., Lowe, D.J., Suzuki, T., and Veres, D.: Crossing new frontiers: extending tephrochronology as a global geoscientific research tool. Journal of Quaternary Science 35 (1-2), 1–8, 2020a.

Abbott, P.M., Jensen, B.J.L., Lowe, D.J., Suzuki, T., and Veres, D. (editors): Tephrochronology as a global geoscientific research tool. Journal of Quaternary Science 35 (1/2), 1–379, 2020b.

Abbott, P., Bonadonna, C., Bursik, M., Cashman, K., Davies, S., Jensen, B., Kuehn, S., Kurbatov, A., Lane, C., Plunkett, G., Smith, V., Thomlinson, E., Thordarsson, T., Walker, J.D., and Wallace, K.: Best practice templates for tephra collection, analysis, and correlation (Version 3.0.0) [Data set]. Zenodo, http://doi.org/10.5281/zenodo.3866266, 2021.

Albert, P.G., Smith, V.C., Suzuki, T., McLean, D., Tomlinson, E.L., Miyabuchi, Y., Kitaba, I., Mark, D.F., Moriwaki, H., SG06 Project Members, and Nakagawa, T.: Geochemical characterisation of the Late Quaternary widespread Japanese tephrostratigraphic markers and correlations to the Lake Suigetsu sedimentary archive (SG06 core). Quaternary Geochronology 52, 103–131, 2019.

Alloway, B.V., Lowe, D.J., Barrell, D.J.A., Newnham, R.M., Almond, P.C., Augustinus, P.C., Bertler, N.A., Carter, L., Litchfield, N.J., McGlone, M.S., Shulmeister, J., Vandergoes, M.J., Williams, P.W., and NZ-INTIMATE members.: Towards a climate event stratigraphy for New Zealand over the past 30,000 years (NZ-INTIMATE project). Journal of Quaternary Science 22, 9–35, 2007.

Alloway, B.V., Froese, D.G., and Westgate, J.A.: Proceedings of the International Field Conference and Workshop of Tephrochronology and Volcanism: Dawson City, Yukon Territory, Canada (31 July–8 August 2005). Institute of Geological and Nuclear Sciences Science Report 2005/22. 69 pp, 2005.

Alloway, B.V., Lowe, D.J., Larsen, G., Shane, P.A.R., and Westgate, J.A.: Tephrochronology, in The Encyclopaedia of Quaternary Science, 2nd edition, edited by Elias, S.A., Mock, C.J., Elsevier, Amsterdam, 4, 277–304, 2013.

Ashworth, A. 2018. INQUA president's report. Quaternary Perspectives 25 (1), 1–2.

https://doi.org/10.5194/hgss-2021-22
Preprint. Discussion started: 22 December 2021

Auer, V.: The Pleistocene of Fuego-Patagonia. Part IV: bog profiles. Annales Academiae Scientiarum Fennicae, Series A, III. Geological-Geographica 80, 1–160, 1965.

Austin, W.E.N., Abbott, P.M., Davies, S.M., Pearce, N.J.G., and Wastegård, S. (editors): Marine tephrochronology: an introduction to tracing time in the ocean. Geological Society, London, Special Publications 398, 1–6, 2014a.

Austin, W.E.N., Abbott, P.M., Davies, S.M., Pearce, N.J.G., and Wastegård, S. (editors): Marine tephrochronology. Geological Society, London, Special Publications 398, 1–213, 2014b.

Barrell, D.J.A., Almond, P.C., Vandergoes, M.J., Lowe, D.J., Newnham, R.M., and NZ-INTIMATE members.: A composite pollen-based stratotype for inter-regional evaluation of climatic events in New Zealand over the past 30,000 years (NZ-INTIMATE project). Quaternary Science Reviews 74, 4–20, 2013.

Begét, J.E., Stihler, S.D., and Stone, D.B. 1994. A 500-year-long record of tephra falls from Redoubt Volcano and other volcanoes in upper Cook Inlet, Alaska. Journal of Volcanology and Geothermal Research 62, 55–67, 1994.

Begét, J.E., Machida, H., and Lowe, D.J. (editors): Climatic impact of explosive eruptions – recommendations for research. PAGES Workshop Report Series 96-3, 1–28, 1996.

Benediktsson, I.O., Björnsson, H., Larsen, G., and Sigmarsson, O.: Glaciology and volcanology on the centenary of Sigurður Þórarinsson's birth: a special issue. Jökull 62, 1–2, 2012a.

Benediktsson, I.O., Björnsson, H., Larsen, G., and Sigmarsson, O. (editors): Glaciology and volcanology on the centenary of Sigurður Þóorarinsson's birth: a special issue. Jökull 62, 1-184, 2012b.

Björnsson, H.: Obituary: Sigurdur Thórarinsson—1912–1983. Journal of Glaciology 29, 521–523, 1983.

Blaauw, M.: Paleochronology building workshop. PAGES News 19 (1), 34, 2011.

Blaauw, M., Christen, J.A., Bennett, K.D., and Reimer, P.J.: Double the dates and go for Bayes – impacts of model choice, dating density and quality on chronologies. Quaternary Science Reviews 188, 58–66, 2018.

Blockley, S.P.E., Blauuw, M., Bronk Ramsey, C., and van der Plicht, J.: Building and testing age models for radiocarbon dates in Lateglacial and Early Holocene sediments. Quaternary Science Reviews 26, 1915–1926, 2007.

Blockley, S.P.E., Bourne, A.J., Brauer, A., Davies, S.M., Harding, P.R., Lane, C.S., MacLeod, A., Matthews, I.P., Pyne-O-Donnell, S.D.F., Rasmussen, S.O., Wulf, S., and Zanchetta, G.: Tephrochronology and the extended intimate (integration of ice-core, marine and terrestrial records) event stratigraphy (8-128 ka b2k). Quaternary Science Reviews 106, 88-100, 2014.

Blong, R., Enright, N., and Grasso, P.: Preservation of thin tephra. Journal of Applied Volcanology 6, 10, 2017.

Bolton, M.S.M., Jensen, B.J.L., Wallace, K., Praet, N., Fortin, D., Kaufman, D., and de Batist, M.: Machine learning classifiers for attributing tephra to source volcanoes: an evaluation of methods for Alaska tephras. Journal of Quaternary Science 35, 81–92, 2020.

https://doi.org/10.5194/hgss-2021-22
Preprint. Discussion started: 22 December 2021

Bronk Ramsey, C., Albert, P.G., Blockley, S.P.E., Hardiman, M., Housley, R.A., Lane, C.S., Lee, S., Matthews, I.P., Smith, V.C., and Lowe, J.J.: Improved age estimates for key Late Quaternary European tephra horizons in the RESET lattice. Quaternary Science Reviews 118, 18–32, 2015a.

Bronk Ramsey, C., Housley, R.A., Lane, C.S., Smith, V.C., and Pollard, A.M.: The RESET tephra database and associated analytical tools. Quaternary Science Reviews 118, 33–47, 2015b.

Bunting, M.J., Blackford, J., Gehrels, M.J., and Gehrels, W.R.: In memoriam and dedication: Richard John Payne (1978-2019). Journal of Quaternary Science 35, 9–10, 2020.

Bursik, M., Kuehn, S.C., Wallace, K.L., and Kurbatov, A.V.: “Tephra 2017 Workshop: best practices in tephra collection, analysis, and reporting leading toward better tephra databases”, https://vhub.org/resources/4166, 2017.

Cameron, C.E., Mulliken, K.M., Crass, S.W., Schaefer, J.R., and Wallace, K.L.: Alaska Volcano Observatory geochemical database, version 2. Alaska Division of Geological and Geophysical Surveys Digital Data Series 8 v. 2, 22 pp., https://www.avo.alaska.edu/geochem/ or http://doi.org/10.14509/30058, 2019.

Cas, R.A.F.: IAVCEI: from small beginnings to a vibrant international association. History of Geo- and Space Sciences 10, 181–191, 2019.

