PRELIMINARY RECONNAISSANCE PALEOMAGNETISM OF SOME LATE MESOZOIC OPHIOLITES, KUYUL REGION, NORTHERN KORYAK SUPERTERRANE, RUSSIA

Alexander Heiphetz and William Harbert, Department of Geology and Planetary Sciences, University of Pittsburgh, Pittsburgh, PA 15260;
Paul Layer, Geophysical Institute, University of Alaska, Fairbanks, AK 99775-0800

ABSTRACT

We have completed a reconnaissance, single-sample-per-site, paleomagnetic study of Late Triassic-Early Jurassic and Early Cretaceous rocks from the Kuyul ophiolite complex, Koryak superterrane, northeastern Russia (61.5° N., 164.5° E.).
Our data reveal a pre- or synfolding characteristic remanent magnetization (ChRM) during stepwise thermal demagnetization (STD). Analysis of STD data for samples of the basalt flows and dikes gives a maximum value for k at 74 percent untilting, and $D=34.6°$, $I=43.5°$, $\alpha_{95}=7.1°$, $k=29.7$, N(number of samples) = 15. For basalt blocks within the melange, in stratigraphic coordinates, $I_s=25.6°$, $\alpha_{95}=55.3°$, $k_s=62.9$, $N=3$. We estimate about 35° of poleward motion for these units. Another set of the basalt flows and dike samples shows better clustering in stratigraphic coordinates ($ks/kg=1.5$), and $D_s=1.5°$, $I_s=78.8°$, $\alpha_{95}=10.3°$, $k_s=20.7$, $N=11$. The $^{40}Ar/^{39}Ar$ analysis of three samples gives a single reliable age of 108.2±1.3 m.y.

INTRODUCTION

Recent geological and geophysical studies have shown that much of the western North America and northeastern Eurasia plate margins are made up of a collage of accreted tectonostratigraphic terranes (Ben-Avraham and Cooper, 1981; Fujita and Newberry, 1982; Zonenshain et al., 1987). However, few paleomagnetic studies have been completed within pre-Tertiary units in northeast Eurasia to substantiate this interpretation. Within the Koryak suprterrane (Fig.1A), there is an ophiolite unit of Late Triassic to Early Jurassic age, the Kuyul ophiolite. To determine (1) the suitability of this unit for further paleomagnetic study and (2) a preliminary displacement history of the region, we have completed a paleomagnetic reconnaissance study of basalt flows, dikes, and a layered gabbro body from the Kuyul ophiolite.

In this paper, we present a reconnaissance paleomagnetic study carried out within the Kuyul ophiolite complex of Late Triassic to Early Jurassic age. In addition to our paleomagnetic investigation, we have completed some preliminary $^{40}Ar/^{39}Ar$ ages for selected samples.

BRIEF GEOLOGICAL OVERVIEW

The Koryak region may be divided into three major tectonostratigraphic superterranes. Progressing from the northwestern Bering Sea into northeastern Russia, these superterranes are the Olyutorsky superterrane, the Ukelayat flysch terrane, and the Koryak superterrane (Fig.1A).

The most outboard of the tectonostratigraphic terranes that make up northeast Russia is the Olyutorsky superterrane. It has been interpreted to represent an accretionary prism composed of at least three large, thrust-fault-bounded, tectonic zones made of Late Cretaceous oceanic basalt and Late Cretaceous-Paleocene island-arc sedimentary units (Astrahantzev et al., 1987). The Ukelayat flysch terrane consists of a thick sequence of Albian-Paleocene sedimentary rocks.

The Koryak superterrane is thrust over the Ukelayat flysch terrane from the north. It is a composite terrane in that it consists of at least seven tectonostratigraphic terranes, varying in age from middle Paleozoic to Early Cretaceous (Sokolov, 1992). Thrusts within the composite terrane are overlapped by Barremian to Maastrichtian sedimentary rocks. Paleomagnetic data from two terranes within the Koryak superterrane, the Khatyrka and Maynitsky terranes (Didenko et al., 1993), show low paleolatitudes for a Late Triassic island arc complex (23.1°±2.5° N. or S.) and a Late Jurassic-Early Cretaceous ophiolite (two localities: 22.0°±3.5° and 29.3°±2.5° N. or S.), suggesting significant poleward displacement of portions of the Koryak suprterrane. An overlapping Late Cretaceous sedimentary sequence shows a paleolatitude of 76.2°±4.0° (assumed to be N.), suggesting accretion of portions of the Koryak suprterrane by the Late Cretaceous (Didenko et al., 1993).

