Dating the Teide Volcanic Complex: Radiometric and Palaeomagnetic Methods

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Abstract

This chapter describes the integration of radiometric dating and palaeomagnetic investigations to decipher the spatial and temporal evolution of volcanic edifices of Tenerife Island. Accurate ages are crucial to reconstruct the recent eruptive history of Tenerife (specifically Teide Volcano and the North West and North East Rift Zones). Samples have been dated using both the K–Ar and the $^{40}Ar/^{39}Ar$ method in order to assess the reliability of the ages obtained. When the two methods yielded similar results and precision, accurate pooled ages were calculated. The correlation of these ages with the geomagnetic polarity of the lavas (referred to as the geomagnetic and astronomical polarity time scales) has recently been successfully applied to establish the magnetic stratigraphy of volcanoes in the Canary Islands and to constrain the main geological units. Moreover, this well-constrained and high resolution geochronological framework is of prime interest to track and study geomagnetic reversals and excursions. As an example, results are presented from three lava flows in Tenerife from the Mono Lake geomagnetic excursion, the youngest in the documented geological record.

6.1 Introduction

Progress in the study of volcanic areas has been, in many aspects, parallel to the development of methods for dating volcanic rocks. Since the pioneering work of McDougall (1963, 1964) in the Hawaiian Islands, radiometric ages (K/Ar and $^{40}Ar/^{39}Ar$) have been determined for many volcanic regions, particularly the Hawaiian and Canary Islands (Fig. 6.1). Consequently, the geochronology, stratigraphy and volcanic history of these archipelagos are presently among the best known in the world.

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Before 2007, although several authors attempted the geological study of the Teide Volcanic Complex (TVC), only limited progress had been made on the reconstruction of the latest (postcaldera) eruptive history of Tenerife. This was mainly due to the lack of geochronological information, restricted at that time to a single age by Ablay et al. (1995) from Montaña Blanca (Fig. 6.2). Without abundant radiometric ages, it was in fact very difficult to distinguish the recent volcanic formations from one another.

Until recently, researchers stated that a more precise reconstruction of the recent eruptive period of Tenerife (Teide Volcano and the North West and North East Rift Zones) was not achievable because of the inapplicability of radiometric dating techniques in this geological context (Araña et al. 2000). The reason invoked was that lavas were too young for K/Ar and $^{40}Ar/^{39}Ar$ dating, and that suitable organic material (charcoal) for radiocarbon dating was absent.

However, since the first K/Ar ages were obtained from the Canary Islands by Abdel Monem et al. (1971, 1972), and in particular during the last decade, considerable efforts have been made to extend the K/Ar and $^{40}Ar/^{39}Ar$ chronology towards younger and younger ages. Based on these techniques, a recent intensive dating program was implemented and abundant K/Ar and $^{40}Ar/^{39}Ar$ ages are now available from lavas of the different Canary Islands.

As far as radiocarbon ages are concerned, in contrast to the Hawaiian Islands, where abundant radiocarbon ages have been determined from modern (present-day carbon) to lavas older than 38 ka (Rubin et al. 1987), radiocarbon dating in the Canaries has, for a long time, been mainly conducted as part of archaeological research, and as such determined on organic remains (shells, roots, etc.).

Only a few dates were obtained from charcoals derived from Canarian lava flows (e.g., Pellicer 1977; Ablay et al. 1995) prior to the works of Guillou et al. (1998) in La Palma, Carracedo et al. (2007) in Tenerife, Rodriguez-Gonzalez et al. (2009) in Gran Canaria, and Pérez Torrado et al. (2011) in El Hierro. These new radiocarbon dates have considerably improved the reconstruction of the recent volcanic history of the central and western Canaries.

Fig. 6.1 Sampling one of the phonolite flows of Teide inside the Orotava Valley that gave radiometric ages and palaeomagnetic data corresponding to the Mono Lake excursion. Pooled K/Ar ages and $^{40}Ar/^{39}Ar$ plateau ages produce the best age estimates for these flows and proved to be very successful to date key events such as geomagnetic field excursions. Conversely, comparison of radiometric and palaeomagnetic data ensures the reliability of the dating methods used to reconstruct the volcanic stratigraphy and history of the Teide Volcanic Complex

Finally, a combination of palaeomagnetic results and radiometric dating on a number of lavas that have recorded characteristic changes in the Earth's magnetic field (e.g., geomagnetic reversals and excursions) was employed to test the precision of radiometric ages because the duration of some of these geomagnetic reversal events is shorter than the intrinsic error of radiometric dating. These investigations focused both on methodological (testing the instrumental capability to measure increasingly lower percentages of $^{40}Ar^{*}$) and geological objectives (refining the geochronology and volcanic stratigraphy and reconstructing the volcanic history of the TVC). In turn, decoupled from the history of the Teide volcano but of great interest for the scientific community, the combined palaeomagnetic and radiometric investigations of geomagnetic instabilities were used to constrain tie points in the magnetostratigraphic time scale used in sediments, in particular for palaeoclimatic applications.

This chapter describes attempts to extend the bracketed time range for which these dating methods are currently applied towards younger

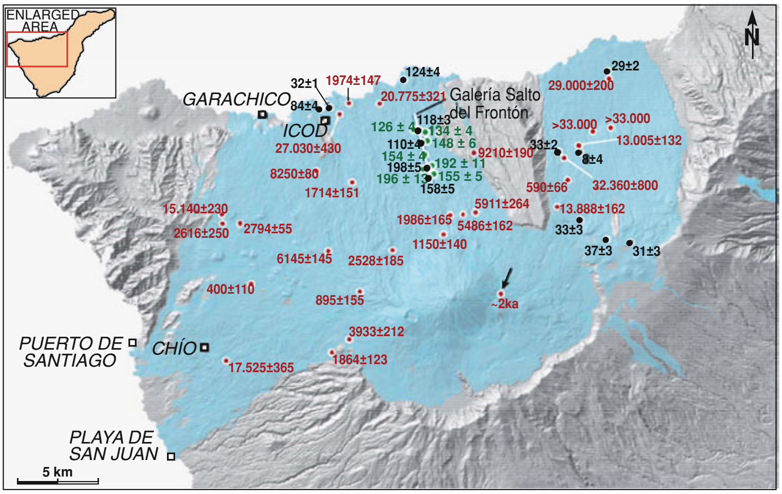

Fig. 6.2 Map of the TVC showing published radiometric ages (Carracedo et al. 2007). Before this work, the only chronological data reported for the TVC was the ~2 ka age dating Montaña Blanca (Ablay et al. 1995), marked with an arrow. Black circles: K/Ar ages, in ka; red circles: ^{14}C ages, in calibrated year B.P.; green circles: $^{40}Ar/^{39}Ar$, in ka

ages using lavas from TVC, comparing the results obtained from three different methods (^{14}C, K/Ar and $^{40}Ar/^{39}Ar$) and combining them with palaeomagnetic investigations for some past geomagnetic instabilities.

6.2 Testing Dating Methods in the TVC

The suitability of the K/Ar and $^{40}Ar/^{39}Ar$ dating methods on increasingly younger ages was tested on two phonolitic lava flows from the TVC, one inside the Orotava Valley (CITF-98) and the other from Playa San Marcos (CITF-301) (see Figs. 8.15 and 8.20), corresponding to the latest stage of evolution of Teide. The results show a remarkable agreement between the two dating methods. Unspiked K/Ar analysis (Charbit et al. 1998) at the Laboratoire des Sciences du Climat et de L'Environnement (LSCE) gave ages of 33.1 ± 1.8 and 31.6 ± 1.9 ka, respectively. Samples with equivalent groundmass to the K/Ar experiments were analysed at the new $^{40}Ar/^{39}Ar$ facility developed at the LSCE. The $^{40}Ar/^{39}Ar$ ages obtained for the two samples, calculated from three independent experiments, are 32.4 ± 1.8 and 31.4 ± 1.7 ka (2σ) (Guillou et al. 2011). Within error, the reported $^{40}Ar/^{39}Ar$ ages agree with the K/Ar ages, and are of similar precision. Therefore, this study demonstrates that precise ages can be obtained from young volcanic rocks using the new $^{40}Ar/^{39}Ar$ method and confirms the accuracy and precision of the K/Ar unspiked method to date the TVC.

This approach is also relevant to check the accuracy of ^{14}C ages used to date the TVC. A charcoal sample, suitable for ^{14}C dating, from within the basal scoriae of phonolitic flow CITF-98 gave a precise pooled K/Ar and $^{40}Ar/^{39}Ar$ age of 32.2 ± 1.2 ka. Using this date and the available calibration curve INTCAL09 14C (Reimer et al. 2009) a ^{14}C age of about 28.2 ka for this flow would be expected (Fig. 6.3). This age is approximately 4 ka younger than the radiocarbon age of 32.36 ± 800 years BP (2σ) which was actually obtained from the charcoal using the AMS technique (Carracedo et al. 2007). The K/Ar and $^{40}Ar/^{39}Ar$ age of this sample at 32.2 ± 1.2 ka is retained as the reliable calendar age for this flow.

There are two main interpretations for the discrepancy between the ^{14}C and K/Ar clock derived ages. The first one would be to question the radiocarbon calibration. Given the stringent criteria adopted these days to update the

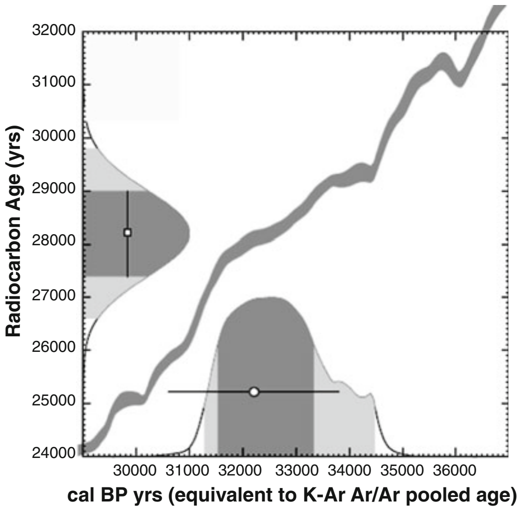

Fig. 6.3 Radiocarbon Age vs. Calibrated Age diagram established using the Radiocarbon calibration program: CALIB REV6.0.0. (Copyright M. Stuiver and P.J. Reimer). White circle: Pooled K/Ar $^{40}Ar/^{39}Ar$ age used as reference to recalculate; *white square* radiocarbon age (from Guillou et al. 2011)

calibration curve between 0 and 50,000 years, we discard this first hypothesis. Errors in ^{14}C dates and their possible sources were already documented over 30 years ago and are evident in several volcanic areas such as the Eifel (Bruns et al. 1980), the provinces of Grosseto and Siena (Saupé et al. 1980), and in the Azores (Pasquier-Cardin et al. 1999). In these areas, significant to large ^{14}C depletions may occur in many plants, due to assimilation of ^{14}C endogenous CO_2, the consequence of which, as demonstrated by the study of modern plants, is an error in excess of the radiocarbon ages that can reach some ka. We suggest that the apparent older radiocarbon age discussed here results from the fact that the analysed charcoal probably derived from a plant which grew close to active volcanic fumaroles, which are sources emitting ^{14}C-free CO_2.

6.3 Dating Old Teide

The oldest sequences of the TVC, outcropping in the northern coastal cliffs, have been dated between 84 ± 4 and 124 ± 4 ka (see Fig. 6.2; Carracedo et al. 2007). However, several *galerías* (water tunnels) cross the entire post-collapse sequence, providing a unique opportunity to determine the age of the oldest lava sequences of the volcano, the rates of volcanic growth, and the evolution of magmas along the construction of the TVC.

Ages obtained in two of these *galerías*—Salto del Frontón (Carracedo et al. 2007) and La Gotera (Boulesteix et al. 2012), confirm that the TVC began to develop immediately after the Icod collapse (Fig. 6.4) (see Chap. 7). Constraining the age of this event and the rate of filling the collapse embayment can be used to test the suitability of unspiked K/Ar and $^{40}Ar/^{39}Ar$ methods in this type of volcanic sequence and at these emplacement conditions. In both *galerías*, the K/Ar ages obtained for the earliest post-collapse lavas from two different laboratories and using the same unspiked method (161 ± 5 and 158 ± 5 ka) are indistinguishable within the range of analytical error. However, a flow in the middle of the *galería* Salto del Frontón gave considerably older ages (about 40 ka older), with consistent and indistinguishable results from the two different laboratories, again both using the unspiked K/Ar and $^{40}Ar/^{39}Ar$ techniques (Fig. 6.4a).

A plausible explanation for these apparently contradictory ages may lie in the different depositional contexts along the *galería*. A homogeneous filling of the entire collapse embayment is very unlikely. In fact, post-collapse instability, particularly in the walls of the embayment, and vigorous dissection by erosion of the relatively soft debris result in a very irregular and changing topography in the embayment to which the successive flows have to adjust, lava flows tending to follow previous incisions (see Chap. 3). Lateral changes, even over very short distances, are common, and it is improbable that the oldest possible lava will be identified, to give a true age of the collapse (Fig. 6.4b).

A second potential explanation concerns post-collapse effusive activity, which resumed immediately with very high eruptive rates and frequencies, as indicated by the lack of any sign of discontinuity (interbedded pyroclasts, soils, dykes, etc.). These conditions of intensive volcanism may account for the hydrothermal

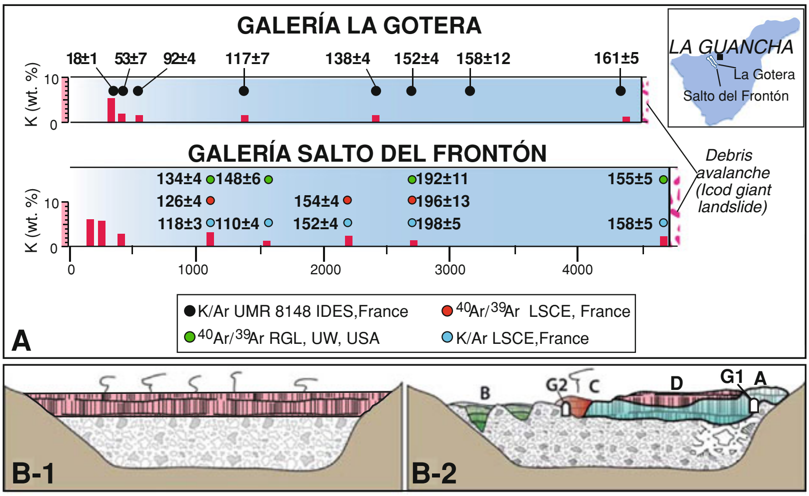

Fig. 6.4 **a** K/Ar and $^{40}Ar/^{39}Ar$ ages obtained by different laboratories from a sequence of lavas in a *galería* on the northern flank of Teide Volcano. The sequence comprises the bulk of the growth of the TVC, from the debris avalanche associated with the ~200 ka giant landslide to the late peripheral phonolitic lava domes. Ages obtained at the end of the *galería* consistently give younger values than the equally consistent values from lavas near the central part of the *galería*. The discrepancy may be explained by hydrothermal alteration of the initial post-collapse sequence and very rapid growth at the early stage of filling of the collapse embayment (based on Carracedo et al. 2007 and Boulesteix et al. 2012). **b** Different conceptions of volcanic filling of the collapse embayment: *B-1* Assuming that the fill of the collapse scar is homogeneous (Boulesteix et al. 2012). *B-2* Post-collapse vigorous dissection by erosion results in a very irregular and changing topography in the embayment to which the successive flows have to adjust (Carracedo et al. 2007). *Galerías* G1 and G2 show the contact of lava flows with the debris avalanche deposits, but the age of the lavas can be very different. Because of erosion and the successive eruptive events, the "minimum" age for the collapse given by G2 would be "younger" than the one provided by G1. The first model (*B-1*) seems geologically unrealistic

alteration observed in the lower part of the lava sequence, at the end of the *galería*. Alteration and exposure to high temperatures (through reheating) can allow radiogenic argon ($^{40}Ar^*$) to be released, causing the calculated K/Ar age to become younger than the "true" age of the dated lava. Similarly, reheating events and diffusion of argon can result in lower $^{40}Ar/^{39}Ar$ ages. Therefore, the internally consistent ages of about 190 ka obtained in the middle of the *galería*, from lavas free of any sign of alteration or reheating (erupted at significantly lower rates and frequencies), may represent a minimum age for the onset of volcanism after the Icod giant landslide.

6.4 Geomagnetic Instabilities in Volcanic Formations of the TVC and the NERZ: Dynamics of the Volcanic Edifices, Mapping and Correlation and Chronological Tie Points

6.4.1 Geomagnetic Reversals

Geomagnetic reversals have been studied to date and correlate volcanic formations in the Canaries since the early 1970s (Carracedo 1975, 1979; Guillou et al. 1996, 2001, 2004a; Carracedo

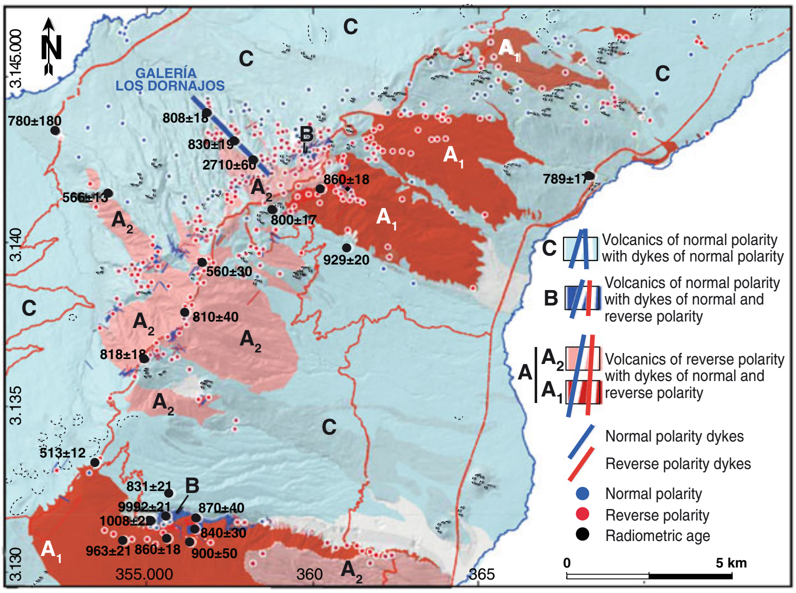

Fig. 6.5 Main magnetostratigraphic units defined as a function of the polarity of 415 oriented cores of lavas and dykes in the NE Rift Zone NERZ. These units have proven to be extremely useful in correlating and reconstructing the successive eruptions that have formed the rift. *Blue* indicates normal polarity, and *red* reversed polarity (from Carracedo et al. 2011)

et al. 2001, 2011). Combined use of palaeomagnetic and isotopic dating (geomagnetic inversions and radiometric dating) also helps to evaluate the reliability of K/Ar ages (Guillou et al. 2004b). This combination of dating techniques (K/Ar and $^{40}Ar/^{39}Ar$) was therefore used to identify and define palaeomagnetic events in the Canaries (Guillou et al. 1996; Singer et al. 2002).

The comparison of the ages and geomagnetic polarity of the lavas with the geomagnetic and astronomical polarity time scales (GPTS and APTS) has been successfully applied to establish the magnetic stratigraphy of volcanoes in the Canary Islands, the NERZ being a good example of this (Fig. 6.5; Carracedo et al. 2011). This combined stratigraphic, isotopic, and palaeomagnetic work has been conducted not only on outcrops (e.g., the Pared de Güímar section, Fig. 6.6), but also in *galerías* from the NERZ, where significant stratigraphic discordances allowing the recognition of a northbound lateral collapse were recognised (Fig. 6.7). These collapses would have been otherwise unnoticeable since post-collapse volcanism filled this basin, extending beyond the coastline to conceal the scar and the avalanche breccia. This approach of integrating geomagnetic reversals and radiometric dating significantly contributed to outlining the spatial and temporal evolution of the NE Rift Zone of Tenerife (NERZ), especially the duration of its main stages of growth and the timing of the catastrophic lateral collapses forming the Valleys of La Orotava and Güímar.

Similarly to many other rift zones, the NERZ evolved very rapidly with high eruption rates, which apparently persisted between 1 Ma and 840 ka. Effusive rates up to 2.5 km^3/k.y. and volcanic growth of 3.5–4 m/k.y have been measured (Carracedo et al. 2011). Such rapid growth, implying high frequency of lava flow emission, allows detailed recording of changes in the geomagnetic field. In fact, the ages obtained for the NERZ activity indicate that this place is probably the most favourable setting to identify a significant part of the normal Jaramillo subchron. Particularly suitable for this purpose is the southern wall of Valley de Güímar (Fig. 6.6a), a 500 m-thick sequence of basaltic flows, and the scar of a ~47 km^3, 10 × 10 km lateral collapse that occurred between 860 and 830 ka ago (respectively the age of the top of the collapse wall and of early lavas filling the embayment; Carracedo et al. 2011). Radiometric (K/Ar) ages constrain the upper part of the sequence between

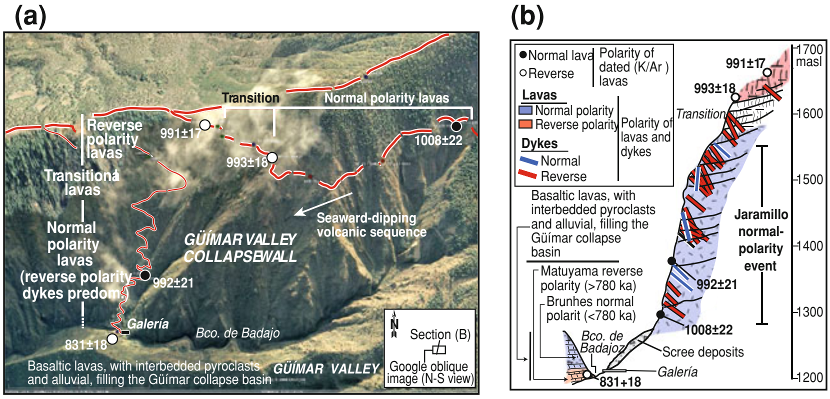

Fig. 6.6 Oblique view (Google Earth) from the north of the southern wall of the Güímar giant landslide scar (the Pared de Güímar). **a** Ages dating the pre- and postcollapse formation. **b** Stratigraphy and magnetostratigraphy of the Pared de Güímar (from Carracedo et al. 2011)

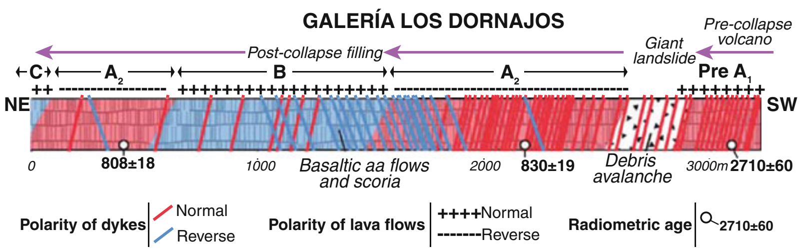

Fig. 6.7 Geomagnetic polarity of the volcanic formations found in the Los Dornajos *galería*, on the north flank of the NERZ. The magnetostratigraphic units shown in Fig. 6.5 are crossed in this *galería*. A debris avalanche deposit and an older formation intersected at the end of the *galería* represent a giant landslide and the pre-collapse deep structure of the rift zone, not visible at the surface (from Carracedo et al. 2011)

1008 ± 22 and 860 ± 18 ka, yielding an eruptive growth of about 3.7 m/ky (equivalent to 2–3 flows/ky). The polarity of this lava sequence shifts from normal polarity at the lower part of the sequence (dated at 1008 ± 22 ka) to reverse polarity at the top (dated at 860 ± 18 ka), indicating that the lower part of the sequence with normal polarity corresponds to the Jaramillo subchron (987–1052 ka; Singer et al. 2004), and the upper part, of reverse polarity, to the Matuyama chron (Fig. 6.6b).

6.4.2 The Mono Lake Excursion

Geomagnetic excursions have attracted increasing interest in the scientific community because, due to their short time constant, they may be used as precise time markers in various geological records. Excursions are relatively brief geomagnetic instabilities characterised by a decrease in intensity associated with large directional shifts from the dipolar field direction (larger than secular variation), immediately followed by a return to the pre-excursional state (see review in Laj and Channell 2007). Geomagnetic excursions are difficult to identify in geological sections. In sediments, palaeomagnetists have recently accessed a number of very suitable marine sequences thanks to palaeoclimatic interest in high sediment accumulation areas coupled with newly developed marine coring facilities. This has greatly increased the number of high-resolution reconstructions of past geomagnetic field changes in which excursions can be identified (Laj and Channell 2007). In volcanic rocks, the identification of excursions is even more challenging due to the sporadic nature of volcanic eruptions.

Eruptions are produced as discrete units separated by comparatively long periods of quiescence. Therefore, the time recorded for the flows is generally only a fraction of the time elapsed to form volcanic sequences. Thus, only incomplete records of geomagnetic variations can be obtained, that usually do not include short excursions. However, it is a critical step to achieve even this as lavas are the only geological archive yielding the absolute dating and absolute palaeointensity data used to characterise the excursional earth magnetic field. The probability of finding short excursions in volcanics increases in sequences with higher eruptive frequencies and ages similar to that of a given excursion. The Mono Lake excursion (MLE), the youngest in the Brunhes chron, has been identified in the TVC.

First identified by Denham and Cox (1971) and further investigated by Denham (1974) and Liddicoat and Coe (1979) at Mono Lake, western USA, the MLE has been initially dated at about 24–25 ka B.P. based on ^{14}C ages on ostracods, ash layers and the assumption of uniform sedimentation rates. Following this pioneering study, other data were obtained from various continental sections (lacustrine and loess deposits) suggesting the global character of the MLE. However, their ages were scattered and imprecise, mainly resulting from difficulties in obtaining reliable ages from continental sedimentary sections (e.g., Kissel et al. 2011). Unfortunately, the most recent $^{40}Ar/^{39}Ar$ investigation of the interbedded ash layers in the Mono Lake type section did not allow the problem to be resolved because of the absence of juvenile eruptive crystals (Cassata et al. 2010).

New absolute age data were therefore needed in order to anchor this excursion to the geomagnetic instability time scale (GITS, Singer et al. 2002). Volcanic records of the MLE were until very recently limited to two volcanic provinces, New Zealand and Hawaii. In the Auckland volcanic field (New Zealand), three

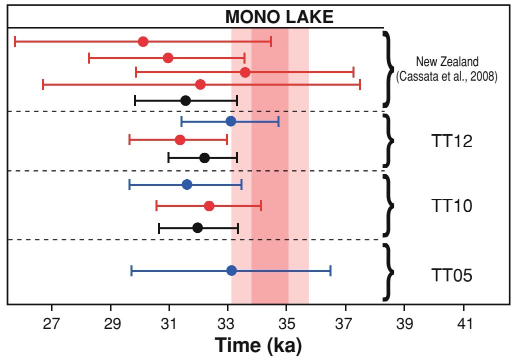

Fig. 6.8 Distribution of the K/Ar and $^{40}Ar/^{39}Ar$ ages obtained from volcanic rocks recording the Mono Lake excursion. *Blue* dots represent K/Ar determinations, *red* dots $^{40}Ar/^{39}Ar$ determinations and *black dots* are for pooled ages (all at 2σ uncertainty relative to ACRs at 1.193 Ma equivalent to FCs at 28.02 Ma). Modified from Kissel et al. (2011)

sites have been dated at 31.6 ± 1.8 ka (plateau pooled age) using $^{40}Ar/^{39}Ar$ (Cassata et al. 2008). In Hawaii, two long volcanic cores (SOH1–SOH4) were drilled through the Kilauea volcano edifice at two different locations, but could not be accurately dated using $^{40}Ar/^{39}Ar$ and/or K/Ar due to the very low radiogenic argon contents of the lavas.

Lavas of Teide Volcano, erupted during the narrow time interval covered by this excursion (Fig. 6.8), provide an opportunity to better refine the age and confirm the global distribution of the MLE (Kissel et al. 2011). Palaeomagnetic data were analysed from three lava flows with appropriate K/Ar ages. All the palaeomagnetic directions are significantly anomalous with respect to the geocentred axial dipole (GAD) field direction at this location (D = 0°; I = 47.2°). Inclinations for two sites TT-05 and TT-12 are shallower than the GAD value (36.9° ± 4.6° and 22.5° ± 4.5° respectively) while the third site (TT-10) has an inclination similar to the GAD value but the declination is strongly deviated at 67.9° (α_{95} = 4.7°) (Kissel et al. 2011).

These directional deviations from the GAD field are associated with low intensity values determined using the Thellier and Thellier (1959) procedure and PICRIT-03 set of criteria (see Kissel et al. 2011 for details). The average

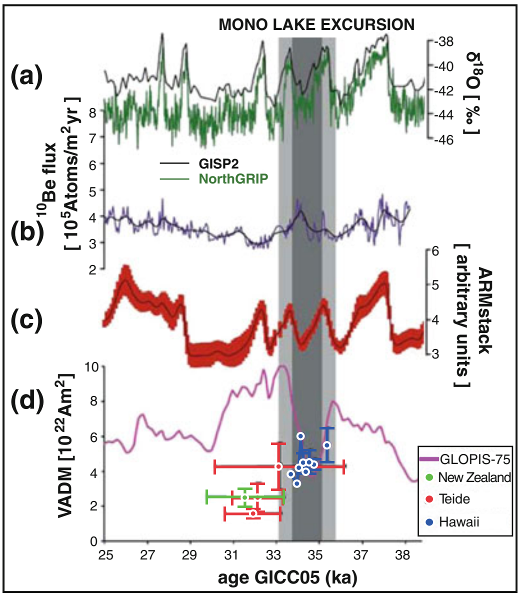

Fig. 6.9 Climatic and geomagnetic records at the time of the Mono Lake excursion. **a** Oxygen isotope records from Greenland ice with GISP2 in *black* (Grootes et al. 1993) and NGRIP in *green* (North Greenland Ice Core Project Members 2004) illustrating changes in atmospheric temperature over Greenland at the time of the Mono Lake geomagnetic excursion. **b** ^{10}Be flux record initially obtained from GRIP core (Muscheler et al. 2004). **c** Sedimentary drift deposit stack as a tracer for changes in the deep circulation strength in the North Atlantic showing similar characteristics and age to those of oxygen isotopes in ice (Kissel et al. 2008). **d** GLOPIS-75 continuous record in *pink* (Laj et al. 2004) and volcanic data reported as VADM values with ages as in Fig. 6.2 (modified from Kissel et al. 2011)

intensities obtained for the three flows are 21.4 ± 6.6 μT (TT-05), 7.8 ± 1.4 μT (TT-10) and 12.4 ± 3.9 μT (TT-12) corresponding to the virtual axial dipole moment (VADM) values of 4.3 ± 1.3 × 1022 Am_2; 1.6 ± 0.3 × 1022 Am_2; 2.5 ± 0.8 × 1022 Am_2 respectively, significantly lower than the present value of 8 × 1022 Am_2.

While for TT10, the angular difference with the directions expected for a GAD field (43.3°) is large, it falls in the range of secular variation (11° and 24.6°, respectively) for TT-05 and TT-12. However, when the intensity of the field prevailing at the moment of emplacement is considered, then even the last two sites cannot be considered as reflecting the usual secular variation. It therefore appears that these flows have recorded an excursion of the geomagnetic field.

The three lavas had been dated using the K/Ar method before the palaeomagnetic sampling. While ^{40}Ar/^{39}Ar dating was not attempted on sample TT-05 because of low radiogenic ^{40}Ar (^{40}Ar*) content, the two other lava flows (TT-10, TT-12) were dated using both unspiked K/Ar and ^{40}Ar/^{39}Ar methods. As shown above, the two methods yielded similar precision and allowed accurate pooled ages to be obtained (samples TT-10 and TT-12 are labelled CITF-301 and CITF-98 respectively in Carracedo et al. (2007) and Guillou et al. (2011).

Given their radiometric age, this is clearly identified as the Mono Lake Excursion, the only one in this age range. The three ages from the Teide flows largely overlap with those from New Zealand (Cassata et al. 2008), confirming the brief duration of the excursion, which is shorter than the uncertainty associated with the radiometric ages. Such a brief duration has already been proposed and evaluated at about 1,500 years for the Laschamp excursion (Laj et al. 2000, 2004).

The new results reported in Fig. 6.9, together with those from the other volcanic localities and from other archives, suggest that the magnetic field intensity during the MLE may have been more reduced than previously believed. At TT-10, it is about 20 % of the present-day field, which is half of the value measured in New Zealand and in Hawaii.

Figure 6.9 shows, in addition, palaeomagnetic and climatic records from different geological archives versus the most recent Greenland ice core age model (GICC05 age model, Andersen et al. 2006). The ^{10}Be peak, around 34 kyr (width at mid-height of about 0.6–0.8 kyr), resulting from the weakening in the Earth's magnetic field intensity at the MLE is significant with respect to the background curve, and it is coeval with the rapid cold stadial within the millennial climatic fluctuation 7 (Dansgaard-Oeschger cycle). The age of about 34 kyr for this fluctuation is defined in the Greenland ice core by annual layer counting.

When integrated into this large dataset, it appears that although the radiometric ages from Tenerife and New Zealand are not statistically different from the ages from ice cores, the mean radiometric age for each formation is systematically younger than the stratigraphic age from the ice cores. However, given the challenge that constitutes obtaining accurate K/Ar and Ar/Ar ages from such young lava flows, this study is extremely encouraging for discovering additional volcanic lavas in which both palaeomagnetic and dating approaches can be combined in order to constrain the age of the MLE.

These new data are, with those from Hawaii, the only two volcanic records of the Mono Lake from the northern hemisphere. This study, together with those conducted in New Zealand and Hawaii, is very promising because they show that significant information can be retrieved from geological sequences recording very brief geomagnetic features and which, therefore, constitute precise tie points for stratigraphic correlations. On the other hand, this is also a test of the precision and accuracy of the radiometric dating methods used to date the Teide Volcanic Complex (Carracedo et al. 2007).

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