Easter Island, SE Pacific: An end-member type of hot spot volcanism

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SUPPLEMENTARY MATERIAL FOR DATA REPOSITORY

Table DR1 - Summary of the published radiometric ages of Easter Island rocks

In Table DR1 we have summarized all the published radiometric ages on Easter Island. Topographic and stratigraphic location of each sample is described. All analyses were done on whole rock samples, if not specified in the sample description. The age data are reported as in the original references and with the uncertainties at the one sigma confidence interval.

All the available ages on Easter Island are consistent with a very recent evolution (<0.94 Ma), with three exceptions, which report ages older than 1.89 Ma (Table DR1). These are:

1) a lava on the northern cliff of Poike (age of 3 Ma; Baker et al., 1974);

2) a transitional basalt on the N coast of Poike (EC307 in Table DR1; age of 2.54±0.28 Ma; Clark and Dymond,1977);

3) a hawaiite on the S coast of Terevaka (EC383 in Table DR1; age of 1.89±0.11 Ma; Clark and Dymond,1977).

However, each of these 3 ages is inconsistent with several data.

Samples 1) and 2) are both taken from the base of the N cliff of Poike. However, other samples in the same position or immediately above (as 177732, EA29, EA28, EH311 in Table DR1; Clark and Dymond, 1977; Clark, 1975; Kaneoka and Katsui, 1985) give 6 ages, all consistent with the interval 0.89-0.52 Ma. Since there are no major unconformities within the lava pile outcropping along the cliffs of Poike, no significant gaps in the evolution of this volcano should be expected.

Sample 3) has been taken on the S coast of Terevaka, at Point One Tea headland. Clark and Dymond (1977) attributed this sample at the Poike shield volcano, but at the locality indicated only the very fresh, hawaiitic lava flow coming from the Maunga Te Oirena cinder cone is exposed on the marine cliff, and no older lavas or significant unconfomities have been observed at its base. The Maunga Te Oirena cinder cone and related lava flow belong to a recent, ESE-trending eruptive fissure developed on the southern slopes of Terevaka volcano. However, sample EC396, also taken from Maunga Te Oirena lava flow, gives a different age (0.21 Ma; Clark, 1975), largely consistent with its stratigraphic position and its location on this portion of the Terevaka volcano.

In addition, paleomagnetic measurements (Isaacson and Heinrichs, 1976; Miki et al., 1998; Brown, 2002) indicate that all analyzed lavas of Easter Island had normal polarity and probably represent the Brunhes normal polarity epoch, beginning at ca. 0.78 Ma in the standard geomagnetic polarity time-scale (Singer and Pringle, 1996; Tauxe et al., 1996). Moreover, geochemical models (Haase et al., 1997) indicate a consistent evolution of the magmas of the island, without gaps.

Based on these evidences, we suggest that these three samples are misfits within the spectrum of determined ages, with the magnetostratigraphy, and with the stratigraphic constraints from geologic mapping and therefore cannot be considered reliable to assess the evolution of Easter Island.

Moreover, two radiometric ages are older than the 0.78 Ma of the Brunhes normal polarity epoch. These are:

1) a tholeiitic basalt at the base of the northern coast of Poike (177732, age of 0.89±0.19 Ma; Clark and Dymond,1977)

2) a tholeiitic basalt at the base of the western coast of Rano Kau (EH 29, age of 0.94±0.19 Ma; Clark,1975).

Considering the associated measurement error, these samples may also fall within the Brunhes epoch, confirming that the subaerial Eastern Island volcanism spans the last ca. 0.78 Ma.

Finally, Terevaka shield-building and caldera-forming periods are poorly dated, with only two ages of <0.77 Ma (Miki et al., 1998) and 0.3 Ma (Baker et al., 1974) respectively. Our assumption that Terevaka shield stage developed during the same time interval of the other two volcanoes is in particular suggested by the maximum age of 0.78 Ma constrained by the normal polarity of several Terevaka shield lavas (Brown, 2002) and the minimum age of 0.24 Ma defined by the dated fissure activity of the rifting stage shown in Figure 4 and Table DR1.

