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A palaeomagnetic study of the volcanic rocks of El-Mane mountain, south of Damascus – Syria

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RESUMEN

Datos paleomagnéticos previamente reportados de esta región son complementados con estudios de desmagnetización térmica de 46 nuevos sitios (14 unidades de flujo). Los sitios, de fuerte consistencia interna y entre ellos, se muestran arreglados estratigráficamente y combinados con datos paleomagnéticos y radiométricos previos, con el fin de establecer una cronología magnetoestratigráfica preliminar. Los resultados se correlacionan cercanamente con los crones 5DR a 6An.1r de la Escala del Tiempo de Polaridad Global. El vulcanismo parece haber ocurrido espasmódicamente a lo largo de un periodo de 3 millones de años, probablemente relacionado con el desarrollo de nuevos sistemas de fracturas más bien que con una inyección quasi-intermitente de magma en cámaras locales. Se confirma que el campo geomagnético no correspondía cercanamente con el de un dipolo axial egocéntrico en esta región para este tiempo, sino que fue posiblemente influenciado por una persistente componente no dipolar. Esto afectó las inclinaciones observadas durante ambos periodos Normal e Inverso; sin embargo, las declinaciones estuvieron más afectadas durante el tiempo de la polaridad Normal que durante el tiempo de la polaridad Inversa. Sobre esta base, es urgente una gran precaución en las interpretaciones de rotaciones tectónicas durante este tiempo en la región del Medio Oriente.

PALABRAS CLAVE: Magnetostratigrafía, rocas volcánicas, tectónica, Damasco, Syria.

ABSTRACT

Previously reported palaeomagnetic data from region El Mane Mountain of Syria are supplemented by thermal demagnetisation studies of 46 new sites (14 flow units). Sites with strong within and between sample consistency are arranged stratigraphically and combined with previous palaeomagnetic and radiometric data to establish a preliminary magnetostratigraphic chronology. This correlates closely with polarity chrons 5Dr to 6An.1r of the Geomagnetic Polarity Time Scale. The volcanism appears to have occurred spasmodically throughout this 3 Ma period, probably in relation to the irregular development of new fracture systems rather than quasi-intermittent injection of magma into local chambers. It is confirmed that the spatial-temporal variations of the geomagnetic field did not correspond closely to that of an axial geocentric dipole in this region at this time, but was possibly influenced by a strong and persistent non-dipole component. This affected the inclinations observed during both Normal and Reversed periods. Nonetheless, the declinations were more affected during times of Normal polarity than during times of Reversed polarity. On this basis, caution is urged in the interpretation of palaeomagnetically determined tectonic rotations, during this time in the Middle Eastern region.

KEY WORDS: Magnetostratigraphy, volcanic rocks, tectonics, Damascus, Syria.

INTRODUCTION AND REGIONAL GEOLOGY

Active volcanism occurred over most of Syria during Miocene to Holocene times. It commenced with subaerial flood basalts in the Early Miocene, mostly 20 to 16 Ma that, by Mid Miocene times, extended over most of southern Syria, Jordan and Saudi Arabia (Benter, 1957), yet this earlier volcanism has not been detected in the Syrian-Lebanese coastal zone (Mouty *et al*., 1992). A period of quiescence followed, up to some 8 Ma ago, when intensive volcanism re-commenced over most of Syria, particularly along the southern and southwestern margins of the Levant fault (the northern extension of the Dead Sea Fault in Lebanon and Syria). This phase of volcanism remained active into prehistoric times; such as the cases of the Majdel Shams volcano (in the Golan Heights) and the Abou Rasein volcano (Jabel Al-Arab) in south-eastern Syria. The area studied is south of Damascus, centered around 33.25ºN 36.25ºE, where mid Lower Miocene basaltic rocks (Ponikarov, 1966) extend over about 600 km^2 in an elongated area c.40 km E-W direction (Figure 1) and c.30 km N-S. The rock types comprise basalts, plagio-basalts, ankarmites and picrites. The rock exposures are distributed over the whole area but cannot always be precisely correlated. In the Jabal El Mane area they extend up to 1088 m above sea level and where some lava sequences are exposed. These Lower Miocene volcanics formed a c.500m thick se-