GEOLOGICAL SETTING

The Kuyul ophiolite terrane is one of the largest (150 x 16 km) ophiolites of northeastern Eurasia. It is located about 30 km east of the Penzhinskaya Bay of the northeastern Sea of Okhotsk along the Kuyul river (Fig.1A,B). The terrane consists of the four main tectonic zones which form a packet in complex structural thrust contact with the Late Jurassic-Early

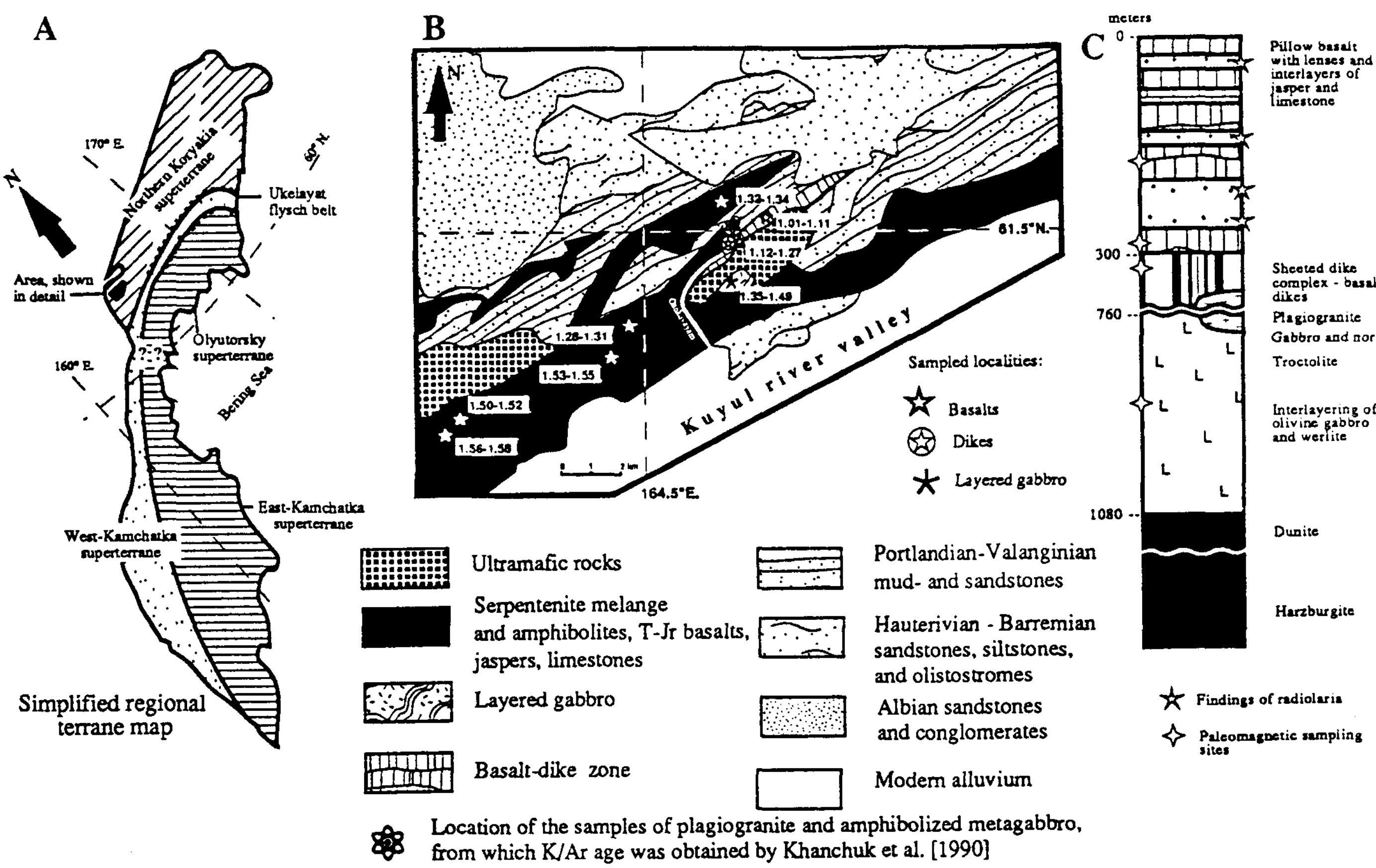

Fig.1: A-Simplified terrane map of northeastern Russia. B-Simplified geological map of the Kuyul ophiolite terrane, showing paleomagnetic localities, and the location of K/Ar age determinations presented in Khanchuk et al., (1990). C-representative stratigraphic column.

Cretaceous terrigeneous sequence of Ainyn terrane (Khanchuk et al., 1990; Sokolov, 1992). S. Sokolov subdivided this terrane into several structural units.

We collected samples within the Gankuvayamsky unit. It is made of a serpentinite melange zone, gabbro-ultramafic zone, and pillow basalt-sheeted dike zone (Fig.1C). Together, these zones form a mega-synform with pillow basalt-sheeted dike rocks in the core and ultramafics, layered gabbro, and serpentinite melange on the limbs. Although the contacts between different petrographic members are tectonic, an entire dissected ophiolite sequence has been mapped within the Gankuvayamsky unit.

The serpentinite melange is the stratigraphically lowest member of the ophiolite association. The melange contains blocks and slabs of massive and pillow basalt and basalt dikes, basaltic volcanic breccia, plagiogranite and ophiolitoclastic olistostrome. Jasper and limestone blocks in the melange contain radiolaria and conodont Permian-Jurassic Tethian-type fauna (Bragin, 1988).

PALEOMAGNETISM

A total of 58 block samples of basalt flows, dikes, and layered gabbro were collected. The orientation of each hand sample was measured using a Soviet magnetic compass with a correction for 4° east declination. After 2-cm cubes were made of each sample, these were stepwise thermally demagnetized in temperatures up to 680 to 700 °C, in a Schonsted oven. The remanence was measured using a SCT 3-axis cryogenic magnetometer (sensitivity $2*10^{-8}$ emu/cc) at the Paleomagnetism Laboratory at the University of Pittsburgh.

We collected 29 samples of basalt. Interpretation of the STD generally shows the presence of at least two magnetic components in these samples (Fig.2A, samples 1.04 and 1.06). The first of them was observed in the range of demagnetization temperatures of 20 to 550 °C. The higher temperature magnetic component was observed at temperatures between 350 and 580 °C. Higher temperature thermal demagnetization of samples that show presence of a stable magnetic component in the range of 600 to 680 °C suggests the presence of primary hematite.

After correction for tilt, the higher temperature component shows better grouping. One of the samples in this group, the jasper sample (1.08), shows an inclination close to the mean, while the declination differs by about 120°. Two samples (1.11, 1.12) show reverse polarity directions of magnetization. In stratigraphic coordinates, the single-sample sites have a ChRM with mean $D_s=30.4°$, $I_s=35.3°$, $k=22.9$, $\alpha_{95}=8.2°$. In geographical coordinates, this component has $Dg=57.9°$, $Ig=62.6°$, $k=7.8$, $\alpha_{95}=14.6°$ (Fig 2C, Table 1).

Basalts from the melange were sampled in two areas (Fig.1B). Complex rotation of blocks within the melange make it impossible to correct the sampled units for original azimuth orientation; therefore, we performed an inclination only averaging using McFadden-Reid (1982) statistics. Because of the small stratigraphic thickness of each block, usually one

Table 1. Single-sample, reconnaissance study results for basalt flows and dikes, Kuyul ophiolite.

Sample #	Geog Dec	Geog Inc.	Bedding Az	Bedding Dip	Strat. Dec	Strat. Inc	74% Dec	74% Inc	t_1 (°C)	t_2 (°C)	n_s
1.01	64.1	75.4	28	60	37.0	18.0	38.2	33.3	350	500	4
1.02	273.9	87.6	35	52	32.3	39.3	31.6	52.7	350	530	5
1.03	12.3	67.0	35	52	24.9	16.1	25.0	29.8	150	300	4
1.04	90.7	76.7	27	45	42.2	38.0	45.4	49.2	350	640	14
1.05	5.1	82.9	27	45	23.7	38.4	22.9	50.0	300	580	8
1.06	297.2	83.0	28	44	17.8	45.8	15.1	56.9	300	450	4
1.07	61.4	78.5	25	70	32.0	10.6	32.8	28.7	300	550	7
1.09	87.2	55.6	340	53	24.0	39.1	34.0	48.2	500	580	4
1.10	55.2	38.6	327	55	23.0	19.7	28.4	27.2	350	550	6
1.11*	81.5	27.2	327	55	45.6	34.4	55.7	36.0	300	550	6
1.12*	77.2	5.8	278	65	48.4	62.3	65.1	49.4	350	600	7
1.13	73.6	28.0	317	83	19.0	26.7	31.2	34.9	150	450	6
1.23**	28.7	74.1	205	70	26.7	54.1	27.0	59.3	150	450	6
1.25**	23.1	33.7	215	85	23.7	28.8	23.6	30.1	530	600	4
1.26**	41.6	67.2	235	75	46.5	52.5	45.7	56.3	350	550	6
Mean	57.9°	62.6°			30.4°	35.3°	34.6°	43.5°			
κ, α_{95}(°)	7.8	14.6°			22.9	8.2°	29.7	7.1°			
N=15											