Figure DR1

Geological map of Easter Island (Chile). Base map and toponyms of the volcanic units of the rifting stage of Terevaka volcano are taken from the 1:25,000 topographic map of the Easter Island of the Instituto Geographico Militar de Chile (2004).

Figure DR2

The Fry plot method is commonly used to define strain orientation in rocks with rigid objects, even though it is also often used to study the spatial distribution of specific features, such as volcanic vents (e.g. Ramsay and Huber, 1983). The method relies on a plot of the position of each particle centre with respect to a particle at the origin. The origin is then sequentially placed on each centre and the relative position of every other centre is plotted. In order to have more detailed results, the method is applied at two distinct areas lying on the S and E slope of Terevaka (Fig. DR1).

Caption of Figure DR2 - Fry plots with the: a) preferred NNE-SSW distribution of the cones on the south slope of Terevaka (focused rift zone); and b) scattered and less defined WNW-ESE distribution of the cones along the east slope of Terevaka (diffuse rift zone).

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TABLE DR1 – SUMMARY OF THE PUBLISHED RADIOMETRIC AGES OF EASTER ISLAND ROCKS

Sample number; location (note)	Rock type (1)	Unit (2)	Method	Age ±1σ Ma	Reference
POIKE					
"Lava from the foot of the high cliffs on the north side of Poike" (without analytical data)	-	P1	K/Ar	3	Baker et al. (1974)
EC307; at the base of the N coast of Poike (on feldspar)	Transitional basalt	P1	K/Ar	2.54±0.28	Clark and Dymond (1977)
177732; at the base of the N coast of Poike, 500m E and above sample EC307	Tholeiitic basalt	P1	K/Ar	0.89±0.19	Clark and Dymond (1977)
EH39; at the base of the S coast of Poike	Tholeiitic basalt	P1	K/Ar	0.75±0.15	Clark and Dymond (1977)
EA29; at the base of the N coast of Poike (the same site of Baker et al., 1974; and sample 177732 of Clark and Dymond, 1977)	Transitional basalt	P1	K/Ar	0.67±0.26 0.69±0.15	Kaneoka and Katsui (1985)
EA28; at the base of the N coast of Poike (the same site of sample EC307 in Clark and Dymond, 1977)	Transitional basalt	P1	K/Ar	0.52±0.29 0.62±0.32	Kaneoka and Katsui (1985)
EH42; S coast of Poike, 100m E and above sample EH39	Transitional basalt	P1	K/Ar	0.59±0.12	Clark (1975)
EH311; N coast of Poike, above sample 17732	Transitional basalt	P1	K/Ar	0.54±0.11	Clark (1975)
EC319; N coast of Poike	Transitional basalt	P1	K/Ar	0.41±0.05	Clark (1975)
OG829; N coast of Poike	Alkalic basalt	P1	K/Ar	<0.30	Gonzalez-Ferran et al. (1974)
E37; S coast of Poike	-	P1	K/Ar	<0.34	Miki et al. (1998)
E10; E coast of Poike	-	P1	K/Ar	<0.20	Miki et al. (1998)
EH361; N coast of Poike, top of sea cliff W of Maunga Parehe (on feldspar)	Alkalic basalt	P2	K/Ar	0.36±0.21	Clark (1975)
E16; N coast of Poike	-	P3	K/Ar	0.14±0.10	Miki et al. (1998)
RANO KAU					
EH29; at the base of W coast of Rano Kau (on feldspar)	Tholeiitic basalt	R1	K/Ar	0.94±0.19	Clark (1975)
EH27; W coast of Rano Kau, above sample EH29	Transitional basalt	R1	K/Ar	0.68±0.14	Clark (1975)
E13; NE slope of Rano Kau, ~150 m asl	-	R1	K/Ar	0.68±0.07	Miki et al. (1998)
EH20; NW coast of Rano Kau, Hanga Mataveri	Alkalic basalt	R1	K/Ar	0.67±0.06	Clark (1975)
EH57; SSW inner wall of the Rano Kau caldera	Transitional basalt	R1	K/Ar	0.48±0.06	Clark (1975)
E12; NE slope of Rano Kau, ~200 m asl	-	R1	K/Ar	0.46±0.05	Miki et al. (1998)
E27; W rim of the Rano Kau caldera	-	R2	K/Ar	0.35±0.04	Miki et al. (1998)
E1; W rim of the Rano Kau caldera	-	R2	K/Ar	0.34±0.03	Miki et al. (1998)
E35; SE slope of Maunga Orito	Rhyolite	R3	K/Ar	0.33±0.04	Miki et al. (1998)