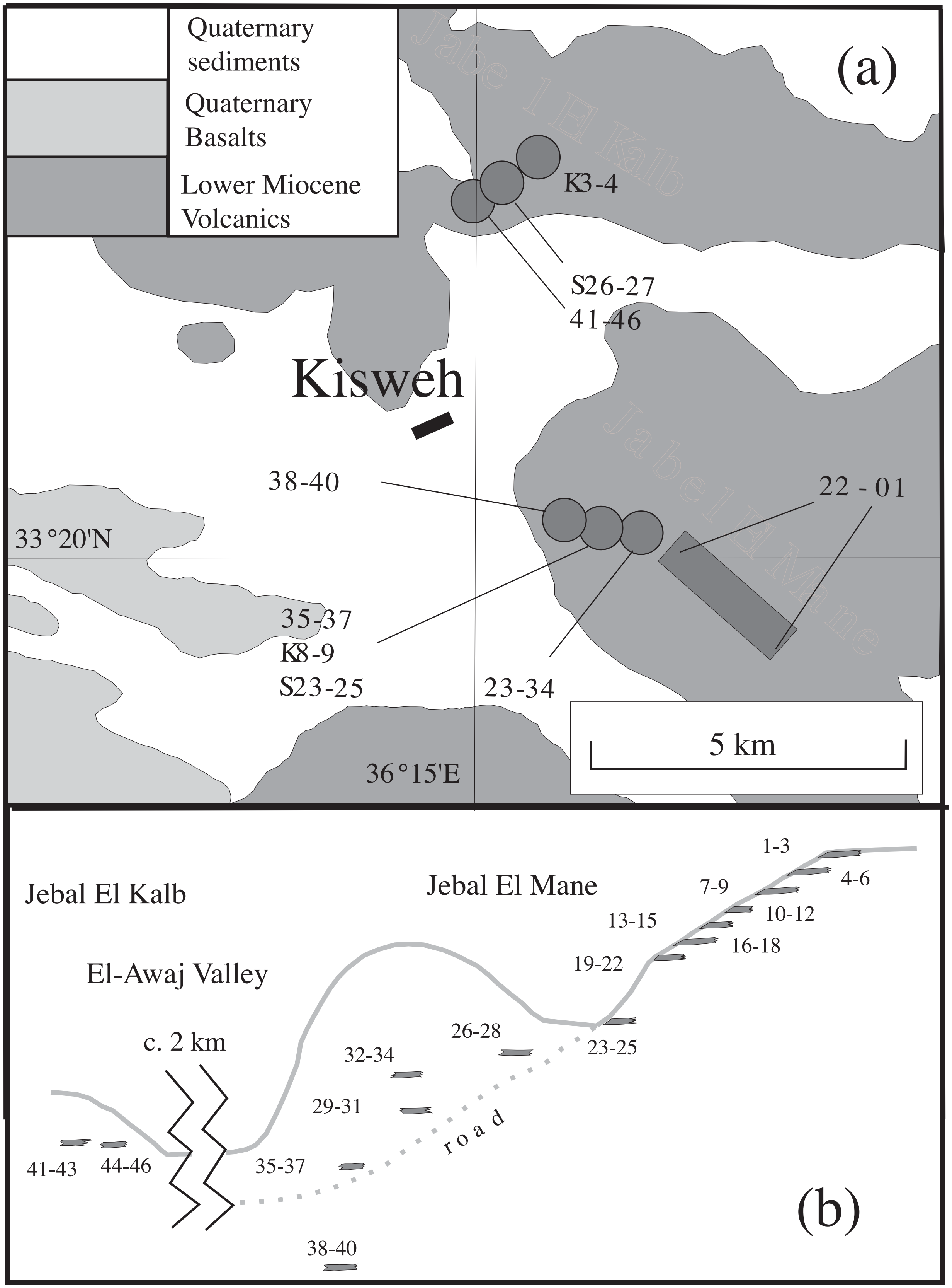

Fig. 1. Outline Geological Map and Sketch Section of the Kisweh Area. (a) The previous sites of Roperch and Bonhommet (1986) are marked by S, and those of Abou-deeb *et al*. (1999) by K. The new sites are numbered. The stratigraphical order is illustrated below (b) as a sketch section as viewed from SW of the village of Kisweh.

quence east of the village of Kisweh with some 15 to 20 flows, separated by thin beds of red clays, in Jabel El-Mane area. These are surrounded on the east and north by the Upper Quaternary (Q_3) conglomerates, sandstone and sandy soils, limestone, calcareous tuff and marl, Quaternary to Holocene basaltic flows (β_1Q_4, β_1Q_1, β_4Q_4) lie to the south and southeast and the Lower Paleocene conglomerates and sandstone border the west.