*Directions inverted to normal polarity. **Dikes are rotated to vertical plane. t_1 and t_2 are the beginning and the end of unblocking interval, respectively, n_s is the number of steps measured within the unblocking interval.

to three samples were collected from each block. After analysis of the STD data using principal component analysis, these single-site samples were divided into two groups: samples with shallow and samples with steep ChRM.

Basalts of the first group (1.32-1.34, 1.50-1.52, 1.56-1.58) show, in stratigraphic coordinates, I_s=25.6°, k_s=62.9 and α_{95}=55.3°, N=3 (Table 2). A similar inclination was observed in the single-sample sites presented in Table 1, although with the small number of independent sites (N=3) these results are only suggestive of those that might be determined by a more thorough study. In geographical coordinates, the mean of these three blocks shows a more random distribution, with I_g=3.3°, k_g= 7.4, and α_{95} >120°.

Table 2. McFadden-Reid (1982) statistics for samples from three basalt blocks within the serpentinite melange (shallow component).

Sample #	Geog. Dec	Geog. Inc	Bedding Azim	Bedding Ang	Strat. Dec	Strat. Inc	t_1 (°C)	t_2 (°C)	n_s
BLOCK 1:									
1.32*	310.0	-5.5	95	48	325.3	42.1	450	580	5
1.33	162.4	47.4	95	48	135.9	17.4	450	600	6
1.34*	307.8	-34.0	95	48	302.2	8.3	450	660	9
BLOCK 2:									
1.50*	201.4	9.0	173	65	35.4	46.2	300	500	5
1.51*	354.6	-48.8	173	65	354.1	16.1	350	530	5
1.52*	29.2	-11.8	173	65	21.1	39.0	350	500	4
BLOCK 3:									
1.56	152.7	23.7	265	60	186.6	30.1	500	580	4
1.57	160.8	20.9	265	60	187.1	22.1	550	600	3
1.58	320.5	31.0	265	60	130.7	9.4	530	600	4
Inclination average of three blocks:									
Mean (N=3)		3.3°				25.6°			
κ, α_{95}(°)	7.4,	> 140°			62.9,	55.3°			

Symbols used are the same as in Table 1.

Samples 1.28-1.31 and 1.53 -1.55, which belong to one long block fractured by small faults, show a ChRM with the steep inclination in stratigraphic coordinates: D_s=273.4°, I_s= 87.3°, k_s=16.0, α_{95}=23.7°, N=4. In geographic coordinates, D_g=318.4°, I_g=43.1°, k_s =3.7, α_{95}=55.7° (Table 3).

Dikes were sampled within the basalt-dike zone, where they outcrop on the northern bank of the Gankuvayam River (Fig.1B). At this locality, several outcrops with a "dike-in-dike" geometry were observed, suggesting they may represent a coherent sheeted-dike complex. The dikes strike to northwest, dipping to the southwest at 65 to 90° angles. The STD characteristics of these dikes are similar to those of the basalt flows, with ChRM being observed at the range of 350° to 600° (Fig.2A, sample 1.26). Two groups of ChRM's were found. While samples 1.23,

Table 3. Line statistics for samples of blocks of basalt dikes (1.28, 1.29) and flows (1.30, 1.31, 1.53-1.55) within the serpentinite melange (steep component).

Sample #	Geog. Dec	Geog. Inc	Bedding Azim	Bedding Ang	Strat. Dec	Strat. Inc	t_1 (°C)	t_2 (°C)	n_s
BLOCK 1:									
1.28**	318.5	75.1	345	77	258.8	83.4	500	550	3
1.29**	355.4	78.8	345	77	74.8	88.0	450	580	5
BLOCK 2:									
1.30	297.9	44.4	105	47	27.7	80.6	580	680	6
BLOCK 3:									
1.31	286.0	11.4	137	70	238.4	59.0	580	660	5
BLOCK 4:									
1.53	2.7	18.1	173	65	47.7	78.6	500	600	5
1.54	13.2	18.2	173	65	66.9	70.1	530	580	3
1.55	6.0	16.7	173	65	51.1	75.3	530	620	5
Average of four blocks (N=4):									
Mean	318.4°	43.1°			273.4°	87.3°			
κ, α_{95}(°)	3.7,	55.7°			16.0 ,	23.7°			

Symbols used are the same as in Table 1.

1.25, and 1.26 show shallow characteristic magnetization the same as in the basalt of the basalt-dike zone, the larger portion of these single-sample sites (1.14-1.22, 1.24, 1.27, N=11), in stratigraphic coordinates, shows a steep ChRM with D_s=1.5°, I_s=78.8°, k_s=20.7, α_{95}=10.3°. In geographic coordinates, this component has D_g= 312.7°, I_g=77.4°, k_g=14.1, α_{95}=12.6° (Fig.2B, Table 4).

Table 4. Line statistics for samples of basalt dikes from the basalt-dike zone (steep component).

Sample #	Geog. Dec	Geog. Inc	Bedding Azim	Bedding Ang	Strat. Dec	Strat. Inc	t_1 (°C)	t_2 (°C)	n_s
1.14	25.9	75.0	288	75	66.0	67.5	250	680	13
1.15	272.0	72.2	242	65	18.7	77.1	250	600	9
1.16	325.6	72.6	245	80	356.7	71.5	450	600	6
1.17	275.5	65.3	252	75	303.0	77.6	530	580	3
1.18	238.2	82.6	252	75	84.7	82.0	580	680	6
1.19	6.4	58.4	20	70	346.7	77.1	530	580	3
1.20	282.9	45.5	230	65	311.7	55.6	580	660	5
1.21	192.8	63.0	227	80	177.1	70.5	150	450	6
1.22	66.8	77.9	227	80	58.0	68.2	200	450	5
1.24	347.9	70.4	242	86	358.0	69.0	400	580	6
1.27	339.3	63.9	230	90	339.3	63.9	150	530	8
N=11									
Mean	312.7°	77.4°			1.5°	78.8°			
κ, α_{95}(°)	14.1,	12.6°			20.7,	10.3°			

Symbols used are the same as in Table 1.

Fifteen single-sample sites of the layered gabbro were collected along the Gankuvayam River from the middle and upper stratigraphic interval of the exposed gabbro-ultramafic unit. The orientation of mineral layers within the gabbro were taken while sampling. Heating to 550-580 °C does not effect the strong (10^{-2}-$5*10^{-3}$Oe) magnetization of gabbro (Fig.2A, sample 1.41). Between 550 and 600 °C, the samples lose between 0.5 and 30 percent of their total intensity of magnetization. A higher temperature (600-660 °C) component fails the fold test (k_g =7.3, k_s=1.4, Fig.2D). The lower temperature (250 to 600 °C) component was found in 10 samples of 15; it was not

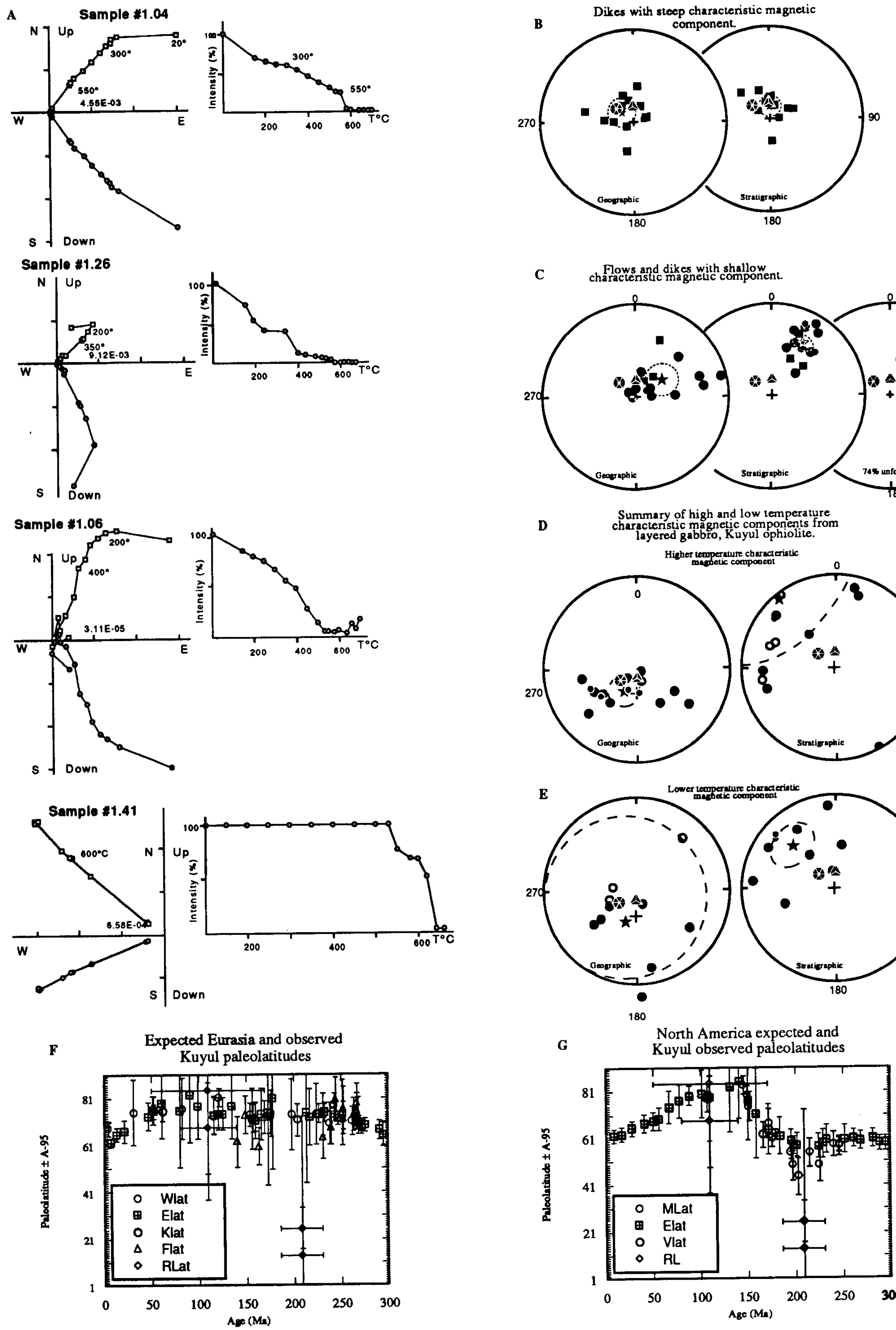
A
Sample #1.04
N Up
300°
20°
550°
4.55E-03
W
E
S Down
Intensity (%)
300°
550°
200
400
600
T°C
Sample #1.26
N Up
200°
350°
9.12E-03
W
E
S Down
Intensity (%)
100
200
400
600
T°C
Sample #1.06
N Up
200°
400°
3.11E-05
W
E
S Down
Intensity (%)
100
200
400
600
T°C
Sample #1.41
600°C
6.58E-04
N Up
W
S Down
Intensity (%)
100
200
400
600
T°C
B
Dikes with steep characteristic magnetic component.
270
90
180
Geographic
Stratigraphic
C
Flows and dikes with shallow characteristic magnetic component.
0
270
90
180
Geographic
Stratigraphic
74% unfolding
D
Summary of high and low temperature characteristic magnetic components from layered gabbro, Kuyul ophiolite.
Higher temperature characteristic magnetic component
0
270
90
Geographic
Stratigraphic
E
Lower temperature characteristic magnetic component
270
90
180
Geographic
Stratigraphic
F
Expected Eurasia and observed Kuyul paleolatitudes
Paleolatitude ± A-95
Age (Ma)
Wlat
Elat
Klat
Flat
RLat
1
21
41
61
81
0
50
100
150
200
250
300
G
North America expected and Kuyul observed paleolatitudes
Paleolatitude ± A-95
Age (Ma)
MLat
Elat
Vlat
RL
1
21
41
61
81
0
50
100
150
200
250
300