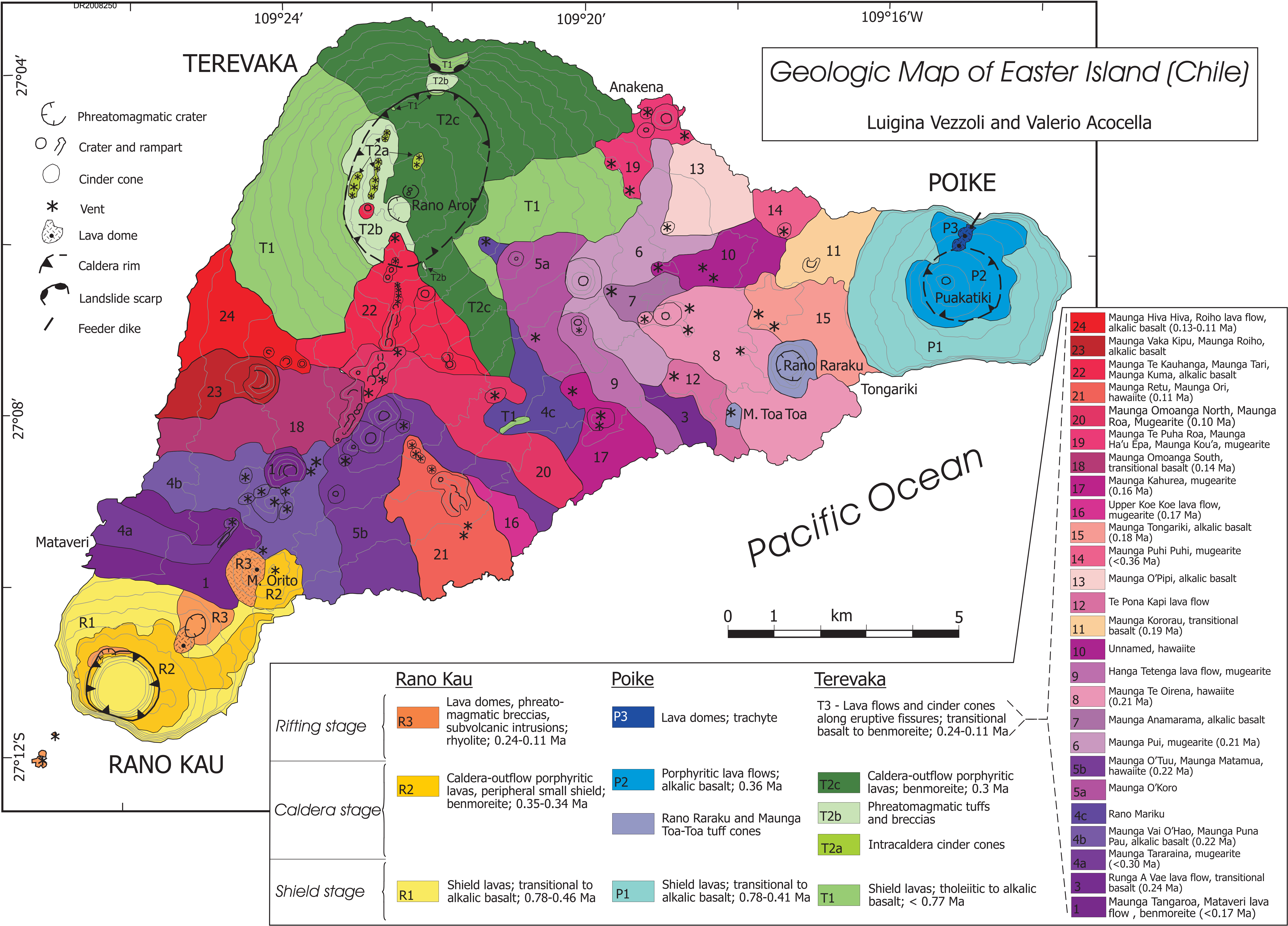
OG806; S slope of Maunga Orito; vitrophyre	Rhyolite	R3	K/Ar	0.34±0.06	Gonzalez-Ferran et al. (1974)
EH10; summit of Maunga Orito	Rhyolite	R3	K/Ar	0.33±0.06	Clark (1975)
EA-O; Maunga Orito, obsidian	Rhyolite	R3	K/Ar	0.24±0.03	Kaneoka and Katsui (1985)
				0.24±0.04	
OG818; Maunga Te Manavai vent; vitrophyre in phreatomagmatic breccia	Rhyolite	R3	K/Ar	0.18±0.03	Gonzalez-Ferran et al. (1974)
E36; NW slope of Maunga Orito	-	R3	K/Ar	0.11±0.04	Miki et al. (1998)

