19. METAGRANITIC ROCKS FROM THE MAZAGAN ESCARPMENT, DEEP SEA DRILLING PROJECT LEG 79, HOLE 544A[1]

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ABSTRACT

Fifty m of basement rocks underlying 185 m of Neogene and Mesozoic sediments were drilled seaward of the Mazagan Slope about 100 km west of Casablanca during Leg 79. These rocks are metagranites with mylonitic textures consisting dominantly of quartz, plagioclase, and potassium feldspar. Chemically, they are strongly peraluminous. This along with the absence of hornblende suggest that these rocks are similar to the S-type granites. Petrographic and chemical data suggest the possible existence of a former weathering surface on top of the Mazagan metