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INTERNATIONAL CONFERENCE

Tephra: Chronology, Stratigraphy, Hazards, & Climate

ABSTRACTS

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Tephra Hazard
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integrating ice core, marine and terrestrial records

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Oral Session Abstracts

Monday 9th September 2024

Oral Session 1 – Tephrochronology and Tephrostratigraphy

Session ID: 1.1

Antarctic time tracers: using tephras to date blue ice records

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Antarctic ice-cores have long been established as iconic climate archives with current activity focused on retrieving a continuous ice record that extends back to 1.5 million years. Discontinuous ice records from blue ice areas are also growing in importance for reconstructing snapshots of ancient climates and ice sheet dynamics, however, the absence of robust age constraints and dating uncertainties mean that such records remain floating archives and cannot be confidently compared to the deep continuous ice cores without better age constraints. We outline the untapped potential of employing tephrochronology to anchor these records. A series of tephra deposits preserved within the Patriot Hills Blue Ice Area underpin a record of environmental change and ice flow dynamics in the Weddell Sea region over the last 140,000 years (Fogwill et al., 2017. Sci.Reports; 2020. Nature Geoscience; Turney et al., 2020. PNAS). Major and trace element compositions of each tephra are employed to establish correlations to distinct tephra events preserved within the Dome Fuji ice-core as well as other englacial and marine records. Our results illustrate the huge potential, as well as the challenges, of exploiting tephrochronology to enhance the dating of disparate Antarctic climate archives.

Session ID: 1.2

Multiple cryptotephra populations accompany mixed tropospheric and stratospheric sulfur anomalies in Antarctic ice

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Polar ice cores are increasingly being used to assess the magnitude, frequency, and impacts of past large explosive volcanic eruptions as volcanogenic sulfur is deposited over the poles, months to years after such events. Sulfur (and sulfate) anomalies can be used to guide bi-polar volcanic synchronisation and to link ice core chronologies together, which is of significant value for deeper records extending back thousands of years. The strength and shape of the sulfur anomaly, and unique isotopic signature, is usually assumed to vary with the size of the eruption and location of the source volcano relative to the poles. Critically, the analysis of any accompanying populations of insoluble particles is required in order to geochemically fingerprint volcanic glass shards to an eruptive source, thereby confirming the identity of the targeted eruption signal.

Within the B40 ice core from East Antarctica (75°0′ S, 0°4.1′ E, 2890 m; 200 m deep; collected December 2012), sulfur isotopes measured from a large non-sea-salt sulfur anomaly at ~236 CE identified overlapping stratospheric and tropospheric signals. The preparation and geochemical analysis of these filtered meltwater samples subsequently detected four compositionally-distinct populations of volcanic glass shards, which have been fingerprinted to the 1.8 ka Taupō eruption of New Zealand, and at least one previously undocumented Antarctic eruption. This discovery not only supports previous volcanic synchronisation of B40 to the WDC06A ice core but establishes a critical tephrochronological link to the Roosevelt Island (RICE) ice core, and accompanying Antarctic englacial and Ross Sea marine sediment core records. Furthermore, it highlights the challenging nature of source attribution for volcanogenic sulfur anomalies, particularly given our limited understanding and record of local Antarctic eruptions.

Session ID: 1.3

Recent developments in geochemical analysis of extremely fine-grained cryptotephra and their application to ice core deposits

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Making robust correlations between tephra horizons and producing detailed tephrostratigraphic frameworks requires accurate and precise geochemical data from analysis of deposited volcanic glass shards. Conventional electron probe microanalysis (EPMA) methods using 5-20 µm beam sizes prevents analysis of very small (<10 µm) or irregularly shaped shards, commonly associated with distal cryptotephra (non-visible tephra layer) deposits.

Recent developments including the 3 µm beam (Hayward, 2012) and Broad Beam Overlap (Iverson et al., 2017) methods, as well as the use of scanning electron microscopy with energy dispersive spectrometry (SEM-EDS) have allowed for increasingly smaller shards to be analysed in distal tephrochronology studies. Despite these advances, it is unclear which approach produces the most accurate and precise geochemical data while minimising common problems of alkali loss and low analytical totals. This complicates decision making when unconventional EPMA methods are required for cryptotephra characterisation.

Here we present and directly compare data from alternative EPMA methods to construct a workflow with recommendations for obtaining the highest quality major element data for tephra <10 µm in size. We show that 3 µm is the smallest beam diameter suitable for use on all glass compositions, and that this 3 µm beam can be overlapped onto the epoxy with a minor compromise in data precision. We also provide data to demonstrate the benefit of light sample polishing on analytical precision. Finally, we test SEM-EDS conditions to determine how and when it is suitable for use. We then demonstrate how these methods can be used in practice to put better constraints on the volcanic sources of very-fine cryptotephras preserved in Greenland ice cores, by analysis of glass shards associated with some of the largest ice-core volcanic sulfate deposits of the 7th Century CE.

Session ID: 1.4

An updated Holocene tephrochronological framework for Greenland, based on investigations of NGRIP, EGRIP and RECAP ice cores

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We provide an overview of recent efforts to update the Holocene Greenland tephrostratigraphy record, through the characterisation of individual ash deposits in the NGRIP, EGRIP and RECAP ice cores, complementing the recent work of Davies et al. (2024).

So far, 72 deposits by have been characterised by EPMA from the different ice cores, which translates to 63 individual volcanic events (since some deposits are found in multiple cores). Fifty deposits are from Iceland, from different volcanic centres with an early to mid-Holocene dominance of basaltic volcanism, with ash originating from both the southern flank zone (typically alkali – transitional alkali basalt composition) and the eastern rift zone (typically tholeiitic basalt composition). Key contributing centres include Grímsvötn, Hekla and Kverkfjöll.

Between 7 and 9.5 ka BP we find a cluster cryptotephra deposits in Greenland ice produced from seven explosive eruptions with a typical Kamchatkan geochemical composition. In addition, there are other distal deposits from the northern Pacific region (two from Japan and two from North America). One of the Kamchatkan events is has a bipolar SO_4 signature, and is clearly linked to a negative isotope anomaly in Greenland's water isotope records, indicating a decade of climatic cooling. Later Holocene deposits found in Greenland ice have mixed geochemical compositions, including well-known historical events such as Öræfajökull 1362 AD, Hekla 1104 AD, Bárðarbunga 1477, in addition to a number of Kamchatkan and unknown silicic deposits.

Session ID: 1.5

Paleovolcanic Records from Mount Logan: The Prospector-Russell and Summit Plateau Ice Cores

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The preservation of pre-Holocene ice in the basal layers of glaciers in Alaska and the Yukon remains uncertain. At most ice core sites, bedrock was not reached, so the presence of pre-Holocene ice cannot be discounted. Mount Logan, in the St. Elias Mountains of southwestern Yukon, is the only site in the North Pacific reported to have pre-Holocene ice (Fisher et al., 2008). The 186 m Prospector-Russell record (PR Col) records the Younger Dryas to Holocene transition close to the base as a sudden reduction in electrical conductivity and depletion of δ18O (Fisher et al., 2008). A freezer failure resulted in the loss of a substantial amount of the PR Col record; however, in 2022, a new 325 m ice core was recovered from the summit plateau. Tephra are being used in the development of the age scale for the Summit Plateau ice core. With no pronounced visible tephra layers, sampling is guided by high-resolution chemical and microparticle data obtained via coupled CFA-ICPMS. Initial results for the new ice core record suggest substantially higher accumulation rates than previously estimated on Mount Logan. Although the basal age is yet to be established, preliminary modelling suggests significantly younger ages than PR Col (>16 ka BP), a conclusion supported by the presence of Katmai-Novarupta 1912 at a depth of 256 m. Due to the large discrepancy in accumulation rates and age scales, previously extracted tephra from the PR Col record has been re-examined to confirm the volcanic eruptions used to constrain the age model. Archived major ion and trace element analyses and remaining material are being used to determine the position of additional potential marker horizons (e.g. Redoubt 1989/90 and Crater Peak 1992) within the original PR Col ice core. Here we present our initial findings of this exploratory work.

Session ID: 1.6

Regional cryptotephra records from the last millenium in northwestern North America

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Tephra are well established stratigraphic marker horizons in sedimentary records from northwestern North America. Downwind of active volcanoes in Alaska, the Aleutians and the Cascades, as well as further flung sources in Kamchatka, the Kurile Islands and Japan, there is plenty of ash to be found. However, the last millennium – bridging the gap between modern and historical records – is a relatively understudied period in this region. It can, in part, be difficult to date accurately, e.g. during periods where the radiocarbon calibration curve has plateaus, or if records are disturbed or variably affected by permafrost formation and thaw. However, this time is also of great interest when considering past climates, environments and people – including features such as the Little Ice Age, the run-up to global scale industrial activity and colonial expansion.

Here, we present a regional summary of distal tephra deposits, compiled from more than 20 peat bogs and lakes that range from central Yukon to SW and SE Alaska. These are primarily cryptotephra records (i.e. non-visible, low concentration ash beds) and are mostly from new, previously unpublished sites. The presented records cover ~1000 years BP – either in its entirety (often using the well-characterised White River Ash (eastern lobe) dated to 1098–1096 cal yr BP as a basal marker), or where a particular eruption was specifically targeted (e.g. Novarupta-Katmai 1912, the largest eruption of the 20th century). These two tephras, along with Augustine 1976, Augustine B and potentially the “Lena” tephra (~400 cal yr BP), are commonly found at several sites, forming a basic framework for the last millenium. We discuss the distinct challenges of working in this area by highlighting both the successes and limitations of our cryptotephra analyses across these sites.

Session ID: 1.7

New constraints on the timing of East Asian explosive volcanism: insights from cryptotephra deposits preserved in marine and lacustrine archives

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Volcanic hazard assessments are in part constrained by our understanding of the past behaviour of eruptive centres, which is largely reconstructed using tephra deposits preserved close to the volcano. However, these near-vent eruption records are often fragmentary and incomplete hampering the accuracy of hazard assessments. Gaps in these near-source records are more acute deeper in time, and consequently reconstructions are biased towards shorter-term records which do not reflect the full range and frequency of eruptive activity. While there is evidence to suggest that even large magnitude eruptions are sometimes lost from the near-source record, owing to burial and/or erosional processes, statistical analysis of global eruption databases reveals that low- to mid-intensity eruptions are especially vulnerable to under-recording.

Here we capitalise on the potential of long, undisturbed records of ash fall events preserved in East Asian marine and lacustrine sedimentary archives, typically positioned >100 km from volcanic sources, to plug the gaps in eruption records. The extraction and identification of microscopic ash layers (cryptotephra) from sedimentary archives is adopted to provide important constraints on the timing of mid-intensity explosive eruptions which are frequently under-reported at source. Following detailed cryptotephra investigations we present a new eruption record captured by high-resolution sediment cores (WB06 and WB08) from off the Wakasa Bay (Sea of Japan), which span the last 100,000 years. Detailed geochemical fingerprinting is used to assign >30 tephra and cryptotephra deposits to volcanic source, and where possible to known eruptions. Furthermore, these chemical signatures are used to link the WB06 and WB08 tephra layers to those preserved in the precisely dated sediments of Lake Suigetsu (Honshu Island), providing important chronological constraints on this newly developed eruption record. Our investigations provide evidence of near-vent under-reporting (or grouping) of explosive eruptions and new insights into the repose periods between pre-historic eruptions at individual volcanoes.

Oral Session 2 – Tephra and Climate

Session ID: 2.1

Re-evaluating the source, style and impacts of the 1800–1840 eruption cluster with new ice-core isotope and cryptotephra analyses

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The early 19th century (1800–1840 CE) is the coldest period in the last 500 years and marks the final phase of the Little Ice Age. A cluster of major volcanic eruptions took place at this time and include the 1815 eruption of Tambora, the 1835 eruption of Cosegüina and two unidentified eruptions in 1808/9 and 1831. Although these events are linked to global climate impacts, major uncertainties remain about the mass and injection height of sulfur and, crucially, the source of the mystery eruptions.

Polar ice-cores preserve exceptional archives of past volcanic emissions. Sulfur isotopes of ice-core sulfate can provide detailed information about the plume injection height and hence climate impact of past eruptions. Cryptotephra deposited alongside the sulfur peaks can constrain the precise timing of volcanism and the eruptive source of these emissions.

Here, we undertake a high time resolution isotopic and cryptotephra analysis of the 1800–1840 period in Antarctic and Greenlandic ice-cores. Our results show clear sulfur isotope ($\Delta^{33}S$) anomalies for all volcanic events, which indicate stratospheric S injections. For the 1831 mystery eruption, large quantities of andesite-dacite cryptotephra are deposited immediately prior to stratospheric fallout. These tephra match the chemistry of one of the youngest Plinian eruptions from the central Kuril islands and identify this region as the source of this major (13 Tg) S emission. For the infamous 1809 mystery eruption, $\Delta^{33}S$ shows a more complex time-evolving pattern suggestive of multiple eruptions. Importantly, ice-core cryptotephra extracted for 1809 corroborate this hypothesis and suggest distinct geochemical tephra populations around this time. Ultimately, this combination of high time resolution S isotopes and cryptotephra offer exciting new insights into the source and style of these major volcanic events, and the role of volcanism at the end of the Little Ice Age.

Session ID: 2.2

The contributions of marine sediment cores to volcanic hazard assessments: present examples and future perspectives

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Rigorous assessment of volcanic hazards relies on setting contemporary monitoring observations within an accurate, longer-term geological context. Revealing that geological context requires detailed fieldwork, mapping and laboratory analysis of the erupted materials. However, many of the world's most dangerous volcanic systems are located on or near coasts (e.g. the Phlegraean Fields and Vesuvius in Italy), islands (e.g. the volcanic archipelagos of the Pacific, south-east Asia, and Eastern Caribbean), or underwater (e.g. the recently erupting Hunga Tonga–Hunga Ha'apai volcano) meaning that much of their erupted material is deposited on the sea bed. The only way to sample this material directly is with seafloor sediment cores. This presentation describes how marine sediment cores are a vital yet underused resource for assessing volcanic hazards by: 1. reviewing the spatio-temporal scope of the marine volcanic record and its main deposit types, 2. providing existing examples in the Mediterranean where marine sediments contribute to volcanic hazard assessments; 3. highlighting the Sunda Arc, Indonesia as a location ripe for research where marine sediment cores are yet to contribute to hazard assessments and 4. proposing that marine sediment cores can contribute to our understanding of very large eruptions which have a global impact. Overall, this presentation aims to promote the utility of tephra preserved in marine sediment cores in future volcanic hazard assessments.

Session ID: 2.3

Records of volcanism from marine sediment cores in the South Shetland Islands region, Antarctica and potential links to local ice sheet changes.

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Marine sediment cores adjacent to Antarctica are valuable because they contain more complete records of the explosive activity of Antarctic region volcanoes than the small number of Antarctic terrestrial sediment cores or the limited tephra preserved in Antarctic ice cores. Volcanic glass shards were identified in two new marine sediment cores from the South Shetland Islands region during the RV *Hakuho Maru* KH-19-6 Leg 4 2019/2020 voyage. Core PC01 was collected in Bransfield Strait and core PC04 in the South Shetland Trough. This region is of volcanological interest for several reasons including that it meets geographic and geological location criteria needed to investigate the relationship between volcanism and glacial isostatic adjustment. We present the results from physical and geochemical characterisation of the volcanic glass shards within these cores together with results of 14C organic carbon dating and paleoenvironmental studies of the cores. Geochemical compositions of the volcanic glass shards were determined via electron microprobe analysis and laser ablation inductively coupled plasma mass spectrometry of individual volcanic glass shards. PC04 hosts 3 layers of tephra comprising volcanic glass shards with bimodal dacite-rhyolite and andesite-basaltic andesite compositions. PC01 contains 14 layers hosting volcanic glass shards. Between *ca.* 6-5 ka the glass shard compositions are primarily basalt-basaltic andesite. At 3 150 ± 200 ka, PC01 glass shard compositions are bimodal comprising rhyolite and basalt-basaltic andesite. Trace element compositions together with the major element compositions provide a geochemical fingerprint consistent with pre- and post-caldera collapse (3 980 ± 125 yr; Antoniades et al., 2018) Deception Island sources for most PC01and PC04 volcanic glass shards. Using biological production, ice sheet melting and land source debris indices we identified at least 3 local ice sheet melting events within PC01 and consider the relationship between the timing of volcanism recorded in the cores and the melting events.