A number of radiometric determinations has been made in this region (Roperch and Bonhommet, 1986; Giannerini *et al*., 1988; Mouty *et al*., 1992; Novikov *et al*., 1993) ranging between 16.7 ± 0.5 Ma and 24.0 ± 0.6 Ma, thus confirming the Lower Miocene age. Palaeomagnetic studies have also been reported by Roperch and Bonhommet (1986) and Abou Deeb *et al*. (1999) showing the existence of both Normal and Reversed polarities. They also found that the average palaeomagnetic inclination was lower than the axial dipole field value expected for this time and latitude. Westphal (1993) and Abdeldayem and Tarling (1996) also reported shallow inclinations of this age in other parts of the Middle East. Roperch and Bonhommet (1986) suggested that such persistent shallow directions may have been caused by a long-term shallow component of the geomagnetic field in much of the Middle East during the Miocene that had largely disappeared by Quaternary times. Regional tilting, associated with either volcanic loading and/or magma chamber collapse to the south of the area, does no explain these shallow inclinations as the sedimentary dips are very small (0-5°) and probably depositional rather than tectonic in origin. The present study combines the previous palaeomagnetic and radiometric observations, together with new studies from sites that are stratigraphically well constrained, in order to attempt a coherent magnetostratigraphic time-scale for this region. Such a scale could then be used to evaluate, as part of an ongoing project, the relationship between the volcanism and fault activity in a region of a developing transforming fault, the Dead Sea fault and its northward extensions, as well as to establish the nature of the geomagnetic field at this time.

SAMPLING, MEASUREMENT AND ANALYSIS

The Middle Miocene basaltic flows (map unit βN^2_1) were sampled using a field drill at 46 separate sites; 40 from Jabel El-Mane and 6 from Jabel El-Kalb (Figure 1 and Appendix). Three separate sites were sampled from each basaltic flow (except M19-M22) and each site comprised 6 or 7 samples in almost all cases. Conventional palaeomagnetic drilling techniques (Collinson, 1983; Tarling, 1983) were employed and virtually all orientations were made using both a sun compass and magnetic compass reading. The field cores were sliced to provide standard samples, 2.5 cm in diameter and 2.1 cm in height. The intensity and direction of remanence were measured with a Digico spinner magnetometer (Molyneux, 1971), which has a background noise-level of *c*.0.02 mA/m. The initial intensity of magnetisation was generally very high, arithmetically averaging 3624±4527 mA/m per flow, and well exceeding the instrumental noise level in all sites, including those of the most weakly magnetised site, M36 (183 mA/m). The highest initial intensities were in site M18 (27483 mA/m) and M17 (10170 mA/m). It is not thought that these very high intensities are associated with lightning as the individual sample vectors are all well defined (*MAD* averaging 0.9°) and mutually consistent (α_{95} = 4.4°). The low-field susceptibilities of all sites were moderately low, the average flow ranging from 3.6 to 44.1 mSI, with an average arithmetic mean of 21±10 mSI.

Incremental thermal demagnetisation in 13 steps (100, 150, 200, 250, 300, 350, 400, 450, 500, 520, 540, 560 and 580°C) was undertaken on 9 samples from different sites (Table 1). On the basis of these studies, all other samples were demagnetised using five temperature levels; 200, 250, 300, 350, 400°C. (Alternating magnetic field demagnetisation up to 100 mT was also undertaken on 9 samples from the same sites of the thermally demagnetised samples, but was found to be ineffective in isolating any characteristic components). A linear vector (Kirschvink, 1980) was defined as having a maximum angular deviation (*MAD*) of less than 5°. On this basis, the measurements from sites M36 and M37 were completely excluded as their individual sample vector *MAD* values exceeded 10°. However, these have similar characteristic susceptibilities to the rest of the section, but have the lowest initial intensity. This may indicate that they acquired their remanences in a weak geomagnetic field (as discussed later). The sample vectors from site M17 were poorly defined, *MAD* values ranging from 3.9 to 9.8° and the mean direction could only be considered as indicative of the magnetic polarity at the time that the site acquired its remanence. In all other sites, single linear vectors were identified (Figure 2), commonly characterised by *MAD* ≤2°. In virtually all sites in the same flow, consistent mean directions could be isolated for each flow (Table 1). However, there were two main exceptions. (i) The mean direction of site M16 (318.6°, +47.3°) was well defined (α_{95} = 1.8°) but differed significantly from that of M18 (104.5°, +18.9°), although also reasonably well defined (α_{95} = 4.4°). The similarity of the mean direction of M16 and those of the sites in the overlying flow (M14 and M15) could indicate re heating. This seems most unlikely as M14 and M15 are some 20 m higher than M16 and M16 has apparently been heated to at least 580°C – with no evidence for a thermal overprint in M18. Although the mean direction of site M16 appears more consistent with those identified in other flows, there are no objective grounds for retaining either site direction as typical for the flow, so both sites are excluded. (ii) Site M13 had a mean direction (276.8°, +74.6°) that was much steeper and more westerly than those for the other two sites from this flow. These averaged (314°, +47°, α_{95} = 3.0°), which was subsequently found to be close to the average normal polarity direction in this region. It is suspected that site M13 may therefore comprise a large block that is no longer *in situ*. On this basis, site M13 has been excluded from further consideration.