<u>TEREVAKA</u>

E22; NE coast	-	T1?	K/Ar	<0.77	Miki et al. (1998)
“Lava from the NW side of M.Terevaka” (without analytical data)	-	T2?	K/Ar	0.3	Baker et al. (1974)
OG931; NNW upper flank	Benmoreite	T2?	K/Ar	0.19±0.12	Gonzalez-Ferran et al. (1974)
E30; W coast at Hanga Mataveri Otai, Mataveri lava flow	-	T3-1	K/Ar	<0.17	Miki et al. (1998)
OG847; Vaihu lava flow	Mugearite	T3-2a	K/Ar	0.24±0.08	Gonzalez-Ferran et al. (1974)
OG850; lower Koe Koe lava flow	Hawaiite	T3-2b	K/Ar	<0.24	Gonzalez-Ferran et al. (1974)
EC370; Runga A Vae lava flow	Transitional basalt	T3-3	K/Ar	0.24±0.05	Clark (1975)
OG807; lava flow from the Tararaina eruptive fissure	Mugearite	T3-4a	K/Ar	<0.30	Gonzalez-Ferran et al. (1974)
EC125; lava flow from Maunga Vai O’Hao	Alkalic basalt	T3-4b	K/Ar	0.22±0.04	Clark (1975)
OG892; Maunga O’Tuu cinder cone	Hawaiite	T3-5b	K/Ar	0.22±0.20	Gonzalez-Ferran et al. (1974)
EC288; Maunga Pui cinder cone	Mugearite	T3-6	K/Ar	0.21±0.04	Clark (1975)
EH296; xenolith on the Maunga Anamarama cinder cone	Alkalic basalt	T3-7	K/Ar	1.92±0.11	Clark (1975)
EC396; lava flow from Maunga Te Oirena	Hawaiite	T3-8	K/Ar	0.21±0.04	Clark (1975)
EC383; S coast at Point One Tea, lava from Maunga Te Oirena	Hawaiite	T3-8	K/Ar	1.89±0.11	Clark and Dymond (1977)
EC323; lava flow from Maunga Kororau	Transitional basalt	T3-11	K/Ar	0.19±0.04	Clark (1975)
E20; NE coast, lava from the Ouko Ouhi Puhi cinder cone	-	T3-14	K/Ar	<0.15	Miki et al. (1998)
OG859; Maunga Puhi-Puhi cinder cone	Mugearite	T3-14	K/Ar	<0.36	Gonzalez-Ferran et al. (1974)
EC384; Tongariki lava flow	Alkalic basalt	T3-15	K/Ar	0.18±0.04	Clark (1975)
E43, S coast near Rua Tuvi, lava from the Koe Koe eruptive fissure	-	T3-16	K/Ar	<0.12	Miki et al. (1998)
EC177; upper Koe Koe lava flow	Mugearite	T3-16	K/Ar	0.17±0.03	Clark (1975)
EC190; lava flow from Maunga Kahurea	Mugearite	T3-17	K/Ar	0.16±0.03	Clark (1975)
EH88; lava flow from the Maunga Omoanga fissure, S sector	Transitional basalt	T3-18	K/Ar	0.14±0.15	Clark (1975)
EC413; lava flow from the Maunga Omoanga fissure, N sector	Mugearite	T3-20	K/Ar	0.10±0.02	Clark (1975)
EC166; lava flow from Maunga Retu	Hawaite	T3-21	K/Ar	0.11±0.04	Clark (1975)
EC153; lava flow from Maunga Retu	Hawaite	T3-21	K/Ar	0.09±0.02	Clark (1975)
EC224; lava flow from Maunga Vaka Kipu	Alkalic basalt	T3-23	K/Ar	0.004±0.05	Clark (1975)