Session ID: 2.4

The Azores as a significant source of distal ash layers in Europe

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In recent years, the Azores have emerged as a significant source of distal ash layers in Europe. Several findings of cryptotephra with trachytic composition have been correlated through geochemical identification with explosive eruptions in the Azores, and it is likely that more will be discovered in the future. The Azores consist of nine larger islands, all of volcanic origin, with volcanic activity on the largest island, São Miguel, being particularly important for distal tephrochronology, at least for the Holocene. Preliminary investigations on São Miguel have shown that tephra from the three volcanoes, Sete Cidades, Fogo, and Furnas, can be distinguished using major element geochemistry. Particularly, the Furnas volcano has experienced major eruptions during the Middle and Late Holocene, with ash dispersing over wide areas, significantly contributing to the establishment of tephra networks in Europe. However, proximal data from the Azores are scarce and more work is needed to differentiate tephra layers from the same volcano. Another challenge is that many eruptions before the 16th century AD are poorly or incompletely dated on the Azores.

Session ID: 2.5

REMOTE SENSING OF VOLCANIC CLOUDS BY MICROWAVE AND THERMAL INFRARED PASSIVE RADIOMETERS

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Explosive eruptions inject in the atmosphere large amounts of volcanic materials, from gases to ash particles. Tracking the dispersal of volcanic ash particles is fundamental to mitigate the volcanic hazard. Depending on the particle sizes, the residence time in atmosphere varies from few hours to days. Bigger particles are mainly responsible to damage infrastructure located around the volcano. Finer particles instead represent a fatal risk for aviation, since they can stick to engines turbines and cause malfunctions or engines failure.

Low Earth Orbit (LEO) satellites are a fundamental asset to monitor volcanoes, especially those located in inaccessible areas. LEO satellites carry different payloads, included thermal-infrared (TIR) and Micro (MW) – Millimetre Waves (MMW) passive radiometers. TIR passive radiometers are sensitive to finer particles, whereas MW-MMW to coarse ash and lapilli.

In this work, we show how the two passive radiometers can be exploited to better characterise a volcanic cloud, in terms of volcanic cloud altitude and ash mass retrieval. For the height estimate we use different meteorological information, such as the temperature gradient, wind intensities and directions. The mass retrieval is performed by using our radiative transfer model algorithm, that is based on the inversion of the forward model. Based on information known from literature, we retrieve cloud physical properties and in turn the Brightness Temperature (BT) signal detected by a passive radiometer. The algorithm is implemented under the simplified assumption of approximating the atmosphere as a single layer to solve the radiative transfer differential equation.

In conclusion, the work shows how volcanic clouds can be better studied if observed at different wavelengths, especially in presence of coarse particles where the TIR signal can saturate.

Oral Session 3 – Tephra and Climate

Session ID: 3.1

Extreme climatic and compound impacts of the Mount Mazama eruption

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The eruption of Mount Mazama was one of the largest volcanic eruptions of the entire Holocene, and ash fallout from the eruption covered large areas of the USA and Canada. However, so far, the large-scale climatic impact of this eruption has been poorly studied. Here, we use new Earth System Model simulations using stratospheric sulfur injections to provide an improved understanding of the potential impacts of this cataclysmic eruption on the global climate and contemporary societies. Extreme regional temperature decreases of over 7°C are simulated in the ensemble mean. Due to the southward shift of the ITCZ, areas in southeast Asia and Africa experience severe drought. Simultaneously, the Mediterranean and Near East experience an extreme increase in summer precipitation due to the consequent shift of the adjacent atmospheric circulation cells. We argue that the compounding occurrences of severe cooling and major decreases or increases in precipitation likely had a significant impact on agrarian societies in these regions, with crop failures and high potential for flooding in the wet areas. Our study powerfully illustrates how large volcanic eruptions can alter the surface climate, with varying and contrasting compound climate anomalies covering much of the land surface. Studying these extremely large past eruptions presents us with scenarios that assist in understanding what would happen when such an eruption occurs in the future – with most likely severe societal consequences around the world.

Session ID: 3.2

Large-ensemble simulations of volcanic impacts on climate throughout the last 9000 years

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Volcanic eruptions are an important factor of climate variability at annual to multidecadal timescales, but the induced cooling is stronger in climate model simulations than in proxy-based reconstructions. This discrepancy may result from uncertainties in the eruption parameters, the aerosol-climate modelling and natural variability, but the computational cost of complex Earth system models prevents their quantification.

Here, we use sequentially three simple models: i) the EVA_H aerosol model calculating the SAOD from SO2 injections; ii) a scaling relationship to convert SAOD to radiative forcing; and iii) the FaIR climate model calculating the global mean temperature based on a range of forcings, including volcanic. Using ice-core and geological records to constrain SO2 injection parameters, we generate an ensemble of 1000 simulations for 6755 BCE – 1900 CE in which SO2 injection and model parameters are resampled within their uncertainties.

Our simulations reveal that the mean volcanic cooling over the last 9000 years is -0.12 ± 0.04 K, with a maximum yearly cooling of -2.0 ± 0.5 K in 5229 BCE. Our simulations capture well the multi-millennial scale and annual scale variability in proxy records, but exhibit important discrepancies at centennial – millennial scale. Critically, our simulations are in excellent agreement with tree ring-based reconstructions of the Northern Hemisphere summer temperature for the 20 largest eruptions of the period 750 – 1900 CE. This highlights the excellent skill of our modelling approach for estimating the radiative forcing and temperature response to volcanic eruptions. The simplicity and versatility of our approach make it accessible to non-expert climate modelers, and ideal to propagate the numerous uncertainties affecting modelling of past eruption impacts.

Session ID: 3.3

Integrating tephrochronology and glacial isostatic modelling to test climate-volcano interactions

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Climate-driven growth and decay of ice sheets and caps over glacial/interglacial cycles may cause changes in the frequency of volcanic eruptions. This phenomenon, known as "glacial pumping," has been attributed to strain regime modulation and lithospheric loading/unloading. The Aleutian Arc-Alaska Peninsula region has a rich tephra record of late-Quaternary volcanism co-located with an extensive record of glacial activity, providing an ideal setting to explore unresolved questions related to climate-volcano interactions. Building on previous work, we develop an improved regional tephra framework comprising >500 primarily Holocene-aged tephra units from a network of more than 20 sites centred around Anchorage, Alaska, and use this record of eruption frequency to understand better the drivers behind fluctuations in explosive volcanism since deglaciation. Our research employs revised age models and an ensemble of glacial system model runs to evaluate potential drivers of Holocene eruption frequency preserved in southcentral Alaska's tephrochronological record. While neither crustal strain nor unloading alone fully predicts volcanic activity, we observe changes in tephra bed frequency tend to correspond to changing rates of simulated deglacial and Holocene isostatic adjustment, suggesting that flexure and vertical movement of the crust modulated the stochastic processes that generated eruptions. This study shows how combining glacial and earth modelling with detailed tephrochronology can shed new light on the relationship between ice sheets and volcanic behaviour, providing new data to explore the potential feedback mechanisms at play.

Session ID: 3.4

Detecting variability in physical and glaciochemical signals of the ~25.5 ka Ōruanui supereruption in ice cores across Antarctica

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Investigating the impacts of explosive supereruptions on climate and the environment remains challenging and controversial, as the sizes of these eruptions from the geological record far exceed those in the historical period. Polar ice cores preserve unique physical and glaciochemical tracers from past eruptions, yielding insights into timing, source region, and transport pathways for local and global events. However, tracers of the largest eruptions are often poorly represented due to challenges in precisely pinpointing their depths in ice cores, limiting investigations of their impacts. Glass shards from Earth's youngest known supereruption, the ~25.5 ka Ōruanui event (New Zealand), have been documented[1] in the West Antarctic Ice Sheet Divide core, providing an incentive for new investigations of the eruption deposits across Antarctica. Here we consider the challenges in locating Ōruanui eruption signals across multiple records. These include variability in data availability and standardisation, coeval eruption signals and non-volcanic sulfate sources, post-depositional processes, and sparse populations of the shards required for robust fingerprinting. Through combining multiproxy records, including sulfate, conductivity, and insoluble particle concentration, we have assessed nine Antarctic ice cores around the eruption interval. We have confidently located the supereruption glaciochemical signal in three cores and tentatively suggested targets in another six. We consider that site-specific conditions play a role in the preservation of volcanic signals. Sites characterised by moderate-high elevation and accumulation (>0.033 m/a ice equivalent), inland location, and moderate-low layer thinning seem optimal for preserving strong signals. We calculate new Ōruanui-derived sulfate deposition fluxes to three key sites, which imply significantly higher Antarctic loading than previously assessed, increasing the estimated climate forcing of this event. Our identification of Ōruanui-derived tracers in multiple cores will provide a unique tie-point to aid investigation of associated climatic and environmental changes associated with this supereruption.

[1]Dunbar et al. (2017) Scientific Reports **7**, 12238

Session ID: 3.5

Identification of Half Cone (Aniakchak, Alaska) Tephra in the Greenland Ice Core Record: Unveiling the Extratropical Source for the 1600 CE Double Eruption Events

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Large, explosive volcanic eruptions impact climate by emitting sulfate aerosols into the stratosphere, recorded in polar ice-cores as sulfate peaks. These eruptions can be traced to volcanic sources through geochemical comparison of ice-core tephras and proximal volcanic deposits. However, identifying the eruptive source of volcanic sulfate in ice cores is challenging. Even well-constrained, historically dated eruptions can present difficulties in assessing their true climate impact due to factors such as multiple sulfate peaks or absence of tephra. The 1600 CE double eruptive events exemplify such complexity.

The VEI 6, 1600 CE eruption of Huaynaputina, Peru is historically dated and associated with an anomalous period of NH cooling at the dawn of the seventeenth century through ice-core sulfate peaks and Northern Hemisphere (NH) tree-ring data. However, assessing the true climate forcing of Huaynaputina is complicated by a distinct double sulfate peak in the Greenland ice-cores, present as a single peak in Antarctica. The sulfate deposited on the Greenland ice sheet is nearly twice that deposited in Antarctica, despite Huaynaputina being at 16°S. Lastly, no tephra correlating with Huaynaputina has been found in Greenland, including several shards identified coincident with the earlier peak. These discrepancies suggest a contemporaneous, unidentified NH eruption.

We combine cryptotephra microanalysis and high-time-resolution measurements of multiple sulfur isotopes to disentangle these sulfate signals. By analyzing the major element chemistry of cryptotephra found in Greenland ice-cores, we identify the ~400 yr BP eruption of Aniakchak's Half Cone as the most likely source for the earlier peak. Sulfur isotope analysis confirms this peak as an extratropical, NH eruption, while the later peak shows the distinct signature of a tropical, stratospheric eruption. These results refine our understanding of these eruptions' source parameters, providing an updated assessment of the sulfur loading and climate impact attributed to Huaynaputina and Aniakchak events.

Session ID: 3.6

Revisiting the 10th-Century Eldgjá Eruption: Modeling the Climatic and Environmental Impacts

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The 10th-century Eldgjá eruption in Iceland is the largest basaltic flood lava eruption of the Common Era. However, the extent of its impacts is unclear due to limited historical records. By combining recent tephra analyses in volcanology and ice-core records, we present a gas emissions scenario for the Eldgjá eruption that spans 937 to 940 CE, co-injecting volcanic sulfur and halogens. The combined tropospheric and stratospheric sulfur emissions are 3-8 times higher than those adopted for Eldgjá in existing paleoclimate simulations. Earth system modeling of this scenario under pre-industrial conditions reveals a compound event with maximum northern extratropics surface cooling of ~2°C in summer-autumn of 939 and 940 CE, prolonged Arctic sea ice growth, and large-scale precipitation changes, concurrent with stratospheric ozone depletion and elevated pollution. These results imply that the combined climatic and environmental effects of the Eldgjá eruption may have significantly impacted human populations at the time.

Tuesday 10th September 2024

Oral Session 4 - Tephrochronology and tephrostratigraphy

Session ID: 4.1

Tracing the provenance of pumice clasts collected from Falkland Islands shorelines using major-minor-trace element analysis

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Pumice rafts derived from sub-marine or coastal eruptions can remain afloat for months, or even years, travelling thousands of kilometres on ocean currents. These common, natural phenomena disperse marine organisms and provide important evidence for sub-marine volcanism yet remain poorly studied in comparison with terrestrial volcanic deposits. In this study, we describe pumice clasts from Falkland Islands (Islas Malvinas) shorelines, including one collected by Charles Darwin in March C.E. 1834, and use major-minor-trace element analyses (LA-ICP-MS and EPMA) to trace their provenance to sub-Antarctic/Antarctic volcanoes. In doing so we test Darwin's two-hundred-year-old hypothesis that pumice in the Falkland archipelago provides "…*a proof of great Southern current*…". We also analyse reference material from the rhyolitic eruption at Protector Shoal (erupted C.E. 1962), and test previous suggestions that pumice rafts from this eruption circum-navigated Antarctica – an eastward journey of >20,000 km – using forward trajectory modelling. Protector Shoal forms the only known silicic submarine volcano of the South Sandwich Islands intra-oceanic arc, 2000 km to the east of the Falkland Islands.

Session ID: 4.2

A Holocene tephrostratigraphy of the continuously varved Boreal lake Nautajärvi, Finland

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Finland sits at the northeastern edge of the European Holocene tephra framework, with the potential for intercontinental eruptions to reach this sub-Arctic location via the North pole, thus potentially enabling the connection of multiple regional tephrostratigraphic frameworks. Numerous Icelandic cryptotephra have been identified in peat sites spanning the last 7 ka, with many of these occurring within the last ~2 ka, sourced from Iceland and North America, highlighting the potential for ultra-distal transportation of tephras to Finland. Extending this framework into the Early Holocene by cryptotephra investigation in annually-laminated (varved) sediments, will improve understandings of the varying eruption patterns and distribution required to reach Finland, and provide more constrained age estimates for early-mid Holocene tephras.

Lake Nautajärvi is located in central-southern Finland (61°48'N, 24°41'E), and has been continuously varved since pre-isolation from the Baltic Sea at the Lake Ancylus stage ~9.6 ka. The Nautajärvi independent chronology is, based on downcore varve counts, ^{137}Cs and palaeomagnetic dating, and validated by comparing with other independently-dated Scandinavian palaeomagnetic variations records. The Holocene varve chronology has an age uncertainty of ±1%. As part of a research project aiming to reconstruct decadal-scale Holocene North Atlantic atmospheric variability using synchronised, annually-resolved climate records, this study employs a targeted approach to locate known eruptions already found in other European varved sequences. Major and minor element analyses are presented here for 40+ peaks within the Holocene, principally sourced from Icelandic volcanoes (Hekla, Katla, Askja, Torfajökull), albeit with several additional sources from North America and Kamchatka. In the last ~2 ka alone, 28 peaks are identified, substantially higher than from nearby lower-resolution records. This continuously varved record should provide a template for correlations and age estimates in sites with less chronological constraint and extends the existing tephrostratigraphy for Finland by over 1000 years into the early Holocene.

Session ID: 4.3

A detailed record of large explosive eruptions in East Asia between 115 and 50 ka preserved in the sediments of Lake Suigetsu, Japan

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Japan has >100 active volcanic centres which have produced some of the largest eruptions globally in the last 200 ka. Reconstructing the past eruption histories of these centres has proved difficult using near-vent eruption records alone. Distal sedimentary archives (e.g. lacustrine cores) can overcome near-vent preservation and accessibility issues and may even capture and stratigraphically separate lower-intensity explosive that are difficult to resolve at source.

The Lake Suigetsu sedimentary sequence, a high-resolution lacustrine core from central Honshu, Japan, is widely regarded as a key palaeoenvironmental archive and record for past volcanism from East Asia. However, the chronology is less well constrained for the older section of the sequence (>50 ka). By improving chronology for the deeper section of this sequence this will facilitate the comparison with palaeoenvironmental records on independent timescales.

We present the findings of a detailed cryptotephra investigation of the Lake Suigetsu sequence spanning 115 to 50 ka. Forty-one cryptotephra horizons are identified interspaced between visible tephra layers associated with large-magnitude eruptions and regional event markers (e.g. Aso-4, K-Tz, Ata). The newly identified cryptotephra deposits are geochemically analysed using major (EMP) and trace (LA-ICP-MS) glass analyses. These chemical fingerprints are used to correlate deposits to subduction related volcanoes located along the three main Japanese islands (Kyushu, Honshu and Hokkaido), and from intraplate volcanoes. Our findings provide geochemical, chronological and ash fall constraints on the activity at multiple volcanic centres. Furthermore, the Lake Suigetsu cryptotephra record reveals distal ash fall from two large magnitude (M6.3-7.4) eruptions, the Plinian Sambe Kisuki (SK) eruption and the caldera-forming Toya eruption, both of which are important widespread tephrostratigraphic makers suitable for linking regional terrestrial and marine sequences at ~100 ka. Finally, our investigations reveal numerous eruption deposits which have not yet been clearly recorded in near-vent sequences, indicating eruption under-recording in proximal areas.

Session ID: 4.4

Building a Holocene Tephrostratigraphic Framework for East Anglia, UK: Insights from Annually-Laminated (Varved) Records

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Varved lake sediments are recognised as valuable archives for constructing regional tephrostratigraphic frameworks, offering the stratigraphic control needed to distinguish multiple eruptions over short intervals and refine the ages of preserved tephras with improved precision. Despite their potential for developing varve chronologies and ideal tephra dating, only three sites with Holocene-age varved sediments have been reported in the British Isles. Among these, Diss Mere in East Anglia is the only site with a continuously preserved and fully published varve chronology for most of the Holocene. Preliminary investigations of a 15.2 m core sequence from The Lay, a nearby lake, have revealed laminations in the lower 4 m of sediment, with upcoming microfacies analysis aimed at confirming their annual origin.

This study presents the tephrostratigraphic record from Diss Mere and The Lay, covering the Holocene and the end of the Last Glacial period. We provide a high-resolution chronology for the East Anglian tephra record based on varve counts, cosmogenic dating (^{14}C and $^{10}Be/^{9}Be$ synchronisation), and tephrochronology. East Anglia is crucial for studying tephra dispersal from various volcanic sources across Northwest Europe and the North Atlantic, receiving tephra from multiple origins. Although much remains to be understood about ash plume trajectories and regional tephra distribution, these records reveal new complexities in European Holocene tephra dispersal, with several tephras identified for the first time in the UK. Source regions extend beyond Iceland, including the White River Ash tephra from Alaska, as well as Azorean and Italian tephras. Lastly, we examine the use of tephrochronology as a tool to delineate environmental responses to climate change and archaeological transitions in the region during the Holocene.

Session ID: 4.5

A candidate source in England for the final eruptive phase of the late Ordovician Kinnekulle Metabentonite of Baltoscandia

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Ordovician strata in the Scandinavian and peri-Baltic region (Baltoscandia) contain numerous horizons of metabentonite (MB), the altered tephra from contemporaneous arc volcanism. Two tephra associated with possible mega-eruptions have been studied in considerable detail: the up to 2 m thick Kinnekulle ('Big') MB, covering an area from Oslo in the west to Belarus in the east; and the Millbrig MB, covering a large part of the US mid-continental region. Both have possible solid rock equivalent volumes of c. 1000 km^3. These mega-eruptions have been inferred to presage global climatic change leading to global cooling, glaciation and faunal mass extinction in latest Ordovician time. Early studies suggested that the MBs might be time-equivalent, but this was subsequently disproved by mineralogical studies and radiometric dating which has become increasingly accurate and precise over time. In 2004 it was suggested that the source of the Kinnekulle MB was likely arc magmatism in Avalonia, on the basis of palaeomagnetic and palaeoclimatic reconstructions. We present new high-precision U-Pb zircon ages and geochemical data for apatite microphenocryts in two igneous suites encountered by boreholes in the concealed Caledonide basement of eastern England. The boreholes lie in the vicinity of The Wash embayment, close to a set of significant negative gravity anomalies inferred to be associated with an extensive concealed (but as yet undrilled) granite batholithic complex. The new isotopic and mineralogical data support the possibility that volcanic calderas predating the batholith may be candidates for the source of the late Ordovician Baltoscandian MBs. The cause of the arc magmatism was the subduction of Tornquist oceanic crust separating Avalonia and Baltica in mid Ordovician time, previously invoked from biostratigraphical and palaeomagnetic evidence.

Session ID: 4.6

Geochemical features of the tephras found in the Achajur area (NE Armenia) and it is source of the eruption

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The fine volcanic ash layers were identified in a study of Pleistocene loess deposits in Achajur area (Sarigyugh, Sevkar) in the northeastern part of Armenia (Wolf et al., 2016; Lomax et al., 2021). Based on reliable geochemical quantitation and tephrochronological studies of bluish tephra layers, we have identified the eruption source. In Geghama volcanic upland we also found new tephra layers, which by major elements composition are similar to those listed, but need for a more detailed study.

The volcanic ash samples were studied with detailed geochemical analysis (bulk rock major and trace elements) and petrological methods (in situ SEM/EPMA) to trace the provenance of the tephra. The tephras are of well-pronounced peralkaline trachyte composition. Despite the diverse chemical compositions and eruption styles of volcanic eruptions conditioned by the Pleistocene collision zone in the Lesser Caucasus, peralkaline rocks are unusual for the volcanism here. 40Ar/39Ar age determinations of sanidine from the volcanic ash layers from the Sarigyugh section yielded an age of 194±8ka (Grigoryan et al.,2018).

Considering the peralkaline nature and key trace elements, we conclude that the tephras found in Achajur area closely resemble those from the AP-1 explosive eruption of Nemrut volcano, located in SE Turkey, approximately 350km from the studied loess sections. According to 40Ar/39Ar dating of several pumice samples from the AP-1 proximal deposit, the age of this eruption is 189.9±5 to 194.5±1.85ka (Sumita&Schmincke, 2013b), which perfectly matches whit the new 40Ar/39Ar age determination of 194±8ka of sample from Sarigyugh section

According to Sumita & Schmincke (2013a), the estimated volume of the AP-1 Plinian eruption may exceed 30km³, corresponding to a volcanic explosivity index (VEI) of 6. The column height for such eruptions could reach over 35km (Newhall & Self, 1982), allowing tephra to be transported long distances by wind and aggregated in loess deposits.

Session ID: 4.7

Katla volcano, Iceland, and its Holocene explosive eruption history

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Explosive volcanic history of the ice-capped Katla volcano, Iceland, is preserved as tephra layers in soils around the volcano. Volcanic activity during historical time is well known through written documents and detailed stratigraphical work on large soil-sections, confirming 21 basaltic historical eruptions of which ten, or a half, left tephra east of the volcano. In addition, 150 prehistorical basaltic tephra units are preserved in a composite key-section east of the volcano. Two additional tephra sections west and south of the volcano have recently been logged and analysed for major elements, containing 172 and 97 tephra units, respectively. Seventeen prehistoric silicic Katla tephra layers serve as marker layers in the stratigraphy around the volcano as well as five layers from the Hekla volcano, one from Eyjafjallajökull and one from Torfajökull volcano. These marker layers are used as a backbone for secure correlation between the three outcrops. Major element analyses of basaltic tephra from the three sections show systematic changes in magma composition, interpreted as changes in its magma transfer system. The eastern key-section shows prehistorical intervals of quiescence up to 160 years, based on its historical preservation the assumption was made that 50% of eruptions were preserved as tephra in the east, reducing the true interval to ~80 years. Hence, the current quiescence interval, >100 years, could be the longest one since Katla eruptions resumed after the large effusive Eldgjá eruption in 939 CE. The aim here is to use the holistic eruption history of the Katla volcano, obtained through correlation of tephra layers in soil sections all around the volcano and their chemical analyses, to better understand the characteristics of Katla volcanism, to obtain a better understanding of duration and significance of quiescence intervals in the volcano and attempt to find if changes in the magma transfer system are predictable.

Oral Session 5 - Tephrochronology and tephrostratigraphy

Session ID: 5.1

Tephrochronology of Sweden: tying the bag together

Simon A. Larsson, Stefan Wastegård

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Tephrochronological research in Sweden in the past few decades has led to (crypto-)tephra discoveries, contributed to methodological development, and aided reconstructions of past climate change. After a career of contributions to the field, professor Stefan Wastegård of Stockholm University is aiming to "tie the bag together" (translated from the Swedish idiom "knyta ihop säcken", meaning to tie up loose ends) with a project funded by the Swedish Research Council. Having sampled several sites in Sweden already, the project formally started in the spring of 2024, with several research questions being targeted.

In Scania, the previously studied Körslättamossen fen has been resampled to expand the palaeoclimate record with additional methods. Here, cryptotephras including the northernmost confirmed finding of the Laacher See Tephra enable correlations to a multitude of sites across the European/North Atlantic region. Selected sediment sections will be scanned by use of computed tomography to test this new tool's limits in reliable cryptotephra detection.

In Dalsland, in an area close to the northern end of the west coast of Sweden, two lakes have been sampled to investigate the sediments deposited during deglaciation – when a connection between Skagerrak and the Baltic Sea stretched across Sweden – for cryptotephra occurrences. The purpose is to assess the marine reservoir effect of these waters based on an independent, tephra-based age model. This would help increase the accuracy of radiocarbon dating of lateglacial sediments and landforms of southern Scandinavia.

Finally, Lake Blektjärnen in Jämtland has been sampled for a Holocene cryptotephra investigation to support the climate record of its marl sediments and to affirm the timing of drainage of the Central Jämtland Ice Lake at the very end stages of the last Scandinavian Ice Sheet.

Session ID: 5.2

Refining the marine tephrostratigraphy of the central Mediterranean (40-90 ka): New insights into Late-Pleistocene Campanian explosive volcanism

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Volcanic hazard assessments rely heavily on the investigation of tephra deposits preserved in near-source volcanic settings. However, these eruption records which provide insights into past explosive activity are often fragmentary due to burial and erosional processes, particularly problematic for older, low-to mid-intensity explosive eruptions, but that extends to larger magnitude events as well. This has major implications on forecasting future eruption scenarios. Fortunately, tephra deposits recovered from distal sedimentary archives can provide a long continuous ash-fall record and, therefore, provide a crucial tool for filling the gaps in long-term eruption records.

In this contribution, we examine tephra deposits preserved in Mediterranean marine sediment cores DED87-07 and DED87-08 (Tyrrhenian Sea) to better constrain the timing, scale, and ash dispersal patterns of the densely populated Campanian volcanoes Ischia and Campi Flegrei (Southern Italy). A particular focus is better resolving the long-term eruptive history leading up to, during and following the caldera-forming Monte Epomeo Green Tuff (MEGT) eruption of Ischia. The islands near-source record is not extensively preserved on land, limiting our understanding of activity leading up to and during one of the largest Late Quaternary explosive eruptions of the central Mediterranean. Major (EMPA) and trace (LA-ICP-MS) element geochemical fingerprinting of the distal tephra's (glass) are integrated with near-source eruption records and combined with a new high-resolution oxygen isotope record (DED87-07) to present new tephrochronological and paleoclimate data which facilitates a refined eruption record for the central Mediterranean.

Session ID: 5.3

Progress in developing a detailed tephrostratigraphy for Nemrut and Süphan, Turkey

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The volcanoes in the Eastern Anatolian Volcanic Province (EAVP) currently have a highly fragmented and under researched tephrostratigraphies. The volcanoes of Nemrut and Süphan are known to be significant sources of volcanic ash in the eastern Mediterranean region as several researchers have found numerous tephra layers originating from these two volcanoes within important archaeological and palaeoenvironmental records. However, without sufficient proximal glass geochemistry and eruption history from these volcanoes, the tephra layers cannot be reliably used for tephrochronology.

Here, we present the new insights into the tephrostratigraphy of Nemrut and Süphan, as part of the DFG funded TephroMed and TephroBridge projects. We are investigating the characteristics and chemical composition of the numerous visible tephra layers (V-layers) in the ICDP Ahlat Ridge core, Lake Van (Turkey), and focusing on those erupted in the last Interglacial to glacial period (30-130 ka). The volcanic glasses from certain V-layers have been geochemically characterised, with major and minor (EPMA) and some trace element analyses (LA-ICP-MS) collected so far. In addition, new glass geochemical analyses have been obtained for proximal samples from previously and newly dated tephra outcrops around Lake Van. The new $^{40}Ar/^{39}Ar$ dates and the correlations of the proximal units to the V-layers confirm the ages of key eruption events (V-51 and V-18a) in Lake Van.

Overall, these research projects will continue to develop a comprehensive tephrostratigraphic framework for the Nemrut and Süphan volcanoes in the EAVP. This new data will enable synchronisation of regional records using the tephra layers, which will provide insights into past climatic responses in the eastern Mediterranean, and bridge the gap in knowledge in the current Mediterranean tephrochronological framework.

Session ID: 5.4

Developing Late Quaternary Eastern Mediterranean marine tephrostratigraphy: applications on the Jordanian Palaeolithic sites and implications for regional volcanic histories

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The Eastern Mediterranean is an important region for palaeoenvironmental research because it is sensitive to a complex pattern of climatic and environmental change, influenced by orbital forcing and multiple feedback mechanisms, during the late Quaternary. The Middle to Upper Palaeolithic transition in the Levant is characterized by key archaeological shifts. During this period there is also potential for abrupt climatic transitions to influence the distribution of humans across the region. One issue is the precision and resolution to which we can date Levantine archaeological sites and the wider environmental record. Examination of the cause and impact of climatic changes in this region requires the development of long, continuous, well-dated sedimentary sequences.

This study establishes the first marine crypto-tephrostratigraphy on a well-dated marine core MD81-LC31 from the Levantine Sea, covering the last ~200,000 years and consists of three visible tephra and eight cryptotephra, the majority (two visible and seven cryptotephras) of which derive from Santorini. The detection of multiple sub-Plinian volcanic products in marine sediments distal to Santorini indicates that these eruptions were more explosive than previously thought. In addition, a previously unknown MIS 5e eruption from the Kos volcano is identified. The detection of an unknown Kos eruption adds to our knowledge of the active and hazardous nature of Kos/Nisyros/Yali volcanic complex.

We also present detailed cryptotephra stratigraphic profiles from two Jordanian archaeological sites in the Jebel Qalkha area, one Early Upper Palaeolithic (EUP) to Epipalaeolithic site – Tor Hamar, and another Late Middle Palaeolithic (LMP) site – Tor Faraj. Our data show the potential for sites in this region to be correlated into Anatolian and Aegean volcanic records and distal environmental records from marine cores and the Dead Sea sequence. This would allow further underpinning of studies that link environmental change with early human adaptations in the region.

Session ID: 5.5

New records of explosive volcanism at Mayotte, Comoros Archipelago: Constraints from deep-sea sediments.

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Volcanic eruptions onshore and offshore oceanic islands, are a constant threat for inhabitants, especially in densely-populated areas where they raise the issue of massive evacuations in short periods of time. A clear understanding of past eruptive history and volcanic-related activities is, hence, of importance for risks assessment, and developing appropriate responses and monitoring systems to prevent humanitarian catastrophes.

In May 2018, a long and intense seismic crisis started offshore Mayotte, Comoros Archipelago, associated with the formation of a new effusive submarine volcano, Fani Maoré, 50 km east from the coasts. To monitor this submarine eruption, a dense network of instruments were deployed and a wide range of data sets were collected, which shed light onto a major submarine volcanic field (EMVC – *Eastern Mayotte Volcanic Chain*). Stretching from Petite-Terre Island to Fani Maoré, the EMVC is characterized by volcanic edifices of different compositions, resulting either from effusive or explosive activity.

Twenty-eight sediment cores were retrieved in the proximal region of Mayotte's volcaniclastic apron in 2020 and 2021, where more than 300 m of sediment recorded a complex history of non-volcanic and volcanic processes. The tephrochronological and tephrostratigraphical study carried out in one of the cores (MAY15-CS02) reveals the presence of abundant, fresh cryptotephra and tephra layers over the last 50 ka. We present, here, the key results of this study that provides new constraints onto the past subaerial and submarine volcanic activity at Mayotte, which is critical to adequately assess the potential evolution of the current submarine volcanic activity.

Session ID: 5.6

The Holocene tephrostratigraphy and chronology of Isla Hermite, Chile

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Unlike the Northern Hemisphere, the Southern Hemisphere does not have a well consolidated tephrostratigraphy during the Holocene. This is important to address given the quantity of volcanic eruptions during this time period and as variability in climate within this region is poorly understood. Isla Hermite is the westernmost Island of the Islas Hermite, which include Isla Hornos and Cabo de Hornos (Cape Horn), off the coast of Southern Chile. Its position, with proximity to both source volcanoes (in Chile and Argentina) and Antarctic ice cores, makes Isla Hermite a key site for understanding the southern limit of the Patagonian Ice sheet, as well as significant modulations in the Southern Hemisphere Westerly Winds (SHWW). However, at present, dating of this region for constraining ice sheet retreat as well as the change in SHWW strength are limited to radiocarbon dating on bulk material. The prime location of Isla Hermite means that there is potential to receive tephra from the Austral Volcanic Zone (AVZ) and the Southern Volcanic Zone (SVZ) depending on the wind directions.

This study will detail the tephrostratigraphy of two lake cores and one peat core from this Island, alongside the tephrochronology of one of the lake cores, through geochemical analyses of identified cryptotephra horizons. The core section in this study spans a depth of 45cm, and covers ~8ka (cal yr BP). Multiple tephra horizons have been identified in the cores and this study will also outline initial geochemical analyses from the tephra in these cores and discuss potential correlations with known eruptions of Holocene age. This study has the potential to link and refine different sites so that climatic change and ice sheet limit timings during the Holocene can be effectively assessed.

Oral Session 6 - Tephrochronology and tephrostratigraphy

Session ID: 6.1

A Konso Silver Tuff correlative found offshore the Main Ethiopian Rift ?

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The Main Ethiopian Rift (MER) is the northernmost part of the East African Rift System (EARS). Quaternary silicic volcanoes and hominin-bearing sedimentary formations lie within the MER. To date fossils, most studies perform Ar-Ar dating on tuffs stratigraphically above or beneath them. However, such technique requires pure feldspar crystals, which is not always the case, and the uncertainty may be as high as ± 47 ka. The aim of this study is to find cryptotephras in a marine core (MD96-2073) and to precisely date them using our age model.

Core MD96-2073 is a 34 m-long piston core retrieved near Socotra Island, 1500 km north-east (N-E) from the MER. The age model is based on benthic foraminifera $\delta^{18}O$ stratigraphy. To find cryptotephras, sediment was sieved at 45 µm (1 cm resolution) and glass shards were counted under a stereo microscope. Major and trace elements were analysed by electron microprobe and laser ablation mass spectrometry.

Six cryptotephra layers have been discovered so far. One of them is dated at 155.2 ka (11.4 ka at 95 % confidence intervals). It is 10 cm thick, with maximum values of ~20,000 shards/g. Based on major elements, it may be correlated to the Silver Tuff, from Konso, Ethiopia, dated at 155 ka (28 ka at 2 sigma).

The Silver Tuff is a key tephrostratigraphic marker, providing a minimum age for the Herto *Homo sapiens* fossils. If the correlation is confirmed, this « marine » age could be used, and would reduce the age uncertainty of the fossil. It would also offer the possibility of correlation between marine (MD96-2073) and continental/lake (Chew Bahir core) record, potentially improving our understanding of the regional paleoclimatic context.

Session ID: 6.2

Progress on the Pliocene tephrostratigraphy in the West Turkana Basin (Kenya)

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The west Turkana basin (Kenya, East African Rift System) preserves an over 4 Ma-long record of cultural, fauna and geological evolution. While key sites have been the focus of paleoanthropological and palaeoenvironmental studies, routine stratigraphical and geological investigation has identified tephra horizons providing isochrons for the sedimentary record. Widespread Pliocene tuffs at sites across the northwestern region of the basin (e.g. Nariokotome, Nachukui) have long been linked to the Koobi Fora formation, East of Lake Turkana, and to the Shungura sediments in Ethiopia. Key Pliocene tuffs include Moiti (3.97 Ma), Lokochot (3.60 Ma) and Tulu Bor (3.44 Ma).

We have recently identified and analysed tuffs at various localities south of the Turkwel river, in the southwestern region of the basin. Major element abundances in well-preserved glass have enabled us to securely correlate three tuffs of our dataset with the Lokochot and Tulu Bor tuffs. These correlations provide new dated horizons for this less studied southwestern region of the basin and extend the existing tephrostratigraphic record of the wider region. Future characterization of additional tuffs sampled during fieldwork conducted in 2023 and 2024 should further spread existing correlations between the northern sites all the way to the Kanapoi formation (> 4 Ma), south of the Turkana basin.

Session ID: 6.3

Late Holocene eruption history of the Main Ethiopian Rift at lake Babogaya, Bishoftu Volcanic Field – new insights into the volume and reach of the Wendo Koshe Younger Pumice eruption

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Tephras resulting from explosive volcanism in the Main Ethiopian Rift (MER) have enabled crucial advancements in palaeoenvironmental and geoarchaeological investigations of early hominin evolution and dispersal. However, our understanding of the Holocene eruption record is comparatively limited despite evidence of sub-surface activity at several central silicic systems. Studies of proximal outcrops in the central MER reveal evidence of high-frequency explosive activity over the last 20 ka but still suffer from a magnitude bias and poor chronological control. The largest late Holocene eruption, the VEI 5 Wendo Koshe Younger Pumice (WKYP) eruption from the Corbetti Volcanic Complex (dated to 1.2 – 1.9 cal ka BP), further demonstrates the magnitude of potential pyroclastic hazards in this region.

Distal ash layers preserved in many lake sediment sequences can complement proximal stratigraphic investigations by providing insights into regional explosive eruption histories. In the MER, identification of distal tephra deposits from several eruptive centres in lake sediment records offers the opportunity to improve chronologic and eruption constraints on Holocene volcanism, as well as to correlate regional palaeoenvironmental records.

Here, we present a detailed tephrostratigraphic record from Lake Babogaya, a varved maar lake in the Bishoftu Volcanic Field. This record contains eruption deposits, as both visible and cryptotephra layers, from at least three volcanic centres across the rift during the late Holocene, including Boset-Bericha and Corbetti. The core chronology, built from seven ^{14}C dates, provides improved age control for the Boset-Bericha and Corbetti tephras. One visible tephra correlates chemically to the Wendo Koshe Younger Pumice, alongside two additional deposits identified and characterised at lakes Haro Kori and Wergoba in the southeastern Ethiopian Highlands. These provide improved constraints on the dispersal area for this tephra and allow re-assessment of total erupted volume.

Session ID: 6.4

Connecting Holocene palaeoenvironmental archives from Tanzania with far-travelled tephra from the Rungwe Volcanic Province

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Undisturbed sediments accumulated within the world's deepest lakes provide some of the best quality, longest, proxy records of palaeoenvironmental change. However, constructing independent, absolutely-dated chronologies can be challenging due to the limited age-ranges of dating techniques and complexity in interpreting results affected by catchment and lake sedimentary or biological processes. Radiocarbon dating, for example, in stratified deep lakes may be affected by reduced CO_2-exchange with the atmosphere and storage of old carbon at depth, leading to freshwater reservoir effects that may vary in space and time.

Tephrochronology may be applied within lake sediment records regardless of age, presuming tephra layers can be detected, characterised and correlated to a dated eruption or contemporary deposit. Methods to detect layers of tephra that are too fine to be seen with the naked eye (cryptotephra) have enabled tephrostratigraphies to be extended across continents and into sites many 100s of km distant from any volcanic source.

We demonstrate the potential of (crypto-)tephrochronology for correlating and dating lake sedimentary sequences >500 km apart in Lake Tanganyika and Lake Malawi – two of the largest and deepest lakes on the planet. This is made possible by the compilation of a revised proximal reference dataset of Holocene eruptions of the Rungwe Volcanic Province (RVP), in southern Tanzania. The dataset contains geochemical data from outcrops of RVP pyroclastic deposits and from the stratified, dated, visible RVP tephra layers preserved within the nearby shallow Lake Masoko sediment record, which is unaffected by freshwater reservoir effects.

Our correlations allow us to refine existing age estimates for widespread RVP tephra layers and to add robust age estimates to the Lake Tanganyika and Lake Malawi sequences. We highlight the potential to apply these methods to longer sequences and reduce the considerable chronological uncertainties involved in dating and correlating these important deep-lake palaeoenvironmental records.

Session ID: 6.5

Opportunities to synchronise and date archaeological and climate records in Northwest Africa using volcanic ash (tephra) layers

Danielle McLean[1], Emma Horn[1], Simone Aguiar[2], Nick Barton[1], Richard Brown[3], Holger Kuhlmann[4], Steffen Kutterolf[5], Bryce Mitsunaga[6], Sebastien Nomade[7], Nicholas O'Mara[8], José M. Pacheco[2], Adriano Pimentel[2], Ricardo S. Ramalho[9], Julie Christin Schindlbeck-Belo[5], Amy Styring[1], Kevin Uno[6], Yunbei Xu[1], Victoria C. Smith[1]

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Archaeological sites in Northwest Africa are rich in human fossils and artefacts providing proxies for behavioural and evolutionary studies. However, these records are difficult to underpin on a precise chronology, which can prevent robust assessments of the drivers of cultural/behavioural transitions. Past investigations have revealed numerous volcanic ash (tephra) layers interbedded within the Palaeolithic sequences, likely originating from large volcanic eruptions in the North Atlantic (e.g., the Azores, Canary Islands, Cape Verde) and the Mediterranean. These tephra layers offer a unique opportunity to provide new relative and absolute dating constraints (via tephrochronology) to synchronise key archaeological and palaeoenvironmental records in this region. Here we outline the initial investigations into the eruptive history of the source volcanoes and discuss diagnostic glass compositions essential for correlating the tephra layers. Moreover, we present new tephrostratigraphic investigations through the sediments of several key archaeological sites in Morocco and marine cores from the North Atlantic. The newly identified tephra can be used to: (1) insert chronological constraints for the sequences when the eruption age is known, and (2) serve as time-stratigraphic markers to precisely synchronise records (without any chronological imprecision). This work provides the first steps in establishing a tephrostratigraphic framework for NW Africa and offers new possibilities for comparing climatic and cultural transitions during the Palaeolithic.

Session ID: 6.6

Geochemical insights into major explosive eruptions from volcanoes across the Azores Archipelago

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Accurate geochemical fingerprinting of volcanic ash (tephra) is essential for correlating and dating eruptive events for tephrochronological purposes and constraining eruption dispersal and magnitude. This study focuses on characterising proximal volcanic deposits and distinguishing tephra from major eruptions in the Azores Archipelago. Azorean tephra is widely dispersed, appearing in distal records thousands of kilometres from its source. However, the absence of comprehensive glass chemistry studies has meant that the distal geochemical fingerprints could not be linked to specific volcanoes or individual eruption events. Our research provides new major and trace element analyses of proximal eruption deposits from the largest eruptions (Magnitude >4), providing insights into inter-island magma differentiation and the range of compositions erupted. Key elements for distinguishing deposits from the different islands and volcanic centres include Al, Fe, K, Zr, Rb, Y, Nb, La, Yb, and Th. Principal Component Analysis (PCA) indicates that the large eruption deposits have distinct geochemical fingerprints, facilitating robust correlations of tephra layers in sedimentary records such as marine cores and archaeological sites. These geochemical fingerprints are also invaluable for reconstructing detailed eruption histories, particularly for volcanoes with limited exposures on the islands. Our findings enhance the understanding of melt chemistry variability from Azores eruptions, improving the precision of tephra correlations in both proximal and distal records.

Thursday 12th September 2024

Oral Session 7 - Tephrochronology and tephrostratigraphy

Session ID: 7.1

Variable preservation of the 1991 Hudson tephra in small lakes and on land

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Volcanic ash (tephra) preserved in terrestrial environments and lake sediments contains information about volcanic processes and can be used to infer eruptive parameters and frequency of past eruptions, contributing to the understanding of volcanic hazards. However, tephra deposits can undergo transformation from their initial fallout sedimentation to being preserved as a tephra layer in the sedimentary record. The process is likely to be different in lakes and in terrestrial (soil) sequences. Here we compare the thickness, mass loading and grain size of tephra layers from the 1991 eruption of Cerro Hudson, Chile, from small lakes and adjacent terrestrial settings to measurements of the tephra made shortly after the eruption. We analysed samples from 35 cores in total from six small lakes (< 0.25 km^2), located 76 and 109 km from the volcano in two contrasting climatic areas (cool and humid northern site, and warm and dry southern site), and made 73 measurements of tephra thickness and 11 measurements of grain size in adjacent terrestrial areas. The major element geochemistry of our samples confirmed they were from the 1991 Hudson eruption. We found that some of the measured characteristics of the preserved tephra layers were comparable to those recorded in 1991 shortly after initial deposition, but that there was considerable variability within and between locations. This variability was not predictable and lake sediments did not preserve a notably more accurate record of the fallout than terrestrial sites. However, in aggregate the characteristics of the preserved tephras were similar to those recorded at the time of deposition, suggesting that, for palaeotephra research, a sampling strategy involving a wide range of environments is more robust than one that relies on a single sedimentary record or a single type of sedimentary environment.

Session ID: 7.2

Linking terrestrial and marine late Miocene sedimentary sequences of western North America with tephrochronology

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Multiple volcanic sources in North America – including the Snake River Plain-Yellowstone Plateau (SRP-YPVF) and Southern Nevada (SNVF) volcanic fields – have produced many large eruptions resulting in dozens of tephra since the Miocene. Many source-proximal eruptive deposits are extensively studied. Frequently tephra layers from a common magmatic source have similar glass shard composition indistinguishable by major- and minor-element concentrations, but with distinctive trace elements. Recent tephrochronology in coastal California over 1300 km from SRP-YPVF found multiple tephra layers from SRP-YPVF and SNVF, suggesting these distal tephra provide robust marker beds for Miocene to present stratigraphy across a wider geographic area than previously recognized.

This study focuses on the informally-named Powerline sequence (PS) in the central Mojave Desert, California, which is 1100 km from SRP-YPVF and 200 km from SNVF. Here we identified 20 discrete tephra layers interbedded with paludal and fluvial sediments and capped by a 4.55 Ma basalt flow. Preliminarily, the oldest PS tephra correlates with the ca. 9.3 Ma Maguire Peak upper tephra, which erupted from the SRP-YPVF and is found in marine and non-marine deposits at several other California locations. Initial examination of glass shards from other PS tephra suggests that it preserves a number of previously unrecognized tephra layers erupted from the SRP-YPVF, SNVF, and as-yet unknown sources. These distal tephra layers are commonly several centimeters thick, allowing determination of trace element composition using solution ICP-MS analysis of 200-mg glass separates.

These interpretations indicate that the SRP-YPVF and SNVF erupted more frequently and violently than previously known. The multiple tephra layers will result in estimated ages for eruptions currently unique to the PS, but that are likely to be found elsewhere in future. A solid tephrochronologic tie between Miocene marine formations and these non-marine units could also form the basis for future paleoclimate and paleotectonic studies.

Session ID: 7.3

Developing a tephrochronology as a regional tool for synchronising and dating archaeological records in the

Simon Blockley (1), Rhys Timms (1), Ariel Malinsky-Buller (2), Jen Sherriff (3), Dustin White (4)

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This presentation will outline the recent history of studies that use volcanic ash (tephra) as a tool to synchronise and date archaeological records in the Southern Caucuses. The presentation will review work on published sites from in Georgia and Armenia (for example Ortvale Klade and Kalavan; Cullen et al. 2021; Malinsky-Bulleret al., 2021), in MIS3 and then present tephra geochemical results from several unpublished sites in Armenia. The presentation will then review available and forthcoming geochemical data from the local and regional source volcanoes. These data will be used to discuss the potential and challenges for reliable correlation between archaeological records across the region. Because many of the volcanic centres in Armenia and Turkey produce widespread explosive volcanism there is also potential for records from the southern caucuses to be compared to sites further afield, including both archaeological and environmental records. This potential will be discussed with reference to the wider regional record of the Eastern Mediterranean and the Levant. The presentation will then examine what further work needs to be undertaken to secure correlations between records in the region and beyond.

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Malinsky-Buller, A., Glauberman, P., Ollivier, V., Lauer, T., Timms, R., Frahm, E., Brittingham, A., Triller, B., Kindler, L., Knul, M.V. and Krakovsky, M., 2021. Short-term occupations at high elevation during the Middle Paleolithic at Kalavan 2 (Republic of Armenia). *PLoS One*, *16*(2), p.e0245700.

Session ID: 7.4

Cryptotephra quantification in lacustrine sediments: Two workflows for sites with distant Laacher See tephra fallout

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Cryptotephra research is a major tool for dating sediments and understanding the environmental impacts of past volcanic events. Lakes, providing relatively stable environments, are excellent repositories for (crypto)tephra layers, creating valuable continental archives. Despite common studies on marine and peat tephras, quantifying cryptotephra in lacustrine records remains underexplored. We introduce two innovative workflows for quantifying cryptotephra in lake sediments affected by distant Laacher See tephra fallout. Our approach begins with identifying potential cryptotephra position and deposit thickness by scanning the sediment (e.g., XRF, CT, MS) for anomalous horizons in order to delineate the cryptotephra layer within the sediments. We then confirm the presence and source of the cryptotephra using scanning electron microscopy, electron microprobe analysis, and polarizing microscopy to visually and geochemically fingerprint the tephra. The first quantification method involves shard extraction using stepwise density separation with heavy liquids, followed by quantifying the shards using standardized markers and a polarizing microscope, providing a robust laboratory technique. The second method is software-based, utilizing SEM-based automated mineralogy analysis on thin sections combined with customized image analysis. This method examines the glass phase area fraction, depth-dependent variation, particle concentration, clustering behavior, total particle count, and size distribution. It also enables the analysis of even the smallest particles (≥ 5 µm), at the same time providing geochemical stability and statistical robustness. Both methods offer efficient and precise cryptotephra quantification, enhancing our understanding of shard concentration and distribution and enabling multi-site comparisons of shard influx in continental cryptotephra deposits. The approaches are versatile and can be applied to other tephra deposits and sediment types, broadening their applicability in cryptotephra research.

Session ID: 7.5

Refining high spatial resolution trace element analysis of singlegrain vitreous tephra shards by LA-ICP-MS

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Tephra layers, deposited in sedimentary archives can provide unique opportunities to synchronise palaeoclimatic and archaeological records over the Quaternary. Tephra correlation is based on the geochemical characteristics of tephra which are controlled by magmatic process of the source volcano. However, small non-visible ash layers (cryptotephra) shards usually have travelled long distances are usually found with particularly small size ranges, resulting in technical problems during geochemical analysis. Recent analytical developments of EPMA allows precise and accurate tephra major element compositions from very small tephra shards. The most common technique used to analyse trace elements for small tephra shards is downhole drilling with a very small laser spot, using LA-ICP-MS. However, this remains problematic as small shards are also very thin meaning the laser can ablate through the shard very rapidly limiting the duration of analysis, resulting in problems of downhole fractionation and low precision. This often minimises the application of LA-ICP-MS analyses in distal tephra studies, and restricts them to larger shards. Trace element compositions are important for tephra correlation as tephra from either the same source volcano or different sources can have the indistinguishable major element compositions if the magmatic processes are very similar.

Here we propose a rastering sampling strategy for small tephra trace element analysis on LA-ICP-MS. The rastering sampling strategy has been tested on MPI-DING glass standards and natural cryptotephra shards. The study demonstrates that the method of rastering the laser beam with a small spot size along the tephra surface generates a higher precision analysis profile, without the problem of downhole element fractionation when drilling with a smaller size laser beam. This is important as more ultra-distal cryptotephra being detected in multiple studies across the globe and many of these require trace elements to confirm correlations based in large part so far on major elements only.

Session ID: 7.6

Challenges, opportunities and lessons learnt from tracing tephra at its dispersal limits

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In this talk, we will talk about our experience in tracing tephra at its spatial dispersal limits. The volcanic eruption we studied is the ~74 ka Youngest Toba Tuff (YTT) eruption of the Toba caldera (Sumatra, Indonesia), which was the largest volcanic eruption during the Quaternary period, thus having attracted much discussion regarding its impact on global climate and evolution of early modern humans. Chew Bahir (SW Ethiopia) and Lake Towuti (Sulawesi, Indonesia) were selected as our study sites given their locations close to the limits of the currently known range of the YTT tephra dispersal to the west and east, respectively, with an aim to eventually reconstruct climatic and environmental responses to the YTT at those sites. Unfortunately, our effort to trace YTT tephra has not been successful so far, probably due to issues related to depositional environment, taphonomy, and ash dispersal. Nevertheless, our effort has opened up unexpected opportunities, which included finding another tephra layer in Lake Towuti that would contribute to a better understanding of the regional volcanic history and refinement of contested age-depth models by applying the independent age markers.

Session ID: 7.7

TIP, the Tephra Information Portal, Prototyping a Framework for FAIR Data Communities

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Observations and data are the foundation of science, but inefficiencies in data management, access, and integration continue to pose major barriers to scientific progress and public data availability. Improving this situation to make the world's data more readily Findable, Accessible, Interoperable, and Re-usable (FAIR, Wilkinson et al. 2016), is a goal shared by governments, scientists, and the public alike. Scientific researchers need to ensure that the data which they generate are openly accessible, well-integrated, maintained for the long-term, and re-usable for further research and education. Consequently, researchers need systems which streamline the tasks of high-quality data curation and help to make data more accessible.

We plan to develop a sustainable Framework for FAIR Data Communities to address the lack of standardized, machine-readable, FAIR compliant data with the global tephra research community as a test case. We will build on existing cyberinfrastructure at IEDA2 (EarthChem, SESAR) and integrate other resources and data, including StraboSpot, GeoDIVA, TephraBase and others. Objectives include: (a) helping researchers select a data repository; (b) ensuring consistent formats and rich metadata; (c) creating a central catalog and integrated critical mass of curated tephra data; (d) serving a single point of discovery, access, and use; (e) providing protected workspaces with user authentication and management; (f) incorporating disciplinary standards; (g) supporting a next-generation toolkit and access mechanisms; and (h) responding to community needs. The tephra research community provides an ideal test case due to its interdisciplinary and multifaceted nature and diverse data types spanning physical properties, stratigraphy, geochemistry, and geochronology among others. This project will leverage a decade of international tephra community-building and consensus-development (e.g.,best practices, goal setting) and a strong track record of engagement to prototype and test cyberinfrastructure, produce training materials, educate users, and increase the accessibility of research tools and data.

Oral Session 8 – Tephra and Volcanism

Session ID: 8.1

Introducing DANTE: a DAtabase of stratigraphy, geochemistry, and geochronology of ItaliaN volcanoes applied to TEphrostratigraphy

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Tephrochronology – the method through which sedimentary successions can be dated and synchronized via geochemical and geochronological fingerprinting of tephra layers – has in recent decades affirmed as an outstanding chronological tool for addressing a number of classical topics in the Quaternary Sciences (e.g., paleoclimatology, archaeology, paleogeography, past sea level change). It has also been increasingly exploited for volcanological purposes, becoming a fundamental and integrative tool for detailed reconstructions of the history, dynamics and tempo of explosive volcanism.

The geodynamic and volcanological setting of the central Mediterranean area, makes this region among the most suitable for successfully developing and applying tephrochrology, which indeed recently underwent a growing interest and production of data spread in a large number of papers and grey literature that aggravates the work of “tephrostratigraphers”.

Here we introduce “DANTE”, a database that aims at gathering all the available glass geochemistry (i.e., major, minor, and trace elements composition, Sr-Nd isotopes) and geochronological (radiometric and stratigraphic) data of both proximal pyroclastic units and distal tephra layers originating from Quaternary Italian volcanoes that have relevance for the application of the tephrostratigraphic method. Indeed, creating a reference database including all this data will provide the scientific community with an instrument that can be employed for a faster and easier way to retrieve geochemical data for tephra investigation. This database will also provide us with an updated state of the art of all the available data of proximal deposits, highlighting potential gaps of knowledge and thus orienting future research to focus on their filling.

Session ID: 8.2

New insights into the relationship between mass eruption rate and volcanic column height based on the IVESPA database

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Understanding the relationship between the mass eruption rate (MER) and volcanic column height is essential for both real-time volcanic hazard management and reconstruction of past explosive eruptions. Using 134 eruptive events from the new Independent Volcanic Eruption Source Parameter Archive (IVESPA, v1.0), we constrain bespoke empirical MER-height relationships for four measures of column height: spreading level, sulfur dioxide height, and two measures of top height, from direct observations and as reconstructed from deposits. These relationships show significant differences, and we discuss implications for their applications in ash dispersion forecast ing and modelling volcanic climate impacts. The roles of atmospheric stratification, wind, and humidity remain challenging to detect across the wide range of eruptive conditions spanned in IVESPA, ultimately resulting in empirical relationships outperforming analytical scaling relationships and the Geneva 1-dimensional (1D) volcanic plume model accounting for atmospheric conditions. However, when excluding the IVESPA events with the highest uncertainties, the 1D model progressively outperforms the empirical MER-height relationship. Our findings highlight persisting challenges in constraining the MER-height relation and reinforce the need for improved eruption source parameter databases documenting uncertainties, as well as improved physics-based models.

Session ID: 8.3

Characterization of tephra layers recorded in marine sediments off Ecuador during the past 10 Ma, and implications on the regional geodynamics and volcanic hazard assessment

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The volcanism of the Northern Andes is characterized by an intense Plio-Quaternary activity, whose onshore deposits have covered older products associated with the early development of the arc. To improve our knowledge of the largest explosive eruptions that occurred in the Northern Andean arc since the Miocene, we analyzed tephra layers (morphology, mineralogy, major-trace element contents, Sr-Pb isotopy, ^{14}C ages) recorded in marine sediments off Ecuador and Colombia.

Along the margin, tephra recorded within shallow sediments were emitted during the Holocene. Identifying the volcanic source of distal tephra is challenging due to the large number of active volcanoes, and to size-dependent fractionation during atmospheric transport that modifies the mineral, chemical and even isotope composition of transported and settled tephra. We therefore developed a new isotopic method based on Pb isotopy, demonstrating that proximal and distal products define a single isotopic line in the $^{208}Pb/^{206}Pb$-$^{207}Pb/^{206}Pb$ space, whose equation is specific to each eruptive center. We then show that these isotopic lines are robust fingerprints of volcanic sources that do not depend on the age, mineral assemblage, and nature of the emitted products. Resulting land-sea correlations show that products of at least 12 explosive eruptions reached the Pacific Ocean since 8 kyr, and that such major events could have a major impact on current populations and infrastructures.

In deep-sea sediments of the Panamá Basin, we identified 27 tephra layers emitted since the Early Pliocene. The long-term evolution of the geochemical composition of magmas, together with the recurrence of explosive eruptions, allow us to discuss the relationship between the regional geodynamics (i.e., subduction of a young aseismic ridge, slab morphology, crustal fault activity) and volcanic activity. In addition, we identified for the first time several Pleistocene rhyolitic tephra layers related to the activity of the Galápagos hotpot, revealing recent oceanic ridge-hotspot interaction.

Session ID: 8.4

Looking back on Hekla volcano – the early history

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The Hekla volcanic system is one of the most active systems in Iceland, producing some of the largest explosive eruptions during the Holocene. Our knowledge on Hekla eruption history is substantial for the late Holocene (4200 cal yrs BP -present), whereas the early and middle Holocene is less comprehensive. To further improve our knowledge of activity of Hekla volcano during these periods, over 320 tephra units have been described and sampled from eight soil sections around the volcano and analyzed for major element composition.

The tephra record from the sections demonstrates that during the early Holocene (10.400-8200 cal yrs BP) the activity was dominated by mafic volcanism characterized by two types of basalts (SiO_2~46-47 wt%); an evolved type (Fe-Ti basalt) with TiO_2>3 wt% and MgO <6 wt%, and a primitive type with TiO_2 <3wt% and MgO >6wt%, akin to that of the Pleistocene basement of Hekla. Early Holocene tephra layers with a more evolved chemical composition (basaltic-andesite to rhyolite) have been identified as well, indicating that the Hekla 5 and Hekla DH tephra layers are not the earliest products of evolved magma in the system. During the middle Holocene (8200-4200 cal yrs BP) the activity of the system changed to infrequent eruptions producing predominantly Fe-Ti basalt and large rhyolitic to basaltic-andesitic eruptions such as the Hekla 5, Hekla Ö and Hekla DH eruptions. The activity in Hekla changed again in the late Holocene, following the Hekla 3 eruption, to predominantly basaltic-andesites and andesite products.

The Fe-Ti basalts produced in the Hekla volcanic system can, interestingly, be very similar to Katla basalts. In some cases, it is challenging to use major elements to distinguish between the two. For such distinction FeOt/TiO_2 ratio and MgO is helpful but some cases cannot be resolved by the major element composition alone.

Session ID: 8.6

Holocene eruptive activity in northwestern British Columbia, Canada: an unacknowledged hazard

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The Northern Cordilleran Volcanic Province (NCVP) encompasses northwestern British Columbia and central Yukon, Canada, and part of the Alaska panhandle, USA. It is an extensional-related volcanic region that has been variably active for the past ~20 million years, during which it has shown great diversity in volcano morphology, eruptive style, and geochemical composition. Despite being home to the largest volcanic complexes and most recent eruptions in Canada, with two to three in the past few hundred years, the post-glacial eruptive record of this region is poorly understood. This lack of knowledge is partially attributable to the remoteness and inaccessibility of the volcanoes themselves.

Previous research on Holocene glacial fluctuations using lake sediments discovered four tephra that originated from the NCVP, dating to ~10,400, 9400, and 7000–8000 cal years BP. This unexpected discovery indicated that this region may have been more active than previously recognized. In 2021 we collected sediment cores from seven lakes along a ~300 km transect through the NCVP, in which further cm-scale tephra layers are apparent. Some of these previously undescribed tephra are younger than those dated, including a tephra near the surface of a core collected from Bob Quinn Lake. Major element geochemistry of the volcanic glass suggests that some of the tephra are much more regionally prevalent and complex than previously thought, and that there are likely repeat eruptions from the same sources.

Despite the remoteness of the known NCVP volcanoes, there are communities and infrastructure that would be affected by further regional volcanic activity. The northern latitude of these explosive eruptive products presents a concern for air travel, particularly due to their unaffirmed and understudied sources. A comprehensive study of the tephra from these most recent eruptions is important to identify volcanic sources and determine which present the largest hazards.

Oral Session 9 – Tephra and Volcanism

Session ID: 9.1

Sub-10 µm airborne particles from the 2021 Tajogaite eruption, La Palma, Canary Islands

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Explosive volcanic eruptions can inject vast amounts of particles and gas into the atmosphere, potentially impacting air quality by increasing PM10 (particulate matter finer than 10 µm in size) in the ambient air. What are the sub-10 µm particles produced by volcanic eruptions, particularly in the case of basaltic activity known to have low fragmentation efficiency? The September to December 2021 basaltic eruption of Tajogaite on the island of La Palma, Canary Islands, was characterized by hybrid activity, i.e., synchronous emplacement of lava flows and production of tephra in fountaining and strombolian activity. The eruption produced a sustained volcanic gas plume, and a sporadic laze plume formed due to the lava flow entering the sea and vaporizing seawater. We sampled PM10 in the ambient air below the path of the volcanic ash plume on October 1, 2021, as well as the tephra depositing on the ground, and characterised the particle size distribution of both. The airborne samples' mineralogical content, near-surface chemistry, and surface texture were determined by Raman spectroscopy, scanning electron microscopy, and EDS analyses. We demonstrate the ubiquitous presence of sub-10 µm volcanic ash (glass shards and fragments, euhedral crystals, and crystal fragments) in the ambient air. Particles from sea aerosol as well as from aerosol originating from the condensation/transformation of volcanic gas are also identified. Evidence for interaction of the sub-10 µm volcanic ash surfaces with volcanic gas/aerosol as well as the background atmosphere loaded in sea aerosol are also observed. We analyse the dispersion pattern of these sub-10 µm volcanic particles comparing evidence from the ground tephra samples and satellite and air quality monitoring data, and determine the amplitude of their impact on air quality. Finally, we discuss the possible health implications in case of human exposure.

Session ID: 9.2

Impacts of a "soft" substrate on maar fragmentation processes and eruptive dynamics: the example of the maar de Jaude, France

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Maars are volcanic edifices produced by small-volume but highly explosive eruptions. These structures are defined by a large crater that cuts through the country rock. Country rock fragments are also abundant in the deposits. This raises the question of whether the substrate has any influence on the fragmentation. The aim of this study is therefore (1) to identify potential interactions between a "soft" sedimentary substrate and the magma and (2) determine the influence for fragmentation efficiency and eruptive dynamics. The maar de Jaude (France), emplaced within the Oligocene and Miocene sediments, is the perfect candidate to observe and quantify these interactions. Today, the maar de Jaude is buried beneath the city of Clermont-Ferrand, with its 150,000 inhabitants, and is part of a quiescent volcanic province. I reconstructed the stratigraphy of the whole sequence of the eruption and performed a facies analyses to identify the different mode of sedimentation of the deposits. This was followed by laboratory measurements of grain size distribution (GSD) and componentry of the deposits and density, porosity and connectivity of the juvenile fragments. Some units are highly indurated. Image analysis was therefore used to obtain the GSD and componentry. Five phases are identified in the eruptive sequence, which is mainly composed of dilute pyroclastic density currents deposits although some fallout deposits from short-lived plumes are present. Vertical variations show a migration of explosions toward the surface. Coarse mixing between sediments and magma is abundant. The texture of the sediments indicates that they were ductile and therefore wet during the interaction with the hot magma. The GSD and components show that the magma was not finely fragmented. This highlights the fact that the explosiveness of a maar may depend on the nature of the water (pure versus sediment-laden) and therefore of the substrate.

Session ID: 9.3

First detection in Australia of cryptotephra likely to be derived from the 25.6 ka Ōruanui supereruption in New Zealand

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Cryptotephra subsampling techniques were used to identify a high concentration (c. 700 shards/g) of glass shards within the Yellow Marsh sediments in northwest Tasmania, Australia. Radiocarbon dating from the overlying sediments coupled with geochemical analysis of the glass shards indicate their similarity to the Kawakawa-Ōruanui Tephra (KOT), derived from the Ōruanui super eruption of 25,580 ± 0.258 cal yr BP (± 2sd) from the Taupō Volcanic Zone, New Zealand. Although cryptotephra from this eruption has previously been identified in Antarctica and modelled to have been transported over parts of southern and eastern Australia, to date glass shards from this eruption have not been identified in Australia. Correlation of this cryptotephra has not been straightforward with discrepancies in age and geochemistry discussed, and alternative source eruptions considered. If the correlation of the cryptotephra to the Ōruanui super eruption is correct, this finding has the potential to allow Last Glacial deposits in the SW Pacific (including those in Australia, New Zealand, and Antarctica) to be irrefutably linked.

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Poster Session Abstracts

Poster Session - Tephra and Climate

Board ID: 1

Reconstruction of past volcanism with proxies in the speleothem record – Toba

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Speleothems (such as stalagmites) are secondary carbonate cave formations which have been used to reconstruct climate through transference of water from the land surface to the cave. Study of trace elements in speleothems using synchrotron-based and mass spectrometry elemental techniques have also been used to reconstruct Holocene volcanic eruptions, working on the assumption that these elemental signals are due to the desorption of trace elements from the tephra to the groundwater. This study investigates the relationship between trace elements and strontium isotopes in a Chinese stalagmite for reconstruction of the Toba super-eruption (VEI 8, ~74 ka BP, Indonesia). Volcanic ash from this eruption was scattered across much of Asia, with ~0.1 cm settling above the cave in which the speleothem formed. High resolution trace element data for established and novel volcanism proxies were collected using laser ablation mass spectrometry in conjunction with 2D elemental mapping. Strontium isotope data reflect changes in the source of dust, with changes in source potentially representing an injection of volcanic material. With this new data, along with future statistical analysis, high resolution carbon and oxygen isotopic data will be acquired to reconstruct the climatic impact of the Toba eruption.

Board ID: 2

Geochemical Fingerprint for classification of tephra from Plinian volcanic eruptions around the East Sea, Korea

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This study focuses on the use of geochemical fingerprinting techniques to classify tephras resulting from Plinian volcanic eruptions in the East Sea, Korea. By analyzing the geochemical signatures of tephra deposits found in marine core sediments, we aim to enhance our understanding of regional volcanic activity. These techniques provide detailed information on the history of the several tephra layers, such as Aso-3 and Aso-3 from Japanese Island and Ulleung tephras from the Ulleung Island of the East Sea. These tephra layers are well-represented in East Sea sediment and show good correlation, serving as useful chronostratigraphic maker. Volcanos such as Backdusan, located on the border between North Korea and China, and Ulleung-do, submarine volcanoes characterized by the explosive volcanism, contribute distal tephra layers to the East Sea and the Japan Island arcs. The tephra layers found in and around East Asia reflecting long-range transportation, which play an important role in stratigraphic studies. The juxtaposition of marine and terrestrial tephra with historical and geological records allows for the synthesis of event association, potentially improving our understanding of paleoclimate variation.

Poster Session - Tephra and Volcanism

Board ID: 3

Timing and eruptive characteristics of the 349 ka Whakamaru supereruption sequence constrained by detailed analysis of tephra sites around New Zealand.

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The Whakamaru supereruption from the central Taupō Volcanic Zone (TVZ), New Zealand [CW1] vented >1,500 km^3 of rhyolitic magma across New Zealand and the South Pacific at ~349 ± 4 ka. The eruptive succession incorporates a complex sequence of welded ignimbrites in the central North Island, and correlated fall deposits of the same age (within error), documented as the Rangitawa or Kohioawa tephras[CW2] , throughout New Zealand, on Chatham Island and in marine cores in the Tasman Sea and south Pacific[CW3] . The inter-relationships and relative timings of these eruptive deposits remain poorly constrained but are vital to understanding the nature and potential impacts of this event. Here, we present major and trace element data from Rangitawa/Kohioawa tephra glass shards collected from multiple sites at cm-scale resolution to characterise any spatial or temporal variability in glass compositions. This work importantly correlates fall deposits preserved in different geological environments, i.e., marine, terrestrial, and lacustrine over proximal, distal, and extremely distal areas to one another. The presence of multiple glass populations within singular fall units highlights the tapping of multiple magma bodies throughout the eruption. Extrapolated over multiple sites this approach will build a robust model of how the Whakamaru supereruption evolved, and the nature of ash dispersal across New Zealand and the South Pacific. Further to this work, post-eruptive environmental impacts will be examined through high-resolution sampling of pollen at proximal and distal sites around New Zealand. These pollen records will be used to develop an understanding of relative environmental change near to, and far from source, along with constraining the timing of the eruption in its climate context.

Board ID: 4

Unveiling the dynamics of the second largest event in the Campi Flegrei explosive history: the M7 Maddaloni eruption (~109 ka)

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A detailed reconstruction of the physical parameters (i.e., intensity and magnitude) and tempo of the past explosive volcanism is pivotal for hazard assessment and risk mitigation. With this regard, the study of tephra layers recorded in proximal and distal successions has been recognized as a powerful tool for reconstructing the eruptive history of source volcanoes.

The Campi Flegrei caldera, southern Italy, is among the most productive volcanoes of the central Mediterranean area, although its volcanic history and eruptive dynamics preceding the major ~40 ka Campanian Ignimbrite eruption are still poorly constrained. Recently, one of the most widespread Late Pleistocene Mediterranean marker tephra, equivalent to the well-known marine X-6 layer, has been correlated by means of stratigraphic, compositional, and chronological data, to the Maddaloni fallout eruptive unit (~109 ka), previously described in proximal settings and attributed to the Campi Flegrei. Using a semi-analytical tephra dispersal model, we combined field data and laboratory analyses to reconstruct, for the first time, the main Eruption Source Parameters of this large explosive event, thus characterising the ash dispersal dynamics as far as distal areas. Our results suggest that the Maddaloni eruption is the second largest event from Campi Flegrei: an early Plinian phase involving ~3-13 km^3 DRE of magma was followed by a co-ignimbrite phase that erupted ~60-90 km^3 DRE, thus ranking a M7 event. This study provides new insights on the capability of the Campi Flegrei magmatic system to repeatedly generate very large explosive eruptions, information which is crucial for the risk assessment of critical infrastructures in Italy and in the Central Mediterranean region.

Board ID: 5

The effects of archaeological fires on volcanic glass shards: An experimental approach

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Fire usage is a common behavior preserved at archaeological sites during the Middle and Later Stone Age throughout South Africa. Many sites preserve multiple combustion features throughout the stratigraphy, demonstrating continuous and habitual use of fire. Additionally, archaeological sediments are chemically complex due to the various other processes occurring on site (i.e., weathering, fauna, plant material, etc.). Because of this, it is critical to understand the taphonomic effects of direct heat and burning on materials present within the sediment. Here, we present an experimental study that tests the effects of heating and burning on the geochemistry of volcanic glass. While many studies have investigated major and trace element mobility in lacustrine, marine, or soil environments, there is a lack of understanding of how fire conditions at archaeological sites affect volcanic glass. This presents an issue when using tephrochronology at archaeological sites with abundant fire use. Therefore, we explore the effects of indirect heating using a kiln and direct heating through actualist fire experiments. Because domestic fires can range between 317 to 950 degrees C, we heated volcanic ash in a kiln in 100-degree increments ranging from 200-900 degrees Celsius. We also mixed volcanic ash in experimental fires to examine the changes in an environment more realistic to an archaeological fire. Following experiments, we measured the major and trace element chemistry to understand the changes that occurred during these processes. Results show that changes for mobile elements like Na and K happen very quickly and at lower temperatures whereas elements like Al or Fe show minimal changes until temperatures reach > 800 C. The results of this study are important for understanding the taphonomic processes that affect the geochemistry of volcanic glass, which is essential for the success of this dating and correlation tool.

Board ID: 6

Eruptive histories of New Zealand's nearshore volcanoes: Insights from marine cores around Tūhua and Whakaari volcanoes

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New Zealand hosts two recently active near-shore volcanoes in the Bay of Plenty: Tūhua (Mayor Island) and Whakaari (White Island). Both volcanoes show evidence for explosive activity as well as caldera and/or flank collapses that may have impacted mainland New Zealand in the past. Whakaari's eruptive history is only partially known due to limited exposure and preservation. Tūhua's geology has been studied extensively but the full extent and ages of its recent explosive activity, especially that accompanying lava extrusion, remain uncertain. Understanding the magnitude and frequency of past eruptions is crucial for hazard and risk assessment for coastal communities. Our study addresses these knowledge gaps by investigating the pyroclastic eruptive histories from marine piston cores collected in October 2023 at locations around both volcanoes. We will assess the numbers, ages, sizes, and compositions of eruptions, including radiocarbon dating of bracketing sediments (e.g., planktic foraminifera) and chemical analysis of tephra horizons (e.g., EPMA, LA-ICPMS) to calculate eruption frequency-magnitude relationships. Initial processing of the 37 recovered cores up to 5.5 m in length revealed >360 visible tephra layers in total. The number of discrete events will be determined once the layers are correlated. Preliminary observations identify several large, but infrequent, peralkaline rhyolite eruptions from Tūhua, and multiple small, but more frequent, andesitic events from Whakaari. The cores also contain relatively young (<20ka) mainland calc-alkaline tephra from the Taupō Volcanic Zone, which facilitates good age constraints within the cores. Additionally, coarse-grained, poorly sorted, shell-rich tephra units observed in proximal Whakaari cores are evidence for mass flow activity. Preliminary observations from core processing alongside ongoing analyses (e.g., CT scanning, iTRAX, EPMA) will be presented and compared to onshore observations, existing tephra records and previous distal coring studies. These datasets will complement existing work to improve the eruptive record of New Zealand's offshore volcanoes.

Board ID: 7

Spatial distribution and grain size characteristics of the May 14, 2018 Shinmoedake eruption deposit, Kirishima Volcano, Japan, based on post-eruption field survey and meteorological datasets

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Following the 2011 magmatic activity, Shinmoedake Volcano, Kirishima Volcanic Complex in southern Kyushu, southwestern Japan, experienced intermittent eruptions in 2018. The May 14 eruption, which was one of the major events in 2018, began with a vulcanian eruption at 14:44, and the eruption plume rose 4500 m above the crater rim. Thereafter, it transitioned to an ash eruption; the plume height decreased gradually until the eruption ceased at 16:10. The tephra fall deposits were distributed more than 27 km to the southeast of the source crater; the mass of the tephra fall deposit was approximately 2.1×10^7 kg, calculated based on an isomass map. The deposit incidence differed between the east and west sides of the major dispersal axis. The deposits found east of the main dispersal axis were primarily composed of coarse to medium sand-sized particles with no fine fraction (fine sand to silt in size). In contrast, the deposits west of the axis were finer-grained than those east of the axis. We analyzed photographs of the eruption plume, along with the regional meteorological data and the dispersal and grain-size characteristics of the deposits, and reached the following conclusion: during the May 14, 2018 eruption, the wind directions above the Shinmoedake crater fluctuated across altitudes. The westerly winds dispersed the eruption plume that rose to a higher altitude, containing coarser tephra associated with the initial vulcanian eruption, further to the east rather than along the main axis. In contrast, a lower-altitude ash eruption plume that was rich in fine materials was dispersed westward rather than along the main axis, which was influenced by northerly winds.

Board ID: 8

Mixed glass compositions in the 230 AD Taupō Tephra: Multiple magma types or particle recycling from earlier deposits?

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The c. 230 AD Taupō Tephra is a widespread marker bed in terrestrial, lacustrine and marine deposits around the North Island of New Zealand. The eruption comprised six phases, generating a characteristic and distinctive suite of fall deposits and ignimbrite. In proximal deposits, crystal-poor juvenile pumices from all fall and ignimbrite units display a very narrow chemical compositional range throughout the eruption sequence. These compositions are distinct from older eruption units, including the 25.5 ka Oruanui supereruption, having lower SiO_2, (73.5–75 wt %) with restricted mineralogy and reverse crystal zonation, suggesting a hotter and less evolved magma source. Distal tephra deposits, however, variably contain glass shards that span a wider range of compositions, from ~74 to 79 wt% SiO_2, with a distinct cluster at 78 ± 0.7 wt % SiO_2. This observation raises the question: did the Taupō eruption actually have multiple, more evolved magma types, not represented in single pumice populations? Here we investigate the relative content and origins of higher-SiO_2 glass in the Taupo Tephra from different depositional settings and geographic locations around the North Island. We infer that the published Taupō Tephra glass field contains a significant proportion of glass shards recycled from earlier eruptions and, in particular, the 25.5 ka Oruanui supereruption that was sourced from a broad vent region within which lie the 230 AD Taupō vent sites. The recycling of glass shards in the 230 AD Taupō event was facilitated by the fine-grained nature of the phreatomagmatic Oruanui eruption deposits and their kilometre-scale intracaldera thicknesses, coupled with the outstandingly explosive nature of the 230 AD Taupō eruption. The mixed modal compositions found in documented locations (including Antarctica), represent a unique double fingerprint for this event and highlight that caution must be taken when interpreting compositional fields and magmatic processes from distal tephra deposits.

Board ID: 9

GROUND- AND SATELLITE-BASED SYSTEMS TO MONITOR VOLCANIC PLUMES: THE ETNA CASE STUDY

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Monitoring active volcanoes is essential to mitigate the volcanic hazard and to prevent fatal risks for population. This is the case of Mt. Etna (Catania, Italy) one of the most active volcanoes in Europe. It is mainly characterized by mild strombolian to powerful lava fountains activities. In this regard, the Istituto Nazionale di Geofisica e Vulcanologia – Osservatorio Etneo (INGV-OE), monitors the Etna through multi-platform sensors.

In this work, we show how the combined use of ground-based sensors (cameras and radars) and satellite radiometers allows a better analysis and characterization of the Etna eruptive activity.

The data used for this study come from different sources: the VIVOTEK IP8172P is a visible camera located in Catania; the thermal-Infrared calibrated camera located in Nicolosi; the X-band (9.6 GHz) polarimetric weather radar located nearby the International Airport Vincenzo Bellini (Catania); the Spinning Enhanced Visible and Infrared Imager (SEVIRI) on board the Meteosat Second Generation Geostationary Satellite.

The synergistic use of these systems allows a more reliable quantification of Eruption Source Parameters (ESPs) such as the Cloud Height, Mass Eruption Rate, Total Mass and Particle Size. Typically, these EPSs are used as input parameters to train volcanic ash transport and dispersal models in the atmosphere. A more accurate estimate of ESPs reduces the uncertainty of numerical dispersal simulations.