Cashman, K.V. and Rust, A.C.: Far-travelled ash in past and future eruptions: combining tephrochronology with volcanic studies. Journal of Quaternary Science 35, 11–22, 2020.

Catto, N.: Retrospective thoughts. Quaternary International 500, 5–6, 2019.

Cole, J.W., Kohn, B.P., Pullar, W.A., Milne, J.D.G., Vucetich, C.G., and Healy, J.: Pyroclastic nomenclature in New Zealand. New Zealand Journal of Geology and Geophysics 15, 686–692, 1972.

Committee for Publishing of Selected Papers by Professor Kunio Kobayashi.: Selected papers of Professor Kunio Kobayashi, Saitama, 673 pp., 1990 (in Japanese).

Crandell, D.R. and Mullineaux, D.R.: Potential hazards from future eruptions of Mount St. Helens volcano, Washington. U.S. Geological Survey Bulletin 1383-C, 1–26, 1978.

Cutler, N.A., Shears, O.M., Streeter, R.T., and Dugmore, A.J.: Impact of small-scale vegetation structure on tephra layer preservation. Scientific Reports 6, 37260, 2016.

Danišík, M., Schmitt, A.K., Stockli, D.F., Lovera, O.M., Dunkl, I., and Evans, N.J.: Application of combined U-Th-disequilibrium/U-Pb and (U-Th)/He zircon dating to tephrochronology. Quaternary Geochronology 40, 23–32, 2017.

Danišík, M., Lowe, D.J., Schmitt, A.K., Friedrichs, B., Hogg, A.G., and Evans, N.J.: Sub-millennial eruptive recurrence in the silicic Mangaone Subgroup tephra sequence, New Zealand, from Bayesian modelling of zircon double-dating and radiocarbon ages. Quaternary Science Reviews 246, 106517, 2020.

Davies, S.M.: Cryptotephras: the revolution in correlation and precision dating. Journal of Quaternary Science 30, 114–130, 2015.

Davies, S.M. and Alloway, B.V.: Yukon ho! International Field Conference and Workshop on Tephrochronology and Volcanism. Quaternary Australasia 23(2), 16-18, 2006.

https://doi.org/10.5194/hgss-2021-22
Preprint. Discussion started: 22 December 2021

Davies S.M., Branch N.P., Lowe J.J., and Turney C.S.M.: Towards a European tephrochronological framework for Termination 1 and the Early Holocene. Philosophical Transactions of the Royal Society, London, Series A 360, 767–802, 2002.

Davies, S.M.,Mortensen, A.K., Baillie, M.G.L., Clausen, H.B., Grönvold, K., Hall, V.A., Johnsen, S.J., Pilcher, J.R., Steffensen, J.P., and Wastegård, S.: Tracing volcanic events in the Greenland ice cores. Past Global Changes (PAGES) 13(3), 10–11, 2004.

Davies, S.M., Larsen, G., Wastegård, S., Turney, C.S.M., Hall, V.A., Coyle, L., and Thordarson, T.: Widespread dispersal of Icelandic tephra: how does the Eyjafjöll eruption of 2010 compare to past Icelandic events? Journal of Quaternary Science 25, 605–611, 2010.

Davies, S.M., Abbott, P.M., Pearce, N.J.G., Wastegard, S., and Blockley, S.P.E.: Integrating the INTIMATE records using tephrochronology: rising to the challenge. Quaternary Science Reviews 36, 11–27, 2012.

Davies, S.M., Abbott, P.M., Meara, R.H., Pearce, N., Austin, W., Chapman, M., Svensson, A., Bigler, M., Rasmussen, T., Rasmussen, S., and Farmer, E.: A North Atlantic tephrostratigraphical framework for 130–60 ka b2k: new tephra discoveries, marine-based correlations, and future challenges. Quaternary Science Reviews 106, 101–121, 2014.

Dugmore, A.J.: Icelandic volcanic ash in Scotland. Scottish Geographical Magazine 105, 168–172, 1989.

Dugmore, A.J. and Newton, A.J.: Isochrons and beyond: maximising the use of tephrochronology in geomorphology. Jökull 62, 39–52, 2012.

Dugmore, A.J., Newton, A.J., Edwards, K.J., Larsen, G., Blackford, J.J., and Cook, G.T.: Long-distance marker horizons from small-scale eruptions: British tephra deposits from the AD 1510 eruption of Hekla, Iceland. Journal of Quaternary Science 11, 511–516, 1996.

Dugmore, A.J., Larsen, G., Newton, A.J.: Tephrochronology and its application to Late Quaternary environmental reconstruction, with special reference to the North Atlantic islands, in Tools for Constructing Chronologies – Crossing Discipline Boundaries, edited by Buck, C.E. and Millard, A.R., Lecture Notes In Statistics, Springer, 173–188, 2004.

Dugmore, A.J., Newton, A.J., and Smith, K.T.: Workshop on the Eyjafjallajökull eruptions of 2010 and implications for tephrochronology, volcanology and Quaternary studies. Tephra in Quaternary Science (TIQS). Edinburgh Workshop Report and Community Statement. 15 pp, https://www.tephrabase.org/tiqs2011/tiqs2011_report.pdf, 2011.

Dugmore, A.J., Thompson, P.I., Streeter, R.T., Cutler, N.A., Newton, A.J., and Kirkbride, M.P.: The interpretative value of transformed tephra sequences. Journal of Quaternary Science 35, 23–38, 2020.

Eden D.N. and Furkert, R.J. (editors): Loess: its Distribution, Geology and Soils. Balkema, Rotterdam, 245 pp., 1988.

Elston, W., Heiken, G.: IAVCEI Working Group on Explosive Volcanism. EOS 65 (26), 411, 1984.

Fairbridge, R.W.: INQUA in New Zealand. Geology 2, 505–506, 1974.

https://doi.org/10.5194/hgss-2021-22
Preprint. Discussion started: 22 December 2021

Freundt, A., Schindlbeck-Belo, J.C., Kutterolf, S., and Hopkins, J.L.: Tephra layers in the marine environment: a review of properties and emplacement processes. Geological Society, London, Special Publications (in press), DOI: https://doi.org/10.1144/SP520-2021-50, 2021.

Froese, D.G., Westgate, J.A., and Alloway, B.V. (editors): Field Trip Guide for the International Field Conference and Workshop of Tephrochronology and Volcanism: Dawson City, Yukon Territory, Canada (31 July–8 August 2005). Institute of Geological and Nuclear Sciences Science Report 2005/26. 132 pp, 2005.

Froese, D.G., Lowe, D.J., Knott, J.R., and Slate, J.L.: Preface – Global tephra studies: John Westgate and Andrei Sarna-Wojcicki commemorative volume. Quaternary International 178, 1–3, 2008a.

Froese, D.G. Lowe, D.J., Knott, J., and Slate, J.L. 2008b. John A. Westgate — global tephrochronologist, stratigrapher, mentor. Quaternary International 178, 4–9, 2008b.

Froese, D.G., Slate, J., Lowe, D.J., and Knott, J.R. (editors): Global tephra studies: John Westgate and Andrei Sarna-Wojcicki commemorative volume. Quaternary International 178, 1–319, 2008c.

Froggatt, P.C.: Standardization of the chemical analysis of tephra deposits. Report of the ICCT working group. Quaternary International 13-14, 93–96, 1992.

Froggatt, P.C. and Lowe, D.J.: A review of late Quaternary silicic and some other tephra formations from New Zealand: their stratigraphy, nomenclature, distribution, volume, and age. New Zealand Journal of Geology and Geophysics 33, 89–109, 1990.

Gehrels, M.J., Newnham, R.M., Lowe, D.J., Wynne, S., Hazell, Z.J., and Caseldine, C.: Towards rapid assay of cryptotephra in peat cores: review and evaluation of various methods. Quaternary International 178, 68–84, 2008.