There appears to be a clear stratigraphically controlled polarity zonation. The uppermost flow, M01-03, was of Reversed intermediate (Ri) polarity (Table 1 for definition), with all flows in the c. 300 m below it (M04-06 to M19-22) of Normal or Normal intermediate polarity (Table 1). All flows below this were of Reversed polarity. The flow sampled at sites M41-46 has a clear Reversed polarity and is stratigraphically similar to the lower sites in the section. However, before considering these new observations further, the previous palaeomagnetic and radiometric data in the region must be assessed. The source locations for the palaeomagnetic data of Abou-Deeb *et al*. (1999) are known. The location of the radiometric data of Novikov *et al*. (1993) is not given in their paper, but their probable locations have been provided by one of the co-authors, Dr. Samir Hanna. The locations of the Roperch and Bonhommet (1986) sites are derived from their map, giving the chance to be identified in the field (albeit with some uncertainty) partially on the basis that their sampling was from the freshest exposures with relatively ready access from the road. Consequently, a stratigraphic sequence can be attempted using all data. Certainly, sites M41-46 were sampled in the flow dated by Novikov *et al*. (1993) as 20.40 ± 0.8 Ma. A Reversed polarity flow of probably similar age, S26, has been reported by Roperch and Bonhommet (1986), but also a Normal polarity flow, S27, also of about the same age has been found. Abou-Deeb *et al*. (1999) identified three Reversed polarity flows, K3-5, also approximately matching the age of M41-46. M35 37 was chosen as corresponding to Roperch and Bonhommet (1986)'s original site S24, for which they reported an Ar^{39}/Ar^{40} of 19.5 Ma. The mean direction they obtained was 165.4, -40.6, α_{95} = 4.4°, but most of the recent samples were rejected as being inadequately defined, although of distinctly Reversed polarity. There is therefore not independent con-

Table 1

Mean magnetic properties at the flow level

Flow Units	Susc.	Magn.	Dec.	Inc.	α_{95}	*MAD*	Pole	Comments (See text)
1-03	17.1	6555.7	122.3	-5.7	8.6	2.8	Ri	
4-06	17.4	3975.0	309.9	41.3	2.3	1.0	Ni	
7-09	27.0	7823.3	307.2	36.4	2.7	0.9	Ni	
10-12	13.1	3817.7	308.6	33.2	2.6	0.9	Ni	
14,15	17.5	1304.3	314.0	47.1	3.0	3.6	N	M13 excluded
16,18	23.3	15750.3	-	-	-	0.9	-	All deviant
19-22	37.2	2484.0	315.2	37.7	3.3	2.2	N/Ni	
23-25	21.3	2436.3	186.8	-35.7	2.6	1.4	R	
26-28	7.6	665.7	184.1	-30.2	1.3	0.9	R	
32-34	24.7	1550.7	165.8	-37.1	2.7	2.5	R	
29-31	21.9	3009.0	160.4	-12.5	2.5	0.8	R	
35[1]	27.4	398.7	155.2	-3.4	8.4	3.0	R	M36, M37 excluded
38-40[2]	9.0	1096.7	155.5	-11.7	2.0	0.9	R	
41-46[3]	22.1	1937.0	174.9	-38.2	1.8	1.5	R	Relation unclear

The flows are given in stratigraphic order, from the top down. The stratigraphic position of M41-46 is discussed in the text. Magn. is the arithmetic mean initial intensity (mA/m) and Susc. is the room temperature low field susceptibility (mSI). The maximum angular deviation, *MAD* (Kirschvink, 1980), is also the arithmetic mean value. The mean declination (Dec.) and inclination (Inc.) are based on the sample values (6 per site), as are the Fisherian (Fisher, 1953) estimates of angular precision, α_{95}° for a 95% Probability. The polarities are based on the latitude of the corresponding virtual geomagnetic pole (VGP):

Normal = N = VGP latitude >50°N; N(i) if 30-50°N
Reversed = R = VGP latitude >50°S; R(i) if 30-50°S
Intermediate = I = VGP latitude <30°N/S.