EI9209; Roiho lava flow at Maunga Hiva Hiva (on plagioclase)	Alkalic basalt	T3-24	$^{40}Ar/^{39}Ar$	0.13±0.02	O'Connor et al. (1995)
EC206; Roiho lava flow	Alkalic basalt	T3-24	K/Ar	0.11±0.02	Clark (1975)
EC201; Roiho lava flow	Alkalic basalt	T3-24	K/Ar	0±0.05	Clark (1975)

(1) According to the TAS diagram of the Figure 3.
(2) Stratigraphic units name as shown in Figure 5. For the eruptive centres of the fissural activity of the Terevaka volcano (unit T3), number refers to the stratigraphic order exposed in the Figure 10.



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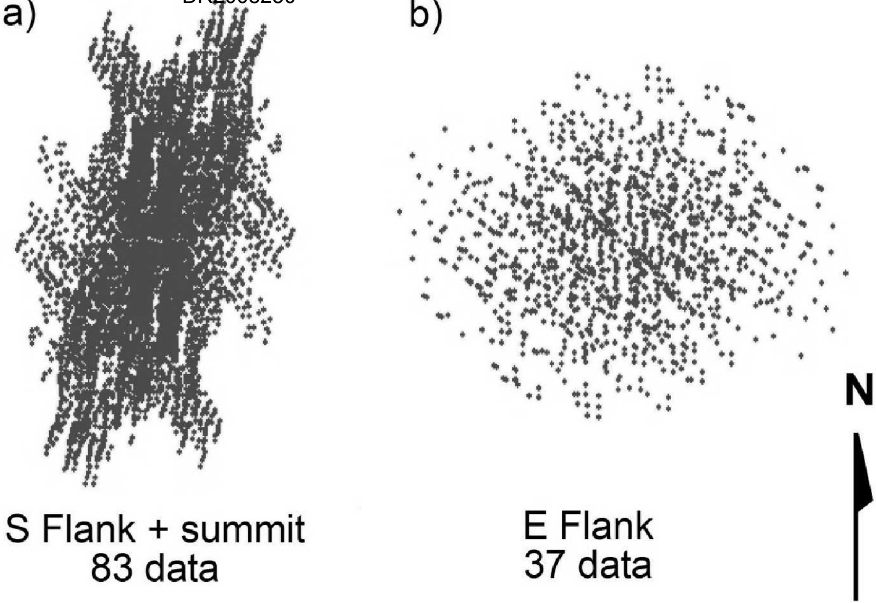
Geologic Map of Easter Island (Chile)
Luigina Vezzoli and Valerio Acocella
109°24′
109°20′
109°16′W
27°04′
27°08′
27°12′S
TEREVAKA
POIKE
RANO KAU
Anakena
Rano Aroi
Rano Raraku
Tongariki
M. Toa Toa
Puakatiki
Mataveri
M. Orito
Pacific Ocean
0 1 km 5
Phreatomagmatic crater
Crater and rampart
Cinder cone
Vent
Lava dome
Caldera rim
Landslide scarp
Feeder dike
Rano Kau
Poike
Terevaka
Rifting stage
Caldera stage
Shield stage
R3 Lava domes, phreato-magmatic breccias, subvolcanic intrusions; rhyolite; 0.24-0.11 Ma
R2 Caldera-outflow porphyritic lavas, peripheral small shield; benmoreite; 0.35-0.34 Ma
R1 Shield lavas; transitional to alkalic basalt; 0.78-0.46 Ma
P3 Lava domes; trachyte
P2 Porphyritic lava flows; alkalic basalt; 0.36 Ma
Rano Raraku and Maunga Toa-Toa tuff cones
P1 Shield lavas; transitional to alkalic basalt; 0.78-0.41 Ma