Gudmundsdóttir, E.R., Larsen, G., Björck, S., Ingólfsson, O., Striberger, J.: A new high-resolution Holocene tephra stratigraphy in eastern Iceland: improving the Icelandic and North Atlantic tephrochronology. Quaternary Science Reviews 150, 234–249, 2016.

Gudmundsson, M.T., Pedersen, R., Vogfjörd, K., Thorbjarnardóttir, Jakobsdóttir, S., Roberts, M.J.: Eruptions of Eyjafjallajökull Volcano, Iceland. EOS 91 (21), 190–191, 2010.

Haflidason, H., Eiríksson, J., and van Kreveld, S.: The tephrochronology of Iceland and the North Atlantic region during the Middle and Late Quaternary: a review. Journal of Quaternary Science 15, 3–22, 2000.

Hall, V.A. and Alloway, B.V. (editors): Tephra. Past Global Changes (PAGES) 13(3), 5–17, 2004.

Hall, V.A. and Pilcher, J.R.: Late-Quaternary Icelandic tephras in Ireland and Great Britain: detection, characterization and usefulness. The Holocene 12, 223–230, 2002.

Hayward, C.: High spatial resolution electron probe microanalysis of tephras and melt inclusions without beam-induced chemical modification. The Holocene 22, 119–125, 2012.

Heiken, G. and Wohletz, K.: Tephra deposits associated with silicic domes and lava flows. Geological Society of America Special Papers 212, 55–76, 1987.

https://doi.org/10.5194/hgss-2021-22
Preprint. Discussion started: 22 December 2021

Hopkins, J.L., Bidmead, J.E., Lowe, D.J., Wysoczanski, R.J., Pillans, B.J., Ashworth, L., Rees, A.B., and Tuckett, F.: TephraNZ, Version 1.0, Interdisciplinary Earth Data Alliance (IEDA) [code], https://doi.org/10.26022/IEDA/111724, 2020.

Hopkins, J.L., Lowe, D.J., and Horrocks, J.H.: Tephrochronology in Aotearoa New Zealand. New Zealand Journal of Geology and Geophysics 64 (2/3), 153–200, 2021a.

Hopkins, J.L., Bidmead, J.E., Lowe, D.J., Wysoczanski, R.J., Pillans, B.J., Ashworth, L., Rees, A.B.H., and Tuckett, F.: TephraNZ: a major- and trace-element reference dataset for glass-shard analyses from prominent Quaternary rhyolitic tephras in New Zealand and implications for correlation. Geochronology 3, 465–504, (https://doi.org/10.5194/gchron-3-465-2021), 2021b.

Holt, K.A. and Lowe, D.J.: Active tephra in Kyushu 2010: international field conference. Quaternary Australasia 27 (2), 7–10, 2010.

Houghton, B.F. and Wilson, C.J.N.: Explosive rhyolitic volcanism: the case studies of Mayor Island and Taupo volcanoes. New Zealand Geological Survey Record 12, 33–100, 1986.

Howorth, R. New formations of late Pleistocene tephras from the Okataina Volcanic Centre, New Zealand. New Zealand Journal of Geology and Geophysics 18, 683–712, 1975.

Howorth, R., Froggatt, P.C., Vucetich, C.G., and Collen, J.D. (editors): Proceedings of Tephra Workshop, 30 June–1 July, 1980, Victoria University of Wellington. Geology Department, Victoria University of Wellington Publication 20, 1–100, 1981.

Hunt, J.B.: Foreword [to 'Distal tephrochronology, tephrology and volcano-related atmospheric effects']. Global and Planetary Change 21, vii–viii, 1999a.

Hunt, J.B. (editor): Distal tephrochronology, tephrology and volcano-related atmospheric effects. Global and Planetary Change 21, 1–196, 1999b.

Hunt, J.B.: Peter Graham Hill (1942–2010) – inspirational tephra analyst and mentor. Quaternary International 246, 17–18, 2011.

Hunt, J.B. and Hill, P.G.: Tephra geochemistry: a discussion of some persistent analytical problems. The Holocene 3, 271–278, 1993.

Hunt, J.B. and Hill, P.G.: An inter-laboratory comparison of the electron probe microanalysis of glass geochemistry. Quaternary International 34-36, 229–241, 1996.

Hunt, J.B. and Hill, P.G.: Tephrological implications of beam size – sample-size effects in electron microprobe analysis of glass shards. Journal of Quaternary Science 16, 105–117, 2001.

Hunt, J.B., Clift, P.D., Lacasse, C., Vallier, T.L., Werner, R.: Interlaboratory comparison of electron probe microanalysis of glass geochemistry, in: Proceedings of the Ocean Drilling Program, Scientific Results, edited by Saunders, A.D., Larsen, H.C., and Wise, S.W. Jr., 152, 85–91, 1998.

Jensen, B.J.L., Pyne-O'Donnell, S., Plunkett, G., Froese, D.G., Hughes, P.D.M., Sigl, M., McConnell, J.R., Amesbury, M.J., Blackwell, P.G., van den Bogaard, C., Buck, C.E., Charman, D.J., Clague, J.J., Hall, V.A., Koch, J., Mackay, H., Mallon, G., McColl, L., and Pilcher, J.R.: Transatlantic distribution of the Alaskan White River ash. Geology 42, 875–878, 2014.

Jensen, B.J.L., Davies, L., Nolan, C., Pyne-O'Donnell, S., Monteath, A.J., Ponomareva, V., Portnyagin, M., Booth, R., Bursik, M., Cook, E., and Plunkett, G.: A latest Pleistocene and Holocene composite tephrostratigraphic framework for northeastern North America. Quaternary Science Reviews, in press.

Juvigné, E.T. and Raynal, J.-P.: Avant-propos [to 'Tephras – chronology, archaeology']. Les Dossiers de l'Archaéo-Logis 1, 7–8, 2001a.

Juvigné, E.T. and Raynal, J.-P. (editors): Tephras – chronology, archaeology. Les Dossiers de l'Archaéo-Logis 1, 1–262, 2001b.

Juvigné, E., Lenoble-Pinson, M., and Raynal, J.-P.: Tephra nomenclatura en langue française. Les Dossiers de l'Archeo-Logis 1, 11–15, 2001.

Karátson, D., Veres, D., Lowe, D.J.: INTAV tephra conference "Crossing New Frontiers: Tephra Hunt in Transylvania", 24 June–1 July, 2018, Moieciu de Sus, Romania. IAVCEI News 4/2018, 9–11, 2018.

Kaizuka, S. (compiler): Reports of the IX Congress of the International Union for Quaternary Research [in Christchurch]. The Quaternary Research (Daiyonki-Kenkyu) 13, 71–90.

Kile, D.E.: Memorial of Ray E. Wilcox, 1912–2012. American Mineralogist 98, 1372–1374, 2013.

Kinder, M., Wulf, S., and Appelt, O.: Detection of the historical Askja AD 1875 and modern Icelandic cryptotephras in varved lake sediments – results from a first systematic search in northern Poland. Journal of Quaternary Science 36, 1–7, 2021.

Kobayashi, K.: Report from the VIth Congress of INQUA (Warszawa). The Quaternary Research (Daiyonki-Kenkyu) 2, 125–132, 1962.

Kobayashi, K.: Report from the conference on tephrochronology held at the VIth International Congress of INQUA. Report on the VIth International Congress on Quaternary, Warsaw (1961) 1, 781–789, 1965.

Kobayashi, K.: Methods of identification of particular tephra layers. Études sur le Quaternaire dans le Monde, VIIIth INQUA Congrès Paris, compiled by Ters, M., Centre National de la Recherche Scientifique 2, 981–984, 1969.

Kobayashi, K.: Some basic problems in tephrochronology. The Quaternary Research (Daiyonki-Kenkyu) 11, 211–218, 1972.

Kobayashi, K. and Shimizu, H.: Pleistocene tephras in the northern part of Ina Valley, central Japan. Journal of the Faculty of Liberal Arts and Science, Shinshu University 12, 20–52, 1962.