[1] Equivalent to site S24 of Roperch and Bonhommet (1986), with a radiometric age of 19.5 Ma.
[2] Radiometric age of 20.0 Ma (Giannerini *et al*., 1988)
[3] Radiometric age of 20.4 Ma (Novikov *et al*., 1993)

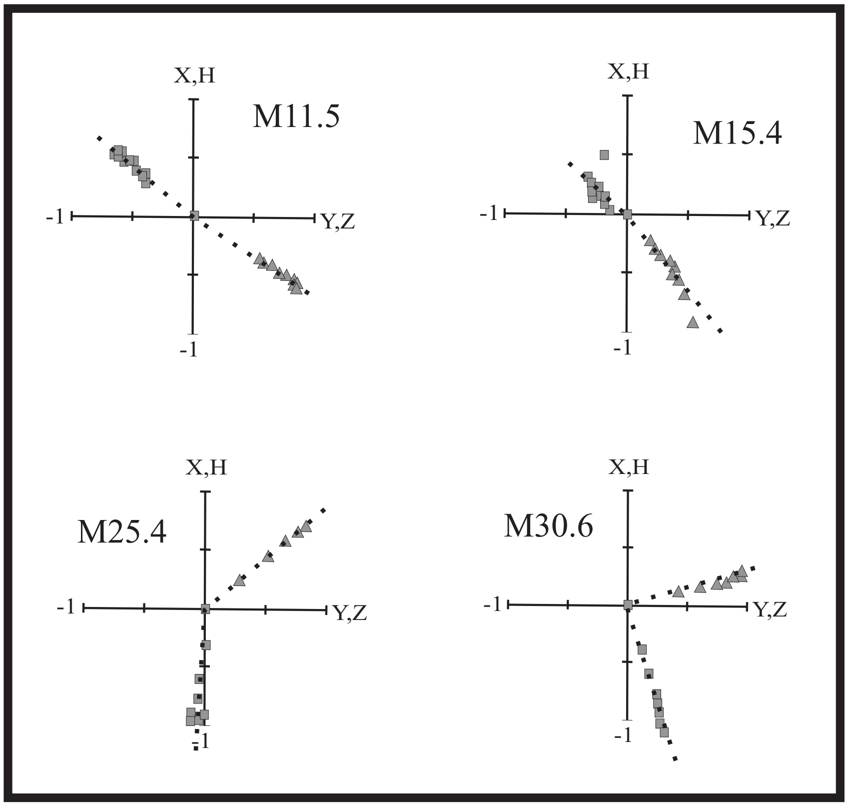

Fig. 2 Examples of thermal demagnetisation behaviour. Cartesian plots of the vector changes during incremental (18 steps) heating up to 600°C in zero external magnetic field. The axes are for the declination (x *vs.* y ▲) and vertical (x vs. z ■) components. The intensity of magnetisation is normalised to the maximum intensity, Mmax. The declination and inclination of the vectors, considered to be those of the characteristic magnetisation, are shown as straight dotted lines; their maximum angular deviations (I, Kirshevink, 1980) lie within the width of the line. 11.5, M_{max} 2.57 A/m, *MAD* 1.6º; 15.4, M_{max} 0.94 A/m, *MAD* 1.1º 25.4, M_{max} 2.83 A/m, *MAD* 1.9º; 30.6, M_{max} 4.33A/m, *MAD* 1.4º.

firmation that this was the same flow, but it is highly probable that it is the same. Although all other data come from several kilometres away, Roperch and Bonhommet (1986) also reported Reversed directions for two flows, S23 and S25, of similar age and direction as those of S24. Abou Deeb *et al*. (1999) reported two other flows (K8, K9) of Reversed intermediate polarity that were considered of similar age to M35-37. The radiometric dates in this region are consistent with those obtained elsewhere in Syria for volcanics of similar age. Mouty *et al*. (1992) dated four samples, using whole rock K/Ar method; two from the northern flank of J. El-Mane (19.2 ± 0.6 Ma and 16.7 ± 0.6 Ma), one from the southernmost flank of J. El-Mane (16.7 ± 0.5 Ma), and one from the Kammouneh area (24.0 ± 0.6 Ma). Giannerini *et al*. (1988) has also dated one sample, using K/Ar method, from Jabal El-Mane as 20 Ma.

Interpretations and conclusions

(a) *Magnetostratigraphy and tectonics*

Combining all available data for the El Kisweh area enables a polarity sequence to be determined and compared (Figure 3) to the Geomagnetic Polarity Time Scale (GPTS) of Cande and Kent (1992). The uppermost flow, M01-03, has an easterly to south easterly declination and very shallow inclination. This could be a strong excursion but is more likely to be a polarity transition that would correspond with the bottom of chron 5Dr, giving in an interpolated age of slightly less than 18.3 Ma. The underlying flows of Normal to Normal intermediate polarity therefore correspond to chron 5En, with a duration of 0.5 Myr. These are underlain by a zone that has a distinct Reversed polarity that would clearly correspond with polarity chron 5Er, the base of which has an interpolated age of 19.1 Ma. On the basis of these assignments and the correlation of M34 with S23-24, with a radiometric age of 19.5 Ma, it seems likely that sites K8, K9, S23-25 and M35-37 (Table 2, left column) are associated with the transitional zone just below chron 5Er, or possibly involve an excursion within chron 6n. The individually well defined, but disparate, directions isolated in sites M36 and M37 may well be associated with a brief interval of very weak geomagnetic field. Flow M41-46, together with flows K3-5and S26 (Table 2, right column), all with clearly Reversed polarity and a radiometric age of 20.4±0.8 Ma, seems more likely to be associated with polarity chron 6r. How-

Table 2

Sites of uncertain stratigraphic relationships

Site	Dec.	Inc.	α_{95}		
S26	186.1	-38.4	4.6	RB	R
S27	305.2	45.2	12.0	RB	N
K3	178.9	-47.2	5.9	AD	R
K4	182.7	-40.2	15.8	AD	R
K5	193.0	-35.7	1.4	AD	R
41	178.8	-36.0	1.8		R
42	177.7	-36.7	4.2		R
43	183.5	-37.6	1.5		R
44	171.8	-38.5	2.7		R
45	167.9	-39.5	5.8		R
46	168.2	-40.1	2.6		R

Site	Dec.	Inc.	α_{95}	Ref.	
S23	157.4	-8.4	4.4	RB	R
S24	165.4	-40.6	4.4	RB	R
S25	182.8	-21.0	4.8	RB	R
K8	121.9	11.1	16.7	AD	R
K9	165.7	26.6	12.4	AD	R
M35	155.2	-3.4	8.4		R
M36		Imprecise			N
M37		Imprecise			N

The table on the left comprises sites from the same working quarry and are thus all about 20 Ma in age, but their precise stratigraphical relationships are not known. Similarly, the sites on the right are from a different working quarry and are of a broadly similar age, c. 29.5 Ma, but their precise stratigraphic relationship is unknown. RB and AD are the references to Roperch and Bonhommet (1986) and Abou-Deeb *et al*. (1999). The possible stratigraphic relationships are evaluated in the text and illustrated in Figure 3.

ever, the standard deviation of the radiometric ages, where know, are mostly of the order of ±1 Myr and there are similar possible errors associated with the GPTS. This study cannot, therefore, yet be considered definitive for specifically identifying any one of the 7 polarity zones that occurred between 18 and 21 Ma. Nonetheless, the observations are strongly indicative of such correlations and need to be tested by new, better controlled, radiometric determinations.

Most of the upper series of flows attributed to polarity chron 5En, M04 to M22, have similar mean directions. This could suggest that the flows occurred in rapid succession to each other. This is not the case. There was time for the formation of soils between successive flows, indicating time gaps that are likely to be longer than 1 kyr. Similarly, the flow directions during Reversed chron 5Er are similar, but again the field evidence suggests that these were erupted spasmodically during this period of slightly over 1 Ma. Such observations are not consistent with a magma chamber being continuously active during this mid Early Miocene period, but indicate that the sources are renewed from time to time, possibly in association with increased fracturing of the crust as a consequence of the slow, but relentless opening of the Red Sea and Gulf of Aden. However, there is no clear relationship with the later transform activity, suggesting that the volcanism was mostly during relaxation episodes during the progressive interaction between NW Arabia and the Anatolian complex to the north.