Fig.2 (Preceding page). A-Representative orthogonal vector plots in stratigraphic coordinates and magnetic intensity decay diagrams for basalt flow specimens (samples 1.04 and 1.06), a basalt dike specimen (sample 1.26) and a layered gabbro specimen (sample 1.41) showing thermal demagnetization data. The symbols used are: in the orthogonal vector plot, squares; projection onto horizontal plane, circles; projection onto vertical plane. B-E stereographic projections of ChRM directions of the samples of basalt dikes with steep ChRM (B), basalt flows and dikes with shallow ChRM (C), high-temperature component in gabbro, (D) and low-temperature component in gabbro. Symbols used are: squares-ChRM from dike samples, circles-ChRM from flow samples (B,C) or gabbro samples (D,E), star-mean direction, dashed line-α_{95} cone of confidence, hexagon-representative expected direction, triangle-present-day magnetic field direction. Solid symbols-lower hemisphere directions. E-F-Expected versus observed paleolatitudes using the data from this paper and the APWP's for the Eurasia (E) and North America (F) plates proposed by various authors. Our results are shown as diamonds. E-they are compared with Eurasia expected paleolatitudes for this region from the high-reliability studies of Eurasia by Frei and Cox (1987) (open circles), Halvorsen (1989) (open circle), Johnson et al. (1984) (open circle), the European APWP of Westphal et al. (1986) (closed circles), Irving and Irving (1982) (squares), and Khramov (1987) (open circles). F-they are compared with North America expected paleolatitudes for this region from the high-reliability studies by Irving and Irving (1982) (open square), May and Butler (1986) (solid circle), VanFossen and Kent (1990) (open circle), and Witte and Kent (1989) (we used their Newark B magnetic component: open circle). Please see our companion paper in this volume for these references.

measured in 3 samples, and 2 samples show random components.

This ChRM shows better grouping in stratigraphic coordinates with mean $D_s=315.6°$, $I_s=37.0°$, $k_s=5.5$, $\alpha_{95}=22.7°$, N=10. In geographic coordinates, mean $D_g=246.3°$, $I_g=78.7°$ with corresponding $k_g=1.3$ and $\alpha_{95}=78.8°$ (Fig.2E).

The fold test (Graham, 1949), coupled with the statistical test of McElhinny (1964), compares the directions of magnetizations observed within a tilted structure. The increase in the precision parameter during untilting with maximum being achieved at 100 percent untilting and k_{100}/k_0 ratio (subscript represents the percent of untilting), being larger than some statistically critical level (McElhinny, 1964) is interpreted to show that the magnetization predates folding. If, however, k is a maximum at partial untilting, this may indicate the acquisition of the magnetization during folding (synfolding), a systematic error in the orientation of samples and/or bedding orientation, or the presence of unidentified, unremoved secondary magnetic component(s).

The incremental unfolding test performed on the samples from the Kuyul terrane shows that samples collected from the basalt-dike zone have best grouping at 74 percent untilting, although the mean direction differs insignificantly from that at 100 percent untilting: $D_{74\%}=34.6°$, $I_{74\%}=43.5°$, $k_{74\%}=29.7$, $\alpha_{95}=7.1$, N=15 (Fig.2C, Table 1).

Although we are hampered by the small number of single-sample sites and a lack of the ability to estimate the reliability of individual site results, synfolding magnetization seems to be unlikely because there is good agreement between the results from the flows and dikes and the isolated blocks in the nearby melange. Given the equipment used to collect these samples, an equally reasonable explanation for this best grouping at partial untilting is a systematic error in the estimation of sample orientation and/or of the bedding of the pillow-basalt flows. In either event, grouping at 74 or 100 percent untilting gives a better grouping than geographic coordinates, and the resulting partially or fully untilted inclinations differ insignificantly from one another. Because of the two polarities of the ChRM, the coherent linear paths taken during STD, and the agreement in stratigraphic coordinates between the flows and dikes sampled and the isolated blocks of flows within the melange, we interpret the magnetic component presented in Tables 1 and 2 as a ChRM set during the age of formation of these units, thought to be Late Triassic or Early Jurassic based on fossil ages.

The steeper magnetization observed over similar unblocking temperatures, both in a sampled section of dikes and three basalt blocks within the melange, also is best grouped in stratigraphic coordinates (Tables 3 and 4).

GEOCHRONOLOGY

Previous geochronological data (Khanchuk et al., 1990) show two groups of radiometric ages. Samples dated using the K/Ar method in this region gave ages of 134±2, 133±1, 134±3, and 324±3 m.y. While the older age is problematical, the former ages show consistent Early Cretaceous dates. A ChRM of this age, if acquired near the margins of either the North America or Eurasia plates, would match that of our observed steep ChRM. In an attempt to determine the actual ages of the sampled igneous units, we have used $^{40}Ar/^{39}Ar$ step heating. Using the facility at the Geophysical Institute of the University of Alaska at Fairbanks, we calculated a three-fraction plateau age, obtained from a whole rock sample, of 108.2±1.3 m.y. for paleomagnetic sample 1.31. This is a sample with high unblocking temperature and steep ChRM. A second whole rock sample from a presumed late Paleozoic to early Triassic flow (sample 1.5) has an isochron age of 74.5±2.4 m.y. This sample has a stairstep-down pattern indicative of excess argon and probably reflects a Late Cretaceous thermal event and not a primary age. The third sample (basalt dike, #1.18) was insufficient for analysis of potassium content.

DISCUSSION

An unexpected result of our study is the presence of two different ChRM's in basalt and dikes of the basalt-dike zone and serpentinite melange of the Kuyul ophiolite complex. The shallow component in pillow basalt and sheeted dikes from the basalt-dike zone (15 samples) shows significant flattening and latitudinal anomaly compared to the Eurasia as well as to the North America plate, suggesting that the rock originated about 35° south from Eurasia (Table 5,

Fig.2F,G). This component also shows an approximately 80° clockwise rotation of the basalt-dike zone. The similar component was found in a part of basalt from the serpentinite melange (9 samples from 3 blocks, Table 2), although only inclination determinations were possible in the latter case.

The steeper ChRM observed in basalt flows and dikes (18 samples), indistinguishable in the field from those with shallow magnetizations, shows no statistically significant flattening and latitudinal anomaly with respect to either Eurasia or North America between Paleozoic and the present. We interpret the characteristic magnetization found in basalt flows and dikes with steep magnetization to be significantly younger than those with shallow magnetization.

Table 5. Reconnaissance paleomagnetic results for the Kuyul ophiolite complex, northeastern Russia

Locality	Basalt-dike zone (shallow ChRM see Table 1)	Melange, basalts & dikes (steep ChRM, see Table 3)	
Mean geographic $D(°) / I(°) / \alpha_{95}(°)$	57.9 / 62.6 / 14.6	318.4 / 43.1 /55.7	
Mean corrected for tilt $D(°) / I(°) / \alpha_{95}(°)$	34.6 / 43.5 / 7.1	273.4 / 87.3 / 23.7	
Paleolatitude(°N.)	25.4	84.5	
Paleomagnetic pole*			
Age (m.y.)	200	200	110
Φ(°N.)/Λ(°E.)/A95(°)	67 / 70 / 14	67 / 70 / 14	80 / 170 / 15
$R \pm \Delta R$ (°)	78.3±19.5	-51.8±18.8	-83.6±42.4
$F \pm \Delta F$ (°)	35.1±9.3	-17.6±18.7	-6.8±19.5
$\lambda \pm \Delta\lambda$ (°)	34.5±12.0	-31.1±38.4	-13.2±38.6

*- Data from Piper (1987); Φ and Λ are latitude and longtitude of the Eurasian paleomagnetic pole respectively, A95 is the radius of the 95-percent cone of confidence about this pole; $R \pm \Delta R$, $F \pm \Delta F$, $\lambda \pm \Delta\lambda$ refer to rotation and associated uncertainity, flattening and associated uncertainity (Beck, 1980; Demarest, 1983) and the difference between the expected and observed paleolatitudes (latitudinal anomaly) and the associated uncertainity. For other abbreviations, see text.

CONCLUSIONS

Our study of some igneous rocks from the Kuyul ophiolite indicates a complicated history. Paleomagnetic and initial geochemical data (Krylov and Grigoriev, 1992) suggest at least two ages and two geodynamic environments of igneous rocks in this region. One age, which usually is taken to represent the Kuyul ophiolite as a whole, comes from fossils and is Late Triassic to Early Jurassic. A small number of samples show stable ChRM's, which are better grouped in 74-percent untilted or stratigraphic coordinates. If this magnetic component is interpreted to represent the characteristic remanent magnetization acquired during or shortly after origination of these units, significant northward motion of this ophiolite is suggested. In addition, a significantly steeper characteristic remanent magnetization is recorded in some samples that also appear to be best grouped in stratigraphic coordinates. These units appear to be, both on the basis of the $^{40}Ar/^{39}Ar$ age, and on the basis of their observed ChRM, Early Cretaceous in age. This steep ChRM agrees with that expected, assuming this magnetic component was acquired near their present location on the North America or Eurasia plates.

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