The exact estimate of ESPs is challenging and driven by different conditions, mainly sensors specification and weather conditions. However, the use of complementary remote sensing systems can improve the understating of eruptive phenomena and advance in modelling of volcanic physical phenomena.

Board ID: 10

Impacts of volcanic ash on health and environment in the Auckland Volcanic Field – a project proposal

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The Auckland Volcanic Field (AVF) is a monogenetic basaltic volcanic field, comprised of 53 volcanic centres, with the city of Auckland, New Zealand's biggest urban centre, built on top of it. In the event of a future AVF eruption, ash-fall (tephra) will be one of the mostly likely hazards. It is also one of the most far reaching, and thus has the potential to be one of the most impactful. Volcanic ash deposits from the AVF have been researched extensively within the maar sediment cores within the field. Correlation of these deposits between the cores provides evidence for the dispersal of the volcanic ash over a range of scales, city-wide in the case of a large eruption to locally constrained in small eruptions. However, the geochemical impact of the tephra itself is so-far not investigated from a health and environmental contamination perspective.

The proposed project we detail here is the development of fresh ash simulation methods, followed by geochemical analysis of volcanic ash to determine the concentrations of highly reactive elements (e.g., F, Cl, K, Na, S, and Fe species). These concentrations will be combined with known and estimated gas outputs (for S, Cl, and F) from previous studies to produce a total volatile budget for the eruptions. In addition, the morphology of the glass shards and size fractions will be determined as these factors can lead to respiratory illnesses such as silicosis, and if inhaled or ingested act as carcinogens. Finally, these factors will be applied to existing DEVORA scenario models to assess and forecast impacts of volcanic ash on the health and environment of the city of Auckland.

Board ID: 11

Community Engagement in the Tephra Data Community: facets and solutions for data publication and integration through a Framework for FAIR Data Communities

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The international volcanic ash (tephra) research community creates and curates complex data, spanning several disciplines, acquisition and analytical methods, and dissemination patterns. There are several aspects of this intricate landscape that researchers must navigate when working with tephra sample data: a) sample and data collection, b) storage and management, c) access and sharing, d) use and analytics, e) integrity and security, f) ethical considerations, and g) community engagement.
Building upon the existing efforts of the global tephra community to establish a shared data space within IEDA2 under the EarthChem Tephra Data Community, this effort seeks to simplify the journey of individual researchers from data collection, to publication, sharing, and beyond to reuse. As part of the development process, we will collect feedback from the tephra community on desired functionalities to improve the user experience. Furthermore, we intend to boost 'data-savviness' and purposefully engage with Early Career Scientists and minority-representing institutions to minimize access barriers.
The Framework for FAIR Data Communities will untangle the web of available data resources and streamline tephra researchers' data journey across tools such as SESAR, the EarthChem tools suite (Library, Synthesis,

Volcano Portal, Tephra Community), Antarctic Tephra Database, EARThD, GeoDIVA, and GeoMapApp, Strabo, and TephraBase will lead to faster and more efficient tephra data archiving and data sharing.

Board ID: 12

Eruption Source Parameters of explosive volcanic eruptions for operational simulation of tephra dispersion

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Eruption Source Parameters (ESPs) are crucial for characterising volcanic eruptions and are essential inputs to numerical models used for hazard assessment. Key ESPs of explosive volcanic eruptions include plume height, mass eruption rate, eruption duration and grain-size distribution. ESPs are commonly estimated either from study of previous eruptions at a volcano or analogous volcanoes, with additional insight provided by analysis of unrest signals. When these parameters are published in the scientific literature they are commonly as a single value (e.g. plume height) that represents either a phase, or average characteristics of an eruption, and rarely include information on associated uncertainties.

For operational modelling of volcanic ash, for example, those conducted by Volcanic Ash Advisory Centres (VAACs), ESPs are required that reflect the likely activity at a volcano. Until recently, a single set or small number of parameters were required to produce 2D plots of forecast ash dispersion. However, improved computational efficiencies and recent changes to operational procedures at VAACs will see these plots replaced by 4D probabilistic products. The modelling approaches behind these new products require more complex input parameter information than is currently available. The aim of this presentation is to initiate discussion about how available eruption data could be used to fulfil these needs, and to highlight the importance of including meta- and uncertainty data when publishing ESP data to aid this purpose and, more widely, understanding of volcanic activity.

Poster Session - Tephrochronology and tephrostratigraphy

Board ID: 13

Using ice-cores to precisely date caldera-forming eruptions and widespread isochrons during the Holocene

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Polar ice-cores have long been recognised as unrivalled repositories of past volcanic events and improvements in micro-sampling and analytical techniques are uncovering a growing number of cryptotephra deposits erupted from exceptionally distant volcanoes. We present a series of Middle Holocene cryptotephra deposits detected within the NGRIP ice-core that originate from five different volcanic regions across the Northern Hemisphere (Alaska, Cascades, Iceland, Japan, Kamchatka). Three large caldera-forming events in Kamchatka (KS_2 from Ksudach), the Cascades (Mazama) and North Eastern Japan (Mashu) are identified along with ash from the Hekla 4 eruption in Iceland. High-precision ice-core ages (adopting a 1950 datum for the GICC05 timescale assigned to the Greenland ice cores) are derived for each eruption: Hekla 4 (4325 ± 8 a b1.95k), KS_2 (7089 ± 26 a b1.95k), Mashu (i-f) (7473 ± 33 a b1.95k) and Mazama (7562 ± 35 a b1.95k), all of which can be employed as chronological fix-points in other proxy records where these deposits are also preserved. An additional cryptotephra deposit is thought to originate from Redoubt Volcano (Alaska) and is correlated to a deposit identified in lake records from the Kenai Peninsula. This ensemble of Middle Holocene tephra deposits highlights the pivotal position of the Greenland ice-sheet and its ice-cores to capture deposition from the convergence of several far-travelled ash clouds. Precise age estimates derived from the annually resolved ice-core record greatly enhances the value of these tephra isochrons.

Board ID: 14

Marine tephrostratigraphy offshore Mt. Etna, Sicily

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During RV Meteor Cruise M178, eight gravity cores were taken offshore across the continental margin east of Mt. Etna, Sicily, in order to re-evaluate the volcanic history of pre-historic eruptions and mass wasting events in the marine environment. We examined 87 marine tephra layers; constraining their componentry and petrographic characteristics, as well as major element compositions of glass shards using an electron microprobe. A total of 27 tephra layers are characterized as primary pyroclastic flow and fall deposits, i.e. directly related to an explosive volcanic eruption. The majority (>65%) of the investigated layers, however, are characterized as deposits of secondary density currents, and not necessarily directly related to a volcanic eruption. We use geochemical finger-printing to correlate eleven primary marine tephra layers to seven well-known Mt. Etna eruptions (e.g., M1, TV, FS, FV) within the last 12 kyrs; providing valuable time markers for the marine sediment record. Identification of the S1 sapropel in the marine gravity cores provides additional age constraints. Furthermore, we correlate ten marine tephra layers representing four individual eruptions between the marine gravity cores, and identify another six primary layers in single cores. The marine tephrostratigraphic framework covers 17 widespread volcanic events, and comprises four previously unknown eruptions between 7.7 and 10 ka. The previously unknown eruptions indicate that Mt. Etna was more active than previously thought during that time period. Overall, our study demonstrates the value of integrating terrestrial and marine data sets to enhance understanding of the eruption history of a volcano, such as Etna.

Board ID: 15

Dating the Old Crow tephra using reworked terrigenous glass shards in Bering Sea sediment cores

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The Old Crow tephra has long been interpreted as a key stratigraphic marker across eastern Beringia—the unglaciated region of Alaska and adjacent Canada—for the onset of Marine Isotope Stage (MIS) 5e. However, recent zircon U-Pb dates instead suggest it was deposited ~207 ka during the MIS 7 interglaciation, with wide-ranging implications for understanding the late Quaternary history of eastern Beringia. Because proximal marine sediments commonly contain reworked glass shards from prominent tephra that postdate their deposition on land, we turned to the marine sedimentary record to resolve the age of this key chronostratigraphic marker. We analyzed detrital glass and identified shards of Old Crow tephra from sediments spanning ~250-15 ka at Bering Sea IODP Sites U1343 and U1345. These sites were targeted because they have well-constrained age models based on benthic foraminifera $\delta^{18}O$ and receive terrigenous sediment from eastern Beringia. Results from U1343 are forthcoming and will be presented at the meeting. At Site U1345, detrital Old Crow tephra is absent prior to 160 ka. Old Crow tephra appears abruptly in the detrital shard population ~157 ka, comprising >40% of shards from 157-142 ka, and is present at low concentrations in all samples from 134-15 ka. The abrupt appearance of abundant detrital Old Crow tephra ~157 ka, its absence in earlier intervals, and its presence at low concentrations in all samples 134–15 ka collectively indicate that the tephra was deposited during middle MIS 6, ~159 ± 8 ka. This chronology affirms the long-standing use of Old Crow tephra in eastern Beringia as a marker for the MIS 6/5e transition. As a result, chronologies for the timing of key events in the region (e.g., bison entry into North America; interglacial paleoclimate; permafrost history; the penultimate glaciation) do not require wholesale revision.

Board ID: 16

There she blows! Unravelling the eruptive history of Aso volcano (Japan) using distal ash deposits

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Aso (southwestern Japan) is one of the largest active volcanoes in the world, with a caldera that was formed and modified by a series of at least four catastrophic VEI 6 – 7 eruptions between ca. 270 to 87 ka. These caldera-forming events produced widespread ash deposits blanketing Japan and the surrounding seas, with the final Aso-4 event generating pyroclastic density currents that can be mapped over 160 km from source. Between these cycles, and to the current day, Aso is known to have remained very active, but the frequency and dispersal of these events are poorly constrained. This is unsurprising since the proximal exposures are limited and the numerous cataclysmic events have destroyed and buried older deposits. Here, we highlight the critical role that distal records play in evaluating the eruptive history and hazard potential of Aso caldera. We review the known distal occurrences of tephra deposits erupted from Aso, integrating new data from lake and marine sedimentary records across the East Asian/Pacific region. This detailed tephrostratigraphic framework highlights inconsistencies in tephra correlations and suggests large magnitude events were more frequent and widely-dispersed than previously anticipated. To further supplement this record, we use high-resolution sedimentary cores to identify non-visible ash (cryptotephra) deposits erupted from Aso, which provide new insight into the timing and dispersal of both pre- and post- caldera-forming events. The precisely dated Lake Suigetsu sediment core (central Japan) provides the most comprehensive distal eruption record for Aso, despite being over 530 km NE from the vent. This work serves as a critical reminder that even in volcanic regions that are intensely studied, numerous large Quaternary explosive events remain poorly understood and many are undocumented.

Board ID: 17

A late Pleistocene marine cryptotephra record of the East African Rift

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The Main Ethiopian Rift (MER) is the northernmost part of the East African Rift System (EARS). Quaternary silicic volcanoes and hominin-bearing sedimentary formations lie within the MER. To date fossils, most studies perform Ar-Ar dating on tuffs stratigraphically above or beneath them. However, such technique requires pure feldspar crystals, which is not always the case, and the uncertainty may be as high as ± 47 ka. The aim of this study is to find cryptotephras in a marine core (MD96-2073), to precisely date them using our marine sediment core age model, and to transfer the marine chronology to continental tuffs.

Core MD96-2073 is a 34 m-long piston core retrieved near Socotra Island, 1500 km north-east (N-E) from the MER. A total of 356 $\delta^{18}O$ analyses have been carried out on benthic foraminifera to build the marine sediment core age model, with a 10 cm resolution. Sediment was sieved at 45 µm (10 cm and 1 cm resolution) and glass shards were counted under a stereo microscope.

This sediment core spans, at least, the last 300 ka, with a mean 7 ka uncertainty (95% confidence intervals) throughout. Six cryptotephra-bearing intervals have been identified so far, by counting. Other techniques were not effective to detect them. The first one is dated at 74 ka BP. It has a maximum value of 160,000 shards/g. Based on major and trace elements, it is identified as the Youngest Toba Tuff (YTT). At 155 ka BP, a cryptotephra (20,000 shards/g) might be a correlative of the Silver Tuff, from Konso, Ethiopia. The others are dated at ~119 ka, ~300 ka and older, waiting to be analysed. This preliminary study shows that recent (< 750 ka) volcanic ashes from the MER can be found offshore. These cryptotephras may be used as new tephrostratigraphic markers for the area.

Board ID: 18

Cryptotephra Record in Palaeolake Chew Bahir, Southern Ethiopia: Reconstructing the Pleistocene–Holocene Eruptive History of the Main Ethiopian Rift

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The Main Ethiopian Rift (MER) hosts numerous silicic volcanoes, many have produced explosive voluminous eruptions during the Pleistocene–Holocene. Chew Bahir is a palaeolake in the southern Ethiopian rift, adjacent to the Omo-Turkana Basin. Its location posits it as a mid-range distal receiving site for tephra ejected by explosive MER eruptions. A ~290 m sediment sequence (~620 ka) was recovered close to the western margin of the basin in 2014. High-resolution palaeoclimate reconstruction using geochemical proxies e.g. K/Zr ratio has been conducted on the core, revealing regional climate variability throughout the Middle Pleistocene–Holocene and providing significant implications for understanding the impact of climate change on regional human evolution, dispersal and adaptability.

Ongoing research on cryptotephra analysis aims to produce a relatively continuous and complete record of the Pleistocene-Holocene volcanic history of the MER. Here we present some preliminary results of cryptotephra counts and glass geochemistry on sections of the core. Two marker layers represent the Shala Silver Tuff and Corbetti TA-56, which have been geochemically correlated to their volcanic outcrops and paleoanthropological sequences at Omo-Kibish and Konso (Vidal et al., 2022, QSR & Vidal et al., 2022, Nature). The results of all other layers are currently unpublished, but they show satisfactory potential for cryptotephra preservation and analysis in the Chew Bahir core.

The next step is to complete the cryptotephra analysis on the core, especially focussing on the 300–100 ka, which is important for studying hominin evolution and dispersal in the region. The completed cryptotephra record would serve as a foundational tie-point in the regional tephrostratigraphical framework, allowing the fine-tuning of proximal eruptive chronologies and refining the ages of critical cultural layers in palaeoanthropological sequences. The eruptive record can also be used alongside the already available palaeoclimate record to inform their combined impacts on hominin evolution and dispersal.

Board ID: 19

Tephrostratigraphy of the Totolcingo Lagoon, Serdan Oriental Basin, central Mexico

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Explosive volcanic eruptions can cover the landscape with tephra thousands of kilometers from their vent source. Understanding the frequency of these explosive events is fundamental for hazard assessments in densely populated areas. Because of the partial to complete erosion and covering of the oldest deposits, the correlation of on-land exposures of the volcanic deposits and tephra layers within lake sediment is essential to resolve the stratigraphic order and chronology of pyroclastic eruptions in terrestrial settings. Here, we present preliminary results from a 350 cm-long sediment section recovered from the Totolcingo Lagoon located in the Serdán-Oriental Basin (SOB), central Mexico. Six tephra layers interbedded with lake sediments are preserved. Because the studied site is located 40 km south of the Los Humeros caldera and 40 km west of the Citlaltépetl-Cofre de Perote volcanic range, large-magnitude eruptions from these volcanic centers could be recorded in this lagoon, among other small monogenetic volcanoes from the SOB. Grain-size and componentry analyses, and major element geochemical measurements (EMPA) of the glass and mineral phases of the tephra layers were used to provide preliminary correlations of the tephra layers with their source volcanoes. Tephrochronology and chemical composition could decipher the late Pleistocene-Holocene volcanic history and the magnitude of volcanic eruptions in this region, where more than 3 millions of people are living in a radius of 80 km around the study site (INEGI, 2020).

Board ID: 20

A new contribution to the Holocene Tephrostratigraphy for Meerfelder Maar, Germany.

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Cryptotephra layers found within sediments act as stratigraphic isochrons and chronological tie points between proxy records, enabling assessments of leads and lags within the climate system. Meerfelder Maar has an exceptional sediment record with high-precision chronology and annually-laminated sediments through most of the Last Glacial-Interglacial transition and the Holocene. Its central European location also provides the potential to link this site to other key records contributing to a detailed European and North Atlantic tephrochronological framework, such as the Greenland Ice cores, Diss Mere (UK) and other European lakes. Previous work on this site by Lane et al. (2015) discovered the presence, in abundance of four significant tephra layers from three volcanic centres, the Eifel, Icelandic and Italian regions; during the LGIT but found a decrease in the presence and concentration of cryptotephra layers during the Holocene.

New evidence from Diss Mere, has suggested that fine resolution sampling (e.g. 1cm/0.5 cm samples) may yield greater results when looking for distal tephra layers in annually laminated sediments. Applying this sampling strategy to Meerfelder Maar, we have found several additional cryptotephra layers in higher concentrations than previously found in MFM09, by Lane et al. (2015). The MF1 tephra adds certainty to a previously tentative correlation in the Massive central source region in France and the presence of Torfajökull and Hekla pairings during the early Holocene also found in Diss Mere add clarification of eruption histories of these two volcanos. The new tepha layers facilitate refinement of the chronology for MFM09 through increased correlation of known age tie points in the varve sequence. Correlating records with the aim of

refining timescales to decadal resolution allows us to build a more accurate picture of past climate changes, which in turn, aids in the creation of a more accurate picture of climates of the future.

Board ID: 21

La Soufriere tephrochronology from Lake Flammarion sediment records, Guadeloupe (Lesser Antilles) – preliminary results.

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Guadeloupe Island belongs to the Lesser Antilles Volcanic Arc, which delineates the eastern boundary of the Caribbean Plate, where geodynamic processes contribute to intense volcanic activities. Lake Flammarion is located at an altitude of 1,103 m at the crater bottom of Citerne Volcano, less than 1.5 km southeast of the summit of La Soufrière volcano in Basse-Terre. In November 2023, a 4-meter-long core was collected in the central part of the lake using a Nesje corer, as part of the ANR PALAVAS project. The core sections were scanned using 3D computed tomography (CT) before opening, and X-ray fluorescence (XRF) and hyperspectral spectroscopy data were collected for each section. Together with visual descriptions, at least six thin tephra layers (< 0.5 cm) composed of fine volcanic ash with high Fe, Si, S, and Ca contents were identified. We followed the protocol of Blockley et al.(2005) to isolate glass shards from volcanic rock fragments, altered particles and minerals, organic matter and diatoms, using different density solutions. To comprehend the nature and origin (source) of these tephra layers and identify potential cryptotephra layers, 3D high-resolution digital images of the particles composing each layer were acquired using a Keyence VHX7000 microscope. We present here the key results of our preliminary work, suggesting a phreatic origin for most of the tephra identified. Detailed morphological characterization of single particles will be performed at a later stage, but a reworking origin can already be excluded. Upcoming radiocarbon chronology will help us constrain the timeframe of these phreatic eruptions and, hence, revisit the frequency of such eruptions at La Soufrière and their records in lacustrine sediments.

Blockley, S. P. E. et al., 2005. A New and Less Destructive Laboratory Procedure for the Physical Separation of Distal Glass Tephra Shards from Sediments. *Quaternary Science Reviews 24* , 1952–1960. https://doi.org/10.1016/j.quascirev.2004.12.008.

Board ID: 22

TEPHRAS AND LAVA FLOWS RELATIONSHIP IN THE LESSER CAUCASUS (ARMENIA)

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The Lesser Caucasus Mountains and Armenia sit on a transition within the Arabia-Eurasia collision zone between a very thin lithosphere (< 100 km) to the west, under Eastern Anatolia, and a very thick lithospheric root (up to 200 km) in the east, under western Iran (Sugden et al, 2020). Study region is situated in the NE part of the Anatolian-Armenian-Iranian plateau, an intensely deformed segment of the Alpine-Himalayan belt. Volcanic rocks from across the region show a wide compositional range from basanites to rhyolites. In Armenia from NW to SE within post-collisional volcanic belt, where are spread 497 Quaternary volcanic centers, which 5 is polygenetic type.

In this contribution, we discuss possible temporal and spatial relationships between tephras and lava flows, studies of which will provide insight into volcanic processes, sources of tephras, timing of explosive eruptions, and evolution of volcanic landscapes.

Recently, tephra layers have been found in various places in Armenia, including in the Geghama upland, which still need to be studied. They are mostly covered by lava and pyroclastic flows, as well as loess and colluvium deposits, which makes detection somewhat difficult.

Irind volcano, in Aragats volcanic massive, is a Plinian-type eruption (0.487±0.028Ma, $^{40}Ar/^{39}Ar$), whose pumice is covered by the lava flows of the Ashtarak volcano, which indicates that this lava flow is younger (Jrbashyan et al., 2015; Meliksetian, 2018), and in archaeological object of Nor Geghi found (Adler et al., 2014) tephra layer (308±7ka, $^{40}Ar/^{39}Ar$) is covered by lava flows (197±7 ka, $^{40}Ar/^{39}Ar$) from Menaksar volcano (Geghama upland).

Dating lava flows in conjunction with tephra layers can provide a timeline of volcanic activity and help identify periods of pause or begins of activity.

Board ID:23

Unravelling the eruption dynamics of the Little Mount scoria cone, Budj Bim Volcanic Complex, south east Australia

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The Budj Bim Volcanic Complex (BBVC) is a ~2km long fissure elongated north-west to south-east in Victoria, south-east Australia. The fissure is part of the active intracontinental Newer Volcanics Province (NVP), the site of Australia's most recent volcanic activity. Melbourne, Australia's second largest city with a population >5 million, is partly built on lavas from past NVP eruptions and therefore at risk of future eruptions. Budj Bim is made up of several basaltic scoria and spatter cones aligned along the fissure. The Little Mount scoria cone is located towards the centre of the fissure complex and its internal layers have been revealed due to extensive quarrying. Here we examine samples from Little Mount and a nearby sequence of deposits to reconstruct the dynamics of the eruption at Budj Bim. We use stratigraphic logs combined with particle size analysis and componentry analysis to classify these samples' depositional environments and identify possible correlations between sampling sites. We also use these observations to identify the fragmentation mechanism(s) and evidence of magmatic versus phreatomagmatic episodes. The Little Mount deposits typically consist of layers of basaltic scoria with varying thicknesses and proportions of lithic to juvenile clasts. Within the deposits, a small number of pyroclasts contain white quartz-rich fragments, some of which are bubbly, and others are densely crystalline. Characterising these deposits and understanding the dynamics that govern fissure eruptions provides opportunities to investigate the potential volcanic hazards from future fissure eruptions worldwide.

Board ID: 24

Constraining radiocarbon dating in Baltic Sea sediments using tephrochronology

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Precise and accurate sediment chronologies are essential for studies of past climate changes. In the brackish-marine environment of the Baltic Sea, radiocarbon dating is complicated by varying influx of old carbon and reservoir age changes challenging the construction of a robust age model. One approach to overcome the problem are well-dated isochronous tie-points like tephras. Here, we present for the first time five cryptotephra horizons in the last ~4300 years from sediments of the Western Gotland Basin containing six different Icelandic tephra populations: Hekla-4, Hekla-S and Hekla-3 from the Hekla volcano, Glen Garry and Grákolla sourced from concurrent eruptions of the Askja and Torfajökull volcanoes, respectively, and Askja AD1875 from the Askja volcano. In combination with new and previously published radiocarbon ages, we quantify age offsets for these time snapshots and observe variable age divergences up to more than 1000

years, which seem to be related to changes in sediment facies driven by different water circulation regimes in the Baltic Sea. Our results integrate the Baltic proper in the circum-Baltic tephrochronological lattice as a tool for investigating regional-specific mid to late Holocene climatic and environmental changes.

Board ID: 25

Reference Concentrations for ATHO-G Major Elements and Lipari Obsidian ID-3506 Trace Elements with Retrospective TDI Corrections

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Homogeneous glass reference materials are of great importance for instrument standardization, data quality control, and between-lab comparability for EPMA, LA-ICP-MS, and other micro-analytical techniques. Accurate multi-element characterization is important, ideally including major, minor, and trace elements, and this is typically done by compiling data from multiple methods and laboratories. ATHO-G and Lipari obsidian 3506 are among the most widely-used rhyolitic glasses, but they may also be subject to alkali element migration during EPMA analysis. Thus it is important that any data utilized in the development of reference concentrations be carefully evaluated for effects like Na-loss as this can compromise accuracy. The primary objectives of this work are to re-examine the major element composition of ATHO-G and to extend the characterization of Lipari obsidian ID-3506 to trace elements. ATHO-G of the MPI-DING glass set is a re-melted rhyolite glass derived from an Icelandic obsidian and characterized for major- and trace-elements, but the accuracy of the reference sodium concentration has been questioned. The Lipari 3506 glass is a natural obsidian related to a family of glasses in use for EPMA since at least 1968. The Lipari glass has been extensively used for major-element analysis, but consensus trace element concentrations have not previously been published.

Compilation of new and published data and a new technique for evaluation and correction of Na-loss effects have been applied to the two glasses, including time-dependent intensity (TDI) tests across wide a range of analytical conditions. This shows that ATHO is far more beam-sensitive than most other reference glasses. Filtering out data compromised by sodium-loss and correcting others, in some cases retrospectively, yields consensus targets of 4.25 to 4.37 wt% for Na2O and 74.9 to 75.2 wt% for SiO2. Preliminary trace element targets with uncertainty estimates are also provided for the Lipari glass.

Board ID: 26

Managing, visualising, and sharing large geochemical datasets for tephra correlation and volcanic studies using IntChron Integration Tool

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There is now a wealth of geochemical data for glass (melt) from various volcanoes and tephra layers, which are invaluable datasets for tephrochronology and investigations into compositional evolution of magmatic systems feeding volcanoes. Compiling data from publications and geochemical databases leads to unwieldy spreadsheets and requires diligence to keep records of sources and other associated metadata. Here we show that a project in the IntChron Integration Tool, an open access and versatile online application, can be used to store and manage tephra and other volcano related data and relevant metadata, visualise the geochemistry in plots, and assess tephra correlations using statistical tools. In addition, the JavaScript Object Notation (JSON) text-based file structure means that the files are small, even for large databases, and easily read so that the data can be imported into data repositories and used in other programmes. An IntChron project can be used for general day-to-day workflow with information on sites and samples added while in the field and

geochemical data can be imported as soon as it is generated. The flexibly of the plotting means that the tools with the database can be used to do all the data visualisation, comparison to other datasets, and the statistical tools provide constraints on the correlations and variations.

Board ID: 27

Integrating global tephra chemistry records to enable high precision palaeoenvironmental correlations through the Varved Sediments Database (VARDA)

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A key barrier to robust assessments of the timing, rate, and synchronicity of palaeoclimate variability lies in poorly resolved chronologies. Annually laminated sediments, varves, can overcome this, permitting unparalleled precision and resolution of proxy reconstructions. Tephra layers found within varved sediments serve as important tools for independently dating and correlating distal sedimentary records. In turn, varve chronologies can be used to significantly refine eruption ages. Critically, these ash layers can also act as isochronous markers around which to assess palaeoenvironmental variability over regional to continental-scales.

The Varved Sediments Database (VARDA), launched in 2020, aims to collate high-resolution proxy and chronological data associated with annually-resolved sequences in order to facilitate improved correlations between environmental records. This included the collation of tephra glass chemistry data associated with both visible and cryptotephra layers, focussing initially on records spanning the Last Glacial-Interglacial Transition within Europe.

Here, we present significant updates to VARDA with the integration of a suite of tephrostratigraphic varved records spanning 125 ka, in key records across the globe. Geochemical datasets associated with 164 known individual tephra layers at 51 sites across 5 continents are reported. This required an adaptive approach in order to accommodate a variety of site- and analysis-specific approaches to reporting data – we report on these challenges. Several key tephras are used to build regional site networks in Europe, Asia, and the Americas, with Suigetsu, Monticchio, Lögurinn, and the Eifel Laminated Sediment Archive acting as key varved tephrostratotype sites. Additionally, three cross-continental markers, including the Younger Toba Tuff, enable distal palaeoenvironmental correlations over several thousands of kms.

Board ID: 28

Tephra compositional data: are we doing it right?

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Accurate identifications of tephras rely on a combination of geographic and stratigraphic context, shard morphology, and – perhaps most crucially – geochemical compositional data. The global tephra community is constantly gathering compositional data from new tephra discoveries, adding to the complexity of this field (for instance by presenting new potential correlations for tephras previously considered unique).

The geochemical analysis of tephra glass composition is typically conducted using an electron probe microanalyzer and reported as major-oxide weight percentages (either as raw instrument results or as normalised percentages). Comparisons to datasets of prior findings are carried out to identify potential matches for correlation. While this method has generally been successful, it can be challenging to differentiate between tephras with similar geochemistries, where multiple candidates are available for correlation. The probability of such situations increases as more data are reported.

Statistical methods like principal component analysis or discriminant function analysis have been employed to distinguish sample populations and identify statistically driven matches, but the effectiveness of these methods often hinges on certain assumptions not being violated (for example, data should not be collinear). As compositional data is subject to the constant-sum constraint – a problem that is seldom addressed in tephra studies – it must undergo log-ratio transformations for certain statistical analyses to work properly. Given the lack of consensus on a procedure for curating tephra compositional data that includes log-ratio transformations, we have investigated various options to see what performs best, aiming for a formal recommendation for tephra data treatment.

Board ID: 29 – Shane Cronin

Why the largest eruption witnessed in 140 years is almost invisible in the tephra record

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The 15 January 2022 eruption of Hunga volcano in Tonga broke all previous records for explosive eruptions, including: rise rate and expansion rate of eruption column, height of eruption column (58 km), size of atmospheric pressure waves, size of tsunami, and the amount of water injected into the atmosphere-mesosphere. We are still grappling with the climate influences that this event continues to have on our atmosphere and ocean and developing new physical and chemical volcanology models to understand what drove the hyper-explosivity of this submarine eruption. One observation that was apparent at the outset of field investigations into this eruption was how thin the tephra deposits were. Within ~70 km from source, this ~7 km^3, hyper-explosive event, lasting 11 hours deposited only 2.5 cm of fine-medium ash. Our typical approaches to understanding eruption frequency-magnitude records is to correlate the dispersal, thickness and grainsize of tephra with eruption magnitude. These relationships have proven robust for many types of subaerial eruption. Would we recognise the true magnitude of the 2022 Hunga event just based on its fall deposit? With current approaches probably not. Instead, it would have been classified as a small-scale eruption and hazard models would not reflect its true nature. Here we present the characteristics of fall from

this unusual Hunga eruption and place it in context with the tephra record from past eruptions along the Tongan arc. Can we distinguish actual small eruptions from hyper-explosive submarine ones? We compare and contrast grainsize and particle shape and density properties with the aim of identifying key features that can be used to better classification of geological records of eruptions where subaqueous settings may be a present (or past) influence.

Board ID: 30

Major Holocene cryptotephras layers identified from Jeju Island, Republic of Korea: Implications for regional volcanic eruptions and environmental changes

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Cryptotephras recorded in sediments are valuable materials with which to reconstruct volcanic eruptive history and synchronize environmental changes across large regions. Here we identify four cryptotephras from Jeju Island, Republic of Korea, that constitute tie-points linking tropical to mid-latitude East Asia. The discovery of a tephra of unknown source with trachytic glass compositions at around 2700 cal a BP (named M263a) can be correlated with the HGY263 recorded in the Huguangyan Maar lake in southern China, and SG14-0433 recorded in Suigetsu lake in central Japan. Another population of glass shards with basaltic andesitic to trachybasaltic in composition (named M263b) represents the first cryptotephra record of a Jeju eruption. A rhyolitic tephra at ~7384 cal a BP (H53) can be correlated with the ~7.3 ka Kikai-Akahoya eruption (specifically, the K-Ah tephra) from Kikai volcano, southern Kyushu, western Japan. The tephra coincides with a marked change in aquatic algae communities in Jeju sediments, possibly signifying a climate response to the eruption. Additionally, tephra layers at ~6948 cal a BP (H22) in the Hanon Maar Lake and ~1030 cal a BP (M125) in Mulyoungari swamp exhibit similar glass compositions to the K-Ah tephra, which suggest unknown eruptions from Kikai or a neighboring volcano. Given the widespread distributions of K-Ah and M263a tephra across East Asia, Jeju sediments can be precisely synchronized with those high-resolution sediments from southern China and Japan, providing two Holocene marker horizons for palaeoenvironmental comparisons across east Asia. Our work shows great promise for the improved chronological constraints and inter-site linkages for palaeoenvironmental sequences in the region through the application of tephrochronology.