(b) *The nature of the geomagnetic field*

It is usually expected that palaeomagnetic directions in flows within zones of Normal polarity will be clustered within some 30-40º of the axial dipolar direction for that time, usually with an approximately Fisherian distribution. Conversely flow directions in zones of Reversed polarity will be antiparallel to those in the Normal zones of similar age. In this study, the geomagnetic axial dipoles can be expected to be within a few degrees of the present geographic poles, all of them but areas of strong local tectonic rotations. If this part of Syria was part of the Arabian plate at this time, then the post mid Miocene rotation of Arabia could displace the geomagnetic dipole a few degrees, but this would apply to both Normal and Reversed flow directions. Previous studies (summarised in Abou-Deeb *et al.,* 1999), covering somewhat wider age ranges, indicated that the average directions for different polarities were antiparallel, although they were far shallower than that of the expected inclination for an axial dipole field, *i.e.* c. ±34º instead of c. ±53º. On this basis a significant non-dipole field appears to have affected many areas of the Middle East during Lower Miocene and earlier times (Westphal, 1993; Abdeldayem and Tarling, 1996). In this study, all of the sites have far shallower inclinations than those expected for either a Normal or Reversed axial dipole field. The maximum flow mean inclination is that for M14-15 (+47.1, α_{95} = 3.6º). Consequently most of the Normally magnetised flows have actually Normal intermediate polarity, rather than clearly Normal. Furthermore, the mean declinations for the Normally polarised sites do not centre around 0º, but are, on average, some 40º W. However, the declinations for the Reversely magnetised sites do group close to the expected axial dipole direction of 180º. These mid Lower Miocene volcanics and sediments have zero, or only very shallow dips (0 5º), most of which are original and not of a tectonic origin. The shallowing of the inclination of some 20° cannot be due to tectonics either. Similarly, regional or local tectonic rotation cannot account for changes in declination between periods of Normal and Reversed polarities. It must be concluded, therefore, that such features are of geomagnetic origin, particularly as they appear to typify areas of Miocene volcanism up to a few 100 km from the Kisweh area. As it is generally assumed, in tectonic applications of palaeomagnetism that the average geomagnetic field is that of an axial geocentric dipole, it is urgent that the true nature and extent of this apparently anomalous geomagnetic field is established both for its geomagnetic interest and enabling more precise estimates of Miocene tectonic rotations.

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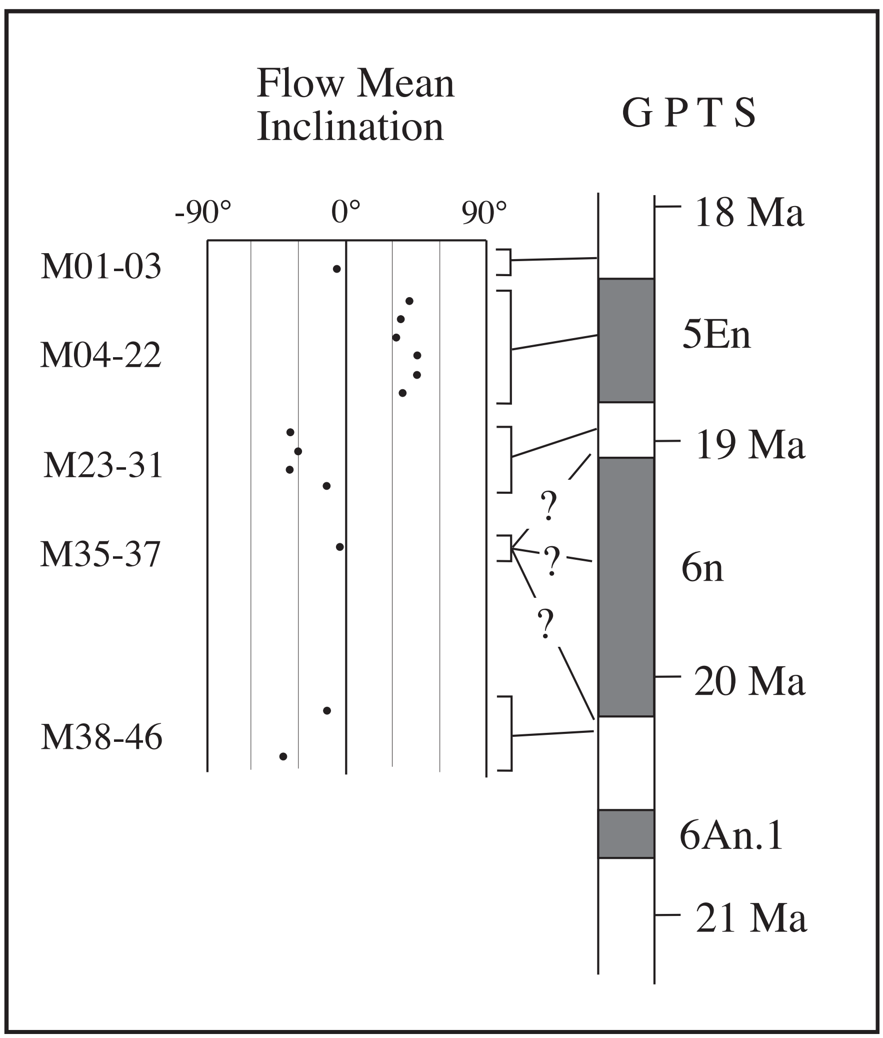