Krüger, S. and van den Bogaard, CV.: Small shards and long distances – three cryptotephra layers from the Nahe palaeolake including the first discovery of Laacher See Tephra in Schleswig–Holstein (Germany). Journal of Quaternary Science 36, 8–19, 2021.

Kuehn, S.C.: Concord EPMA_Oxides_METHOD_FeTi-Ox1.0, Version 1.0. Interdisciplinary Earth Data Alliance (IEDA), https://doi.org/10.26022/IEDA/112110, 2021a.

https://doi.org/10.5194/hgss-2021-22
Preprint. Discussion started: 22 December 2021

Kuehn, S.C.: Concord EPMA_Glass_METHOD_6.0, Version 1.0. Interdisciplinary Earth Data Alliance (IEDA), https://doi.org/10.26022/IEDA/112102, 2021b.

Kuehn, S.C. and Hostetler, A.: Summer Lake Pliocene Tephra Dataset [Version 1.0]. Zenodo, https://doi.org/10.5281/zenodo.4072461, 2020.

Kuehn, S.C. and Lyon, E.: June Lake Tephra Dataset [Version 1.0]. Zenodo, https://doi.org/10.5281/zenodo.4074290, 2020.

Kuehn, S.C., Froese, D.G., Shane, P.A.R., and INTAV intercomparison participants: The INTAV intercomparison of electron-beam microanalysis of glass by tephrochronology laboratories: results and recommendations. Quaternary International 246, 19–47, 2011.

Kuehn, S.C., Pouget, S., Wallace, K., and Bursik, M.I.: Results of the tephra 2014 workshop on maximizing the potential of tephra for multidisciplinary science, in: AGU Fall Meeting Abstracts, 1, 4758. http://dx.doi.org/10.13140/RG.2.1.2454.0002 abstract #V31C-4758, 2014.

Kuehn, S.C., Bursik, M.I., Goring, S.J., Kodama, S., Kurbatov, A., Lehnert, K., Profeta, L., Quinn, D., Ramdeen, S., Wallace, K., and Walker, J.D.: Making tephra data FAIR and connected through community-driven best practices for digital data collection and documentation. EarthCube Annual Meeting, June 15-17, http://dx.doi.org/10.13140/RG.2.2.28695.50083 https://doi.org/10.6084/m9.figshare.14773083.v1, 2021.

Lane, C.S. and Woodward, C.: Tephrochronology, in: Encyclopaedia of Geoarchaeology, 2nd edition, edited by Gilbert, A.S., Springer, Dordrecht, 1–9, https://doi.org/10.1007/978-1-4020-4409-0_185, 2022.

Lane, C.S., Cullen, V.L., White, D., Bramham-Law, C.W.F., and Smith, V.C.: Cryptotephra as a dating and correlation tool in archaeology. Journal of Archaeological Science 42, 42–50, 2014.

Lane, C.S., Lowe, D.J., Blockley, S.P.E., Suzuki, T., and Smith, V.C.: Advancing tephrochronology as a global dating tool: applications in volcanology, archaeology, and palaeoclimatic research. Quaternary Geochronology 40, 1–7, 2017a.

Lane, C.S., Blockley, S.P.E., Lowe, D.J., Suzuki, T., and Smith, V.C. (editors): Advancing tephrochronology as a global dating tool: applications in volcanology, archaeology, and palaeoclimatic research. Quaternary Geochronology 40, 1–145, 2017b.

Larsen, G. and Thórarinsson, S.: H-4 and other acid Hekla tephra layers. Jökull 27, 28–46, 1977.

Larsen, G. and Eiriksson, J.: Late Quaternary terrestrial tephrochronology of Iceland – frequency of explosive eruptions, type and volume of tephra deposits. Journal of Quaternary Science 23, 109-120, 2008.

Leicher, N., Giaccio, B., Zanchetta, G., Wagner, B., Francke, A., Palladino, D.M., Sulpizio, R., Albert, P.G., and Tomlinson, E.L.: Central Mediterranean explosive volcanism and tephrochronology during the last 630 ka based on the sediment record from Lake Ohrid. Quaternary Science Reviews 226, 106021, 2019.

Linqvist, J., Fredriksson, D., and Lundqvist, T.: Minnesord (Obituary) Christer Persson. Geologiskt Forum 102, 30–31, 2019.

Lowe, D.J.: Late Quaternary volcanism in New Zealand: towards an integrated record using distal airfall tephras in lakes and bogs. Journal of Quaternary Science 3, 111–120, 1988.

Lowe, D.J.: Tephra studies in New Zealand: an historical review. Journal of the Royal Society of New Zealand 20, 119–150, 1990a.

Lowe, D.J.: Burning mountains, boiling rivers, and exploding soils. Report on INQUA-ICCT Field Conference and Workshop on Tephrochronology, Mammoth Hot Springs, USA. New Zealand Soil News 38, 125–129, 1990b.

Lowe, D.J. (editor): INQUA Commission on Tephrochronology COT Newsletter 2. Department of Earth Sciences, University of Waikato, Hamilton. 13 pp, 1992.

Lowe, D.J. (editor): INQUA Commission on Tephrochronology COT Newsletter 3. Department of Earth Sciences, University of Waikato, Hamilton. 28 pp, 1994a.

Lowe, D.J. (editor): Intra-conference and Post-conference Tour Guides. International Inter-INQUA Field Conference on Tephrochronology, Loess, and Paleopedology, University of Waikato, Hamilton, New Zealand. 186 pp, 1994b.

Lowe, D.J.: Site-seeing in Germany. A report on the International Union for Quaternary Research (INQUA) 14th International Congress, 3-10 August 1995, Berlin, Germany. New Zealand Soil News 43, 253–260, 1995.

Lowe, D.J.: The Commission on Tephra Studies: a report from the XIV International Inqua Congress, Berlin. Geological Society of New Zealand Newsletter 109, 30 –33, 1996a.

Lowe, D.J.: Preface [to 'Tephra, loess, and paleosols – an integration']. Quaternary International 34–36, 1, 1996b.

Lowe, D.J. (editor): Tephra, loess, and paleosols – an integration. Quaternary International 34–36, 1–261, 1996c.

Lowe, D.J.: Globalization of tephrochronology: new views from Australasia. Progress in Physical Geography 32, 311–335, 2008.

Lowe, D.J.: Tephrochronology and its application: a review. Quaternary Geochronology 6, 107–153, 2011a.

Lowe, D.J.: Active Tephra 2010: International field conference on tephrochronology. PAGES News 19, 33, 2011b.

Lowe, D.J.: Final report for INTREPID Tephra-I Project (INQUA-0907). Quaternary Perspectives 20 (1), 8–11, 2013.

Lowe, D.J.: Marine tephrochronology: a personal perspective. Geological Society, London, Special Publications 398, 7–19, 2014.

Lowe, D.J.: IFG on tephrochrononology and volcanism (INTAV) project "Enhancing tephrochronology as a global research tool through improved fingerprinting and correlation techniques and uncertainty modelling (phase II)" (INTREPID Tephra-II: INQUA-1307s): final report. Quaternary Perspectives 22 (2), 12–15, 2015.

https://doi.org/10.5194/hgss-2021-22
Preprint. Discussion started: 22 December 2021

Lowe, D.J.: News from INTAV [report on EXTRAS Project: INQUA-1710P]. Quaternary Perspectives 25 (1), 9–10, 2018a.

Lowe, D.J.: Report on the INTAV international tephra conference "Crossing New Frontiers: Tephra Hunt in Transylvania". Quaternary Perspectives 25 (2), 9–11, 2018b.

Lowe, D.J. and Alloway, B.V.: Tephrochronology, in: Encyclopaedia of Scientific Dating Methods, edited by Rink, W.J. and Thompson, J.W., Springer, Dordrecht, 783–799, 2015.

Lowe, D.J. and Hunt, J.B.: A summary of terminology used in tephra-related studies. Les Dossiers de l'Archeo-Logis 1, 17–22, 2001.