T3 - Lava flows and cinder cones along eruptive fissures; transitional basalt to benmoreite; 0.24-0.11 Ma
T2c Caldera-outflow porphyritic lavas; benmoreite; 0.3 Ma
T2b Phreatomagmatic tuffs and breccias
T2a Intracaldera cinder cones
T1 Shield lavas; tholeiitic to alkalic basalt; < 0.77 Ma
24 Maunga Hiva Hiva, Roiho lava flow, alkalic basalt (0.13-0.11 Ma)
23 Maunga Vaka Kipu, Maunga Roiho, alkalic basalt
22 Maunga Te Kauhanga, Maunga Tari, Maunga Kuma, alkalic basalt
21 Maunga Retu, Maunga Ori, hawaiite (0.11 Ma)
20 Maunga Omoanga North, Maunga Roa, Mugearite (0.10 Ma)
19 Maunga Te Puha Roa, Maunga Ha'u Epa, Maunga Kou'a, mugearite
18 Maunga Omoanga South, transitional basalt (0.14 Ma)
17 Maunga Kahurea, mugearite (0.16 Ma)
16 Upper Koe Koe lava flow, mugearite (0.17 Ma)
15 Maunga Tongariki, alkalic basalt (0.18 Ma)
14 Maunga Puhi Puhi, mugearite (<0.36 Ma)
13 Maunga O'Pipi, alkalic basalt
12 Te Pona Kapi lava flow
11 Maunga Kororau, transitional basalt (0.19 Ma)
10 Unnamed, hawaiite
9 Hanga Tetenga lava flow, mugearite
8 Maunga Te Oirena, hawaiite (0.21 Ma)
7 Maunga Anamarama, alkalic basalt
6 Maunga Pui, mugearite (0.21 Ma)
5b Maunga O'Tuu, Maunga Matamua, hawaiite (0.22 Ma)
5a Maunga O'Koro
4c Rano Mariku
4b Maunga Vai O'Hao, Maunga Puna Pau, alkalic basalt (0.22 Ma)
4a Maunga Tararaina, mugearite (<0.30 Ma)
3 Runga A Vae lava flow, transitional basalt (0.24 Ma)
1 Maunga Tangaroa, Mataveri lava flow , benmoreite (<0.17 Ma)


a)
b)
S Flank + summit
83 data
E Flank
37 data
N