Fig. 3. The magnetostratigraphic zonation. The site mean inclination values are shown in relation to the Geomagnetic Polarity Time Scale (GPTS of Cande and Kent, 1992) and corresponding radiometric age scale. See text for discussion.

APPENDIX Site locations

Site	Latitude	Longitude	Location
1	33 19 52	36 17 04	The upper flow, near the mountain summit
2	33 19 52	36 17 04	Same as 1, 3 m lower than 1
3	33 19 52	36 17 04	Same as 1, 2 m north of 2
4	33 19 55	36 17 01	Fresh flow, 50 m lower than 1
5	33 19 55	36 17 01	Same as 4, 15 m north of 4
6	33 19 55	36 17 01	Same as 4, 20 m north of 5
7	33 19 59	36 16 59	Fresh flow, 20 m below the previous flow
8	33 19 59	36 16 59	Same as 7, 6 m north of 7
9	33 19 59	36 16 59	Same as 8, 10 m north of 8
10	33 20 03	36 16 55	Fresh flow, about 20 m lower than 7- 9
11	33 20 03	36 16 55	Same as 10, 5 m below 10
12	33 20 03	36 16 55	Same as 10-11, 4 m below 11
13	33 20 05	36 16 52	Fresh flow, about 10 m lower than 12
14	33 20 05	36 16 52	Same as 13, 10 m north of 13
15	33 20 05	36 16 52	Same as 13-M14, between 13 and 14
16	33 20 07	36 16 53	Fresh flow, 30 m NE 0f 13-15 and 20 m lower
17	33 20 07	36 16 53	Same as 16, 20 m west of 16
18	33 20 07	36 16 53	Same as 13, 3 m north of 16
19	33 20 23	36 16 39	Fresh flow, below the last hill
20	33 20 23	36 16 39	Same as 19, 5 m north of 19
21	33 20 23	36 16 39	Same as 19-20, 3 m north of 20
22	33 20 23	36 16 39	Same as 19-21, 3 m south of 19
23	33 20 29	36 16 37	Fresh flow, 50 m NE of 19-22 and 100 m lower
24	33 20 29	36 16 37	Same as 23, 10 m north of 23
25	33 20 29	36 16 37	Same as 23-24, 6 m northeast of 24
26	33 20 35	36 16 27	Fresh flow, middle of ascent
27	33 20 35	36 16 27	Same as 26, 6 m north of 26
28	33 20 35	36 16 27	Same as 26-27, 20 m north of 27
29	33 20 38	36 16 15	Fresh flow, about 200 m northwest of 28
30	33 20 40	36 16 14	Same as 29, 50 m north of 29
31	33 20 40	36 16 14	Same as M29-M30, 10 m north of 30
32	33 20 41	36 16 15	Fresh flow, about 50 m higher than 29-31
33	33 20 41	36 16 15	Same as 32, 5 m north of 32
34	33 20 41	36 16 15	Same as 32-33, 5 m higher than 33
35	33 20 53	36 16 05	Fresh flow, from the first quarry near the road bend
36	33 20 53	36 16 05	Same as 35, 7 m west of 35
37	33 20 53	36 16 05	Same as 35-36, 5 m north of 35
38	33 20 55	36 15 58	Fresh flow, below the road, 200m west of 35-37
39	33 20 55	36 15 58	Same as 38, 5 m east of 38
40	33 20 55	36 15 58	Same as 38-39, 10 m north of 38
41	33 23 22	36 16 17	Fresh flow, from Jabal El-Kalb
42	33 23 22	36 16 17	Same as 41, 20 m west of 41
43	33 23 22	36 16 17	Same as 41-42, 60 m east of 41
44	33 23 15	36 16 44	Fresh flow, from a quarry in Jabal El-Kalb
45	33 23 15	36 16 44	Same as M44, 10 m north of 44
46	33 23 15	36 16 44	Same as 44-45, 6 m north of 45

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