Lowe, D.J., Newnham, R.M., and McCraw, J.D.: Volcanism and early Maori society in New Zealand, in: Natural Disasters and Cultural Change, edited by Torrence, R. and Grattan, J., Routledge, London, 126–161, 2002.

Lowe, D.J., Tonkin, P.J., Neall, V.E., Palmer, A.S., Alloway, B.V., and Froggatt, P.C.: Colin George Vucetich (1918–2007) – pioneering New Zealand tephrochronologist. Quaternary International 178, 11–15, 2008a.

Lowe, D.J., Shane, P.A.R., Alloway, B.V., and Newnham, R.M.: Fingerprints and age models for widespread New Zealand tephra marker beds erupted since 30,000 years ago: a framework for NZ-INTIMATE. Quaternary Science Reviews 27, 95–126, 2008b.

Lowe, J. John, Rasmussen, S.O., Björck, S., Hoek, W.Z., Steffensen, J.P., Walker, M.J.C., Yu, Z., and INTIMATE group: Synchronisation of palaeoenvironmental events in the North Atlantic region during the Last Termination: a revised protocol recommended by the INTIMATE group. Quaternary Science Reviews 27, 6–17, 2008.

Lowe, D.J., Davies, S.M., Moriwaki, H., Pearce, N.J.G., and Suzuki, T.: Enhancing tephrochronology and its application (INTREPID project): Hiroshi Machida commemorative volume. Quaternary International 246, 1–5, 2011a.

Lowe, D.J., Moriwaki, H., Davies, S.M., Suzuki, T., and Pearce, N.J.G. (editors): Enhancing tephrochronology and its application (INTREPID project): Hiroshi Machida commemorative volume. Quaternary International 246, 1–395, 2011b.

Lowe, D.J., Alloway, B.V., Shane, P.A.R.: Far-flown markers, in A Continent on the Move: New Zealand Geoscience Revealed, 2nd Edition, edited by Graham, I., Geoscience Society of New Zealand (GSNZ) with GNS Science, Wellington. GSNZ Miscellaneous Publication 141, 172–175, 2015a.

Lowe, J. John, Bronk Ramsey, C., Housley, R.A., Lane, C.S., Tomlinson, E.L., RESET Team, and RESET Associates: [Introduction] The RESET project: constructing a European tephra lattice for refined synchronisation of environmental and archaeological events during the last c. 100 ka. Quaternary Science Reviews 118, 1–17, 2015.

https://doi.org/10.5194/hgss-2021-22
Preprint. Discussion started: 22 December 2021

Lowe, D.J., Pearce, N.J.G., Jorgensen, M.A., Kuehn, S.C., Tryon, C.A., and Hayward, C.L.: Correlating tephras and cryptotephras using glass compositional analyses and numerical and statistical methods: review and evaluation. Quaternary Science Reviews 175, 1–44, 2017a.

Lowe, D.J., Pearce, N.J.G., Jorgensen, M.A., Kuehn, S.C., Tryon, C.A., and Hayward, C.L.: Dedication (to Stephen Stokes 1964–2014). Quaternary Science Reviews 175, 35, 2017b.

Lowe, D.J. and members of the local organising committee and INTAV executive committee: Foreword: Crossing New Frontiers, in: Book of Abstracts. Crossing New Frontiers: INTAV International Field Conference on Tephrochronology, edited by Hambach, U. and Veres, D., Moieciu de Sus, Romania (24 June–1 July 2018), 1–5, 2018. http://www.bayceer.uni-bayreuth.de/intav2018/en/key_dates/5001/1/16443/INTAV_Programm_final_vers2-2.pdf

Lube, G., Breard, E.C.P., Jons, J., Fullard, L., Dufek, J., Cronin, S.J., and Wang, T.: Generation of air lubrication within pyroclastic density currents. Nature Geoscience 12, 381386, 2019.

Machida, H.: Recent progress in tephra studies in Japan. The Quaternary Research (Daiyonki-Kenkyu) 30, 141–149, 1991.

Machida, H.: Volcanoes and tephras in the Japan area. Global Environmental Research 6, 19–28, 2002.

Machida, H. and Arai, F., 2003. Atlas of Tephra in and Around Japan, revised edition. Tokyo: University of Tokyo Press, 1– 336 (in Japanese), 2003.

Machida, H. and Lowe, D.J. (editors): INQUA Commission on Tephrochronology COT Newsletter 1. Department of Geography, Tokyo Metropolitan University, Tokyo. 7 pp, 1991.

Meara, RH.H., Thordarson, Th., Pearce, N.J.G., Hayward, C., Larsen, G.: A catalogue of major and trace element data for Icelandic Holocene silicic tephra layers. Journal of Quaternary Science 35, 122–142, 2020.

Mahony, S.H., Barnard, N.H., Sparks, R.S.J., and Rougier, J.C.: VOLCORE, a global database of visible tephra layers sampled by ocean drilling. Scientific Data 7, 330 (https://doi.org/10.1038/s41597-020-00673-1), 2020.

Merkt, J., Müller, H., Knabe, W., Müller, P., and Weister, T.: The early Holocene Saksunarvatn tephra found in lake sediments in NW Germany. Boreas 22, 93–100, 1993.

Moar, N.T.: Contributions to the Quaternary history of the New Zealand flora. 4. Pollen diagrams from the western Ruahine Ranges. New Zealand Journal of Science 4, 350–459, 1961.

Momose, K., Kobayashi, K., Minagawa, K., and Machida, M.: Identification of tephra by means of ferromagnetic minerals in pumice. Bulletin of the Earthquake Research Institute 46, 1275−1291, 1968.

Moriwaki, H. and Lowe, D.J. (editors): Intraconference Field Trip Guides. International Field Conference on Tephrochronology, Volcanism, and Human Activity, Kirishima City, Japan (9–17 May, 2010), INQUA International Focus Group on Tephrochronology and Volcanism (INTAV), 1–106, 2010.

Moriwaki, H., Suzuki, T., and Lowe, D.J.: In memoriam and dedication − Shinji Nagaoka (1958–2011). Quaternary International 246, 14–16, 2011a.

https://doi.org/10.5194/hgss-2021-22
Preprint. Discussion started: 22 December 2021

Moriwaki, H., Suzuki, T., Murata, M., Ikehara, M., Machida, H., Oba, T., and Lowe, D.J.: Sakurajima-Satsuma (Sz-S) and Noike-Yumugi (N-Ym) tephras: new tephrochronological marker beds for the last deglaciation, southern Kyushu, Japan. Quaternary International 246, 203–212, 2011b.

Neall, V.E.: Tephrochronology and tephrostratigraphy of western Taranaki (N108-N109), New Zealand. New Zealand Journal of Geology and Geophysics 15, 507–557, 1972.

Neustadt, M.I.: International Union for Quaternary Research (INQUA): Historique des Congrès. INQUA, Moscow, 97 pp., 1969 (translated from Russian by G. Krichevsky and published for the 8th INQUA Congress in Paris as a Supplement to Bulletin de l'AFEQ).

Newton, A.J., Gittings, B., and Stuart, N.: Designing a scientific database query server using the World Wide Web: the example of Tephrabase, in Innovations in GIS 4, edited by Kemp, K., Taylor & Francis, London, 251–266, 1998.

Newton, A.J., Dugmore, A.J., and Gittings, B.M.: Tephrabase: tephrochronology and the development of a centralized European database. Journal of Quaternary Science 22, 737–743, 2007.

Óladóttir, B.A., Larsen, G., and Sigmarsson, O.: Deciphering eruption history and magmatic processes from tephra in Iceland. Jökull 62, 21–38, 2012.

Oldfied, F. (editor): Past Global Changes (PAGES) Implementation Plan. IGBP Secretariat, Stockholm, Report Series 45, 236 pp., 1998.

Pearce, N.J.G.: Towards a protocol for the trace element analysis of glass from rhyolitic shards in tephra deposits by laser ablation ICP-MS. Journal of Quaternary Science, 29, 627–640, 2014.

Pearce, N.J.G., Westgate, J.A., Perkins, W.T., Eastwood, W.J., and Shane, P.A.R.: The application of laser ablation ICP-MS to the analysis of volcanic glass shards from tephra deposits: bulk glass and single shard analysis. Global and Planetary Change 21, 151–171, 1999.

Pearce, N.J., Westgate, J.A., Perkins, W.T., and Wade, S.C.: Trace-element microanalysis by LA-ICP-MS: the quest for comprehensive chemical characterisation of single, sub-10-μm volcanic glass shards. Quaternary International 246, 57–81, 2011.

Pearce, N.J.G., Abbott, P.M., and Martin-Jones, C.M.: Microbeam methods for the analysis of glass in fine grained tephra deposits: a SMART perspective on current and future trends. Geological Society, London, Special Publications 398, 29–46, 2014.

Pearce, N.J.G., Westgate, J.A., Gualda, G.A.R., Gatti, E., and Muhammad, R.F.: Tephra glass chemistry provides storage and discharge details of five magma reservoirs which fed the 75 ka Youngest Toba Tuff eruption, northern Sumatra. Journal of Quaternary Science 35, 256–271, 2020.

Persson C.: Försök till tefroüonologisk datering av några svenska torvmossar. Geologiska Föreningen iStockholm Förhandlingar 88(3), 361–394, doi: 10.1080/11035896609448933, 1966.

Persson C.: Tephrochronological investigation of peat deposits in Scandinavia and on the Faroe Islands. Geological Survey of Sweden C 656, 1–34, 1971.

https://doi.org/10.5194/hgss-2021-22
Preprint. Discussion started: 22 December 2021

Pilcher, J. and Hall, V.A.: Towards a tephrochronology for the Holocene of the north of Ireland. The Holocene 2, 255–259, 1992.

Pilcher, J. and Hall, V.A.: Tephrochronological studies in northern England. The Holocene 6, 100–105, 1996.

Pilcher, J.R., Hall, V.A., and McCormac, F.G.: Dates of Holocene Icelandic volcanic-eruptions from tephra layers in Irish peats. The Holocene 5, 103–110, 1995.

Platz, T., Cronin, S.J., Smith, I.E.M., Turner, M.B., and Stewart, R.B.: Improving the reliability of microprobe-based analyses of andesitic glasses for tephra correlation. The Holocene 17, 573–583, 2007.

Plunkett, G., Pilcher, J., Baillie, M., McClung, L.C.: Obituary – Emerita Professor Valerie Anne Hall BSc PhD FSA FHEA (1946-2016). Quaternary Geochronology 40, 8–11, 2017.

Ponomareva, V., Portnyagin, M., and Davies, S.: Tephra without borders: far-reaching clues into past explosive eruptions. Frontiers in Earth Sciences 3: article 83, doi: org/10.3389/feart.2015.00083, 2015.

Portnyagin, M. V., Ponomareva, V.V., Zelenin, E.A., Bazanova, L.I., Pevzner, M.M., Plechova, A.A., Rogozin, A.N., and Garbe-Schönberg, D.: TephraKam: geochemical database of glass compositions in tephra and welded tuffs from the Kamchatka volcanic arc (northwestern Pacific). Earth System Science Data, 12, 469–486, 2020.

Porter, S.: INQUA and Quaternary science at the Millennium: a personal retrospective. Quaternary International 62, 111–117, 1999.

Preece, S.J., Westgate, J.A., Froese, D.G., Pearce, N.J.G., Perkins, W.T.: A catalogue of late Cenozoic tephra beds in the Klondike goldfields and adjacent areas, Yukon Territory. Canadian Journal of Earth Sciences 48, 1386–1418, 2011.

Riede, F. and Thastrup, M.D.: Tephra, tephrochronology and archaeology – a (re-)view from northern Europe. Heritage Science 1 (15), 1–17, 2013.

Riede, F., Bazely, O., Newton, A.J., and Lane, C.S.: A Laacher See-eruption supplement to Tephrabase: investigating distal tephra fallout dynamics. Quaternary International 246, 134–144, 2011.

Romero, J.E., Alloway, B.V., Gutiérrez, R., Bertin, D., Castruccio, A., Villarosa, G., Schipper, C.I., and 10 others: Centennial-scale eruptive diversity at Volcán Calbuco (41.3°S; Northwest Patagonia) deduced from historic tephra cover-bed and dendrochronologic archives. Journal of Volcanology and Geothermal Research 417, 107281, 2021.

Ross, C.S. and Smith, R.L.: Ash-flow tuffs: their origin, geologic relations, and identification. A. study of the emplacement, by flowage, of hot gas-emitting volcanic ash; its induration by welding and crystallization, and criteria for recognizing the resulting rock. U.S. Geological Survey Professional Paper 366, 1–80, 1961.

Royal Geographical Society: Obituary Sigurdur Thórarinsson, 1912-1983. The Geographical Journal 149, 405–406, 1983.

Saito, Y., Okumura, K., Suzuki, T., Yokoyama, Y., and Izuho, M. (editors): Japanese Quaternary studies. Quaternary International 397, 1–588, 2016.

https://doi.org/10.5194/hgss-2021-22
Preprint. Discussion started: 22 December 2021

Sarna-Wojcicki, A.M.: Tephrochronology, in: Quaternary Geochronology: Methods and Applications, edited by Noller, J.S., Sowers, J.M., and Lettis, W.R., AGU Reference Shelf, 4, American Geophysical Union, Washington, DC, 357–377, 2000.

Schmid, R.: Descriptive nomenclature and classification of pyroclastic deposits and fragments: recommendations of the IUGS Subcommission on the Systematics of Igneous Rocks. Geology 9, 41–43, 1981.

Schminck, H.-U.: IAVCEI: who we are and what we do. Bulletin of Volcanology 51, 229–242, 1989.

Scott, J.M.: Introduction to the special issue on volcanism in Zealandia and the SW Pacific. New Zealand Journal of Geology and Geophysics 64 (2/3), 147–152.

Self, S. and Sparks, R.S.J.: Dedication, in: Tephra Studies, edited by Self, S. and Sparks, R.S.J., D. Reidel, Dordrecht, xi–xii, 1981a.

Self, S. and Sparks, R.S.J.: Preface, in: Tephra Studies, edited by Self, S. and Sparks, R.S.J., D. Reidel, Dordrecht, xiii-xiv, 1981b.

Self, S. and Sparks, R.S.J. (editors): Tephra Studies. D. Reidel, Dordrecht. 481 pp, 1981c.

Self, S. and Sparks, R.S.J.: George Patrick Leonard Walker 2 March 1926–17 January 2005. Biographical Memoirs of Fellows of the Royal Society 52, 423–436, 2006.

Shane, P.A.R.: Tephrochronology: a New Zealand case study. Earth-science Reviews 49, 223–259, 2000.

Shulmeister, J., Turney, C.S.M., Fink, D., Newnham, R.M., Alloway, B.V.: Developing an event stratigraphy for Australasian climate change. EOS 87 (29), 283, 2006.

Slate, J.L. and Knott, J.R.: Tephrochronology: an appreciation of the contributions of Andrei Sarna-Wocjicki. Quaternary International 178, 10, 2008.

Smalley, I.J.: Volcanic ash southern style. Nature 286, 841, 1980.

Smalley, I.J.: Notes for a history of INQUA – the International Union for Quaternary Research. Giotto Loess Research Group, Nottingham Trent University, Nottingham, U.K., https://www.researchgate.net/publication/299976916_Notes_for_a_History_of_INQUA, 2011.

Smalley, I. and O'Hara-Dhand, K.: The Western Pacific Working Group of the INQUA Loess Commission: expansion from central Europe. Central European Journal of Geosciences 2, 9–14, 2010.

Smith, I.E.M. (editor): Late Cenozoic volcanism in New Zealand. Royal Society of New Zealand Bulletin 23, 371 pp., 1986.

Smith, D.G.W. and Westgate, J.A.: Electron probe technique for characterising pyroclastic deposits. Earth and Planetary Science Letters 5, 313–319, 1969.

Smith, V.C., Shane, P.A.R., and Nairn, I.A.: Trends in rhyolite geochemistry, mineralogy, and magma storage during the last 50 kyr at Okataina and Taupo volcanic centres, Taupo Volcanic Zone, New Zealand. Journal of Volcanology and Geothermal Research 148, 372–406, 2005.

Smith, V.C., Staff, R.A., Blockley, S.P.E., Bronk Ramsey, C., Nakagawa, T., Mark, D.F., Tekemura, K., Danhara, T., and Suigetsu 2006 Project Members: Identification and correlation of visible tephras in the

https://doi.org/10.5194/hgss-2021-22
Preprint. Discussion started: 22 December 2021

Lake Suigetsu SG06 sedimentary archive, Japan: chronostratigraphic markers for synchronising of east Asian/west Pacific palaeoclimatic records across the last 150 ka. Quaternary Science Reviews 67, 121–137, 2013.

Sparks, R.S.J., Self, S., Walker, G.P.L.: Products of ignimbrite eruptions. Geology 1, 115–118, 1973.

Steen-McIntyre, V.: INQUA tephrochronology bibliography – a call for references. EOS 52 (7), 520, 1971.

Steinthórsson, S.: Memorial to Sigurdur Thórarinsson, 1912-1983. Geological Society of America Memorials 15, 1–6, 1985.

Steinthórsson, S.: Sigurdur Thórarinsson (1912–1983). Jökull 62, 3–20, 2012.

Suzuki, T.: Chemical analysis of volcanic glass by energy dispersive X-ray spectrometry with Jeol JED-2001 and JSM-5200: analytical procedures and application. Geographical Reports of Tokyo Metropolitan University 31, 27–36, 1996.

Suzuki, T.: Tephra studies on Quaternary explosive eruptions in the Japanese islands. The Quaternary Research (Daiyonki-Kenkyu) 46, 283–292, 2007.

Suzuki, T. and Nakamura, Y.: Report on the COT-J symposium [13-15 March, 2005] entitled 'Reconstruction of development of Kanto tectonic basin: tephrochronology, underground geology and tectonics'. Quaternary Research (QR) Newsletter 12 (3), 19-21, 2005.

Suzuki, T., Moriwaki, H., and Lowe, D.J.: Hiroshi Machida – respected tephrochronologist, teacher, leader. Quaternary International 246, 6–13, 2011.

Suzuki, T., Kasahara, A., Nishizawa, F., Saito, H.: Chemical characterization of volcanic glass shards by energy dispersive X-ray spectrometry with EDAX Genesis APEX2 and JEOL JSM-6390. Geographical Reports of Tokyo Metropolitan University 49, 1–12, 2014.

Swindles, G.T., Lawson, I.T., Savov, I.P., Connor, C.B., and Plunkett, G.: A 7000-yr perspective on volcanic ash clouds affecting Northern Europe. Geology 39, 887–890, 2011.

Swindles, G.T., Outram, Z., Batt, C.M., Hamilton, W.D., Church, M.J., Bond, J.M., Watson, E.J., Cook, G.T., Sim, T.G., Newton, A.J., Dugmore, A.J.: Vikings, peat formation and settlement abandonment: a multimethod chronological approach from Shetland. Quaternary Science Reviews 210, 211–225, 2019.

Tatsumi, Y. and Suzuki-Kamata, K.: Cause and risk of catastrophic eruptions in the Japanese archipelago. Proceedings of the Japan Academy, Series B, Physical and Biological Sciences 90, 347–352, 2014.

Thomas, D. and Lamothe, M.: Dr Stephen Stokes, 1964-2014, https://www.geog.ox.ac.uk/news/articles/140520-stokes.html, 2014.

Thompson, P.I.J., Dugmore, A.J., Newton, A.J., Streeter, R.J., and Cutler, N.A.: Variations in tephra stratigraphy created by small-scale surface features in sub-polar landscapes. Boreas, https://doi.org/10.1111/bor.12557, 2021.

Thórarinsson, S.: Tefrokronologiska studier på Island. Geografiska Annaler 26, 1–217, 1944.

https://doi.org/10.5194/hgss-2021-22
Preprint. Discussion started: 22 December 2021

Thórarinsson, S.: The tephra-fall from Hekla on March 29th, 1947, in: The Eruption of Hekla 1947–1948, edited by Einarsson, T., Kjartansson, G., and Thórarinsson, S., The Icelandic Science Association and the Museum of Natural History, Reykjavík, 2(3), 1–68, 1954.

Thórarinsson, S.: A message sent from Dr Thórarinsson [in 1961], pp. 784-785 in Kobayashi, K. Report on the VIth International Congress on Quaternary, Warsaw 1, 781–789, 1965.

Thórarinsson, S.: Ignimbrit í Thorsmörk. Náttúrufræðingurinn 39, 139–155, 1969.

Thórarinsson, S.: The terms *Tephra* and *Tephrochronology*, in "The World Bibliography and Index of Quaternary Tephrochronology" edited by Westgate, J.A. and Gold, C.M. University of Alberta, Alberta, Canada, xvii–xviii, 1974.

Thórarinsson, S.: Tephra studies and tephrochronology: a historical review with special reference to Iceland, in: Tephra Studies, edited by Self, S. and Sparks, R.S.J., D. Reidel, Dordrecht, 1–12, 1981.

Tomlinson, E.L., Smith, V.C., Albert, P.G., Aydar, E., Civetta, L., Cioni, R., Çubukçu, E., Gertisser, R., Isaia, R., Menzies, M.A., Orsi, G., Rosi, M., and Zanchetta, G.: The major and trace element glass compositions of the productive Mediterranean volcanic sources: tools for correlating distal tephra layers in and around Europe. Quaternary Science Reviews 118, 48–66, 2015.

Tonkin, P.J. and multiple authors: Obituary – A memorial to Colin George Vucetich BAgrSc (Lincoln), born 6th October 1918–died 25 April 2007. New Zealand Soil News 55 (3), 96–101, 2007.

Turney, C.S.M.: Extraction of rhyolitic ash from minerogenic lake sediments. Journal of Paleolimnology 19, 199–206, 1998.

Turney, C.S.M., Davies, S.M., and Alloway, B.V.: Developing regional tephrochronological frameworks for testing hypotheses of synchronous climate change. Past Global Changes (PAGES) 13(3), 16–17, 2004a.

Turney, C.S.M., Lowe, J.J., Davies, S.M., Hall, V.A., Lowe, D.J., Wastegård, S., Hoek, W.Z., and Alloway, B.V.: Tephrochronology of Last Termination sequences in Europe: a protocol for improved analytical precision and robust correlation procedures (SCOTAV–INTIMATE proposal). Journal of Quaternary Science 19, 111–120, 2004b.

van den Bogaard, C. and Schmincke, H.-U.: Linking the North Atlantic to central Europe: a high resolution tephrochronological record from northern Germany. Journal of Quaternary Science 17, 3–20, 2002.

van den Bogaard, C., Dörfler, W., Sandgren, P., and Schmincke, H.-U.: Correlating the Holocene records: Icelandic tephra found in Schleswig-Holstein (northern Germany). Naturwissenschaften 81, 554–556, 1994.

van der Bilt, W.G.M., Lane, C.S., and Bakke, J.: Ultra-distal Kamchatkan ash on Arctic Svalbard: towards hemispheric cryptotephra correlation. Quaternary Science Reviews 164, 230–235, 2017.

Vucetich, C.G.: Obituary – Dr. William Alexander [Alan] Pullar, BSc, AOSM, DSc, FNZIAS. New Zealand Soil News 30, 186–188, 1982.

Waitt, R.B. and Begét, J.E.: Volcanic processes and geology of Augustine Volcano, Alaska. U.S. Geological Survey Professional Paper 1762, 1–78, 2009.

https://doi.org/10.5194/hgss-2021-22
Preprint. Discussion started: 22 December 2021

Wallace, K.L, Bursik, M.I., Goring, S.J., Kodama, S., Kuehn, S.C., Kurbatov, A., Lehnert, K., Profeta, Ramdeen, S., Wallace, K., and Walker, J.D.: Improving discoverability of tephra data through development of data upload templates and collection tools using community-driven best practices recommendations. Goldschmidt Meeting, July 4-9, https://2021.goldschmidt.info/goldschmidt/2021/meetingapp.cgi/Paper/3629, 2021.

Wallace, K., Bursik, M., Kuehn, S., Kurbatov, A., Abbott, P., Bonadonna, C., Cashman, K., Davies, S., Jensen, B., Lane, C., Plunkett, G., Smith, V., Tomlinson, E., Thordarsson, T., and Walker, J.D.: Community established best practice recommendations for tephra studies – from collection through analysis. Nature Scientific Data [manuscript SDATA-21-00892: submitted 5-August-2021], in review.

Wastegård, S. and Boygle, J.: Distal tephrochronology of NW Europe: the view from Sweden. Jökull 62, 73–80, 2012.

Wastegård, S. and Davies, S.M.: An overview of distal tephrochronology in northern Europe during the last 1000 years. Journal of Quaternary Science 25, 500–512, 2009.

Westgate, J.A.: Preface and acknowledgements, in: World Bibliography and Index of Quaternary Tephrochronology, compiled by Westgate, J.A. and Gold, C.M., University of Alberta, Edmonton, UNESCO and INQUA, iii–iv, 1974.

Westgate, J.A. and Gold, C.M. (compilers): World Bibliography and Index of Quaternary Tephrochronology. University of Alberta, Edmonton, UNESCO and INQUA, 528 pp, 1974.

Westgate, J.A., Gorton, M.P.: Correlation techniques in tephra studies, in: Tephra Studies, edited by Self, S. and Sparks, R.S.J., D. Reidel, Dordrecht, 73–94, 1981.

Westgate, J.A., Walter, R., and Naeser, N.: Preface [to 'Tephrochronology: stratigraphic applications of tephra'], Quaternary International 13-14, 5, 1992a.

Westgate, J.A., Walter, R., and Naeser, N. (editors): Tephrochronology: stratigraphic applications of tephra. Quaternary International 13-14, 1–203, 1992b.

Westgate, J.A., Perkins, W.T., Fuge, R., Pearce, N.J.G., and Wintle, A.G.: Trace-element analysis of volcanic glass shards by laser ablation inductively coupled plasma mass spectrometry: application to tephrochronological studies. Applied Geochemistry 9, 323–335, 1994.

Wilson, C.J.N.: Post-conference Tour Day 1: Hamilton-Tokaanu, in: Intra-conference and Post-conference Tour Guides, International Inter-INQUA Field Conference on Tephrochronology, Loess, and Paleopedology, edited by Lowe, D.J., University of Waikato, Hamilton, New Zealand, 74–100, 1994.

Wilson, C.J.N.: George Walker 1926-2005. Geological Society of New Zealand Newsletter 136, 47–50, 2005.

WoldeGabriel, G., Hart, W.K., Heiken, G.: Innovative tephra studies in the East African Rift System. EOS 86 (27), 255, 2005.

Wright, J.V., Smith, A.L., and Self, S.: A terminology for pyroclastic deposits, in: Tephra Studies, edited by Self, S. and Sparks, R.S.J., D. Reidel, Dordrecht, 457–463, 1981.

https://doi.org/10.5194/hgss-2021-22
Preprint. Discussion started: 22 December 2021

Wulf, S., Hardiman, M.J., Staff, R.A., Koutsodendris, A., Appelt, O., Blockley, S.P.E., Lowe, J.J., Manning, C.J., Ottolini, L., Schmitt, A.K., Smith, V.C., Tomlinson, E.L., Vakhrameeva, P., Knipping, M., Kotthoff, U., Milner, A.M., Müller, U.C., Christanis, K., Kalaitzidis, S., Tzedakis, P.C., Schmiedl, G., and Pross, J.: The marine isotope stage 1–5 cryptotephra record of Tenaghi Philippon, Greece: towards a detailed tephrostratigraphic framework for the eastern Mediterranean region. Quaternary Science Reviews 186, 236–262, 2018.

https://doi.org/10.5194/hgss-2021-22
Preprint. Discussion started: 22 December 2021

Appendix A

Named persons in selected group photos. Anon. = anonymous

Fig. 4 (lower) Participants in the field on 4 December, 1993, near Haruna volcano, northern Kanto, Japan, during the PAGES/INQUA-COT workshop on the climatic impact of explosive volcanism. Photo: anon.

Standing at back (from left): Fusao Arai, Hiroshi Machida, Takehiko Mikami, David Pyle, Tom Simkin, Janice Lough, David Lowe, James Begét, Greg Zielinski, Katherine Hirschboeck, Haraldur Sigurdsson, Tsutomu Soda, Takeshi Noto, Nat Rutter, Koji Okumura.

Crouching in front (from left): (anon), Makiko Watanabe, Takehiko Suzuki, Suzanne Leroy, Valerie Hall, Hiroshi Moriwaki, Takaaki Fukuoka, Sumiko Kubo, Mika Kohno, Tatsuo Sweda, Kunihiko Endo, Shinji Nagaoka. Photo: anon.

Fig. 5 (upper) Participants in the integrative triple-discipline (tephra-loess-paleosols) meeting at University of Waikato, Hamilton, New Zealand, photographed on 8 February, 1994. Photo: Ross Clayton (University of Waikato).

Standing at back (from left): Takehiko Suzuki, Hiroshi Moriwaki, Sue Donoghue, Brent Alloway, John Westgate, Dennis Eden, Amanjit Sandhu, Yoshitaka Nagatomo, Keiji Takemura, Liping Zhou, Akira Hayashida, Étienne Juvigné, (anon), Jun'ichi Kimura, John Bruce, James Begét, Kotaro Yamagata

Standing (from left): Roma Lane, David Manning, John Hunt, Shane Cronin, Peter Almond, Alan Palmer, Takuo Yokoyama, Yoshinaga Shuichiro, Gordon Curry, Ken Verosub, Colin Vucetich, Margaret Vucetich, Carolyn Olson, Michael Singer, Takashi Sase, (anon), Richard Hay, Peter Kamp

Seated (from left): Hiroshi Machida, Jiaqi Liu, Carol Smith, Alan Hull, Colin Wilson, Milan Pavich, Brad Pillans, Glenn Berger, Liddy Bakker, David Lowe, Phil Tonkin, Kerry Stevens, Bernd Striewski, Graham Shepherd, John Catt, Janet Slate

Crouching in front (from left): Benny Theng, Arno Kleber, Jim Dahm, Roger Briggs, Peter Hodder, Tim Naish, Michael Green, Mike Vennard, Denis-Didier Rousseau, Andrew Hammond

Figure 7 (Upper) Participants in the 2005 'Tephra Rush' meeting on 3 August, 2005, in Dawson City, Yukon Territory, Canada (from Froese et al., 2008a, p. 2). Photo: Brent Alloway.

Standing in arc around the back (from left): Hiroshi Machida, Takaaki Fukuoka, David Lowe, Roland Gehrels, (anon), Stefan Wastegård, Warren Huff, Phil Shane, James Riehle, (anon), (anon), (anon), John Westgate

Seated directly in front of back row (from left): Hiroshi Moriwaki, (anon), (anon), Siwan Davies, Brad Pillans, (anon), (anon)

Seated second row from front (from left): Shari Preece, Takehiko Suzuki, Paul Matheus, (anon), Nick Pearce, Duane Froese

Seated front row (from left): Kaori Aoki, (anon), James Begét, Maria Gehrels, Brent Alloway, Caitlin Buck, Britta Jensen, Grant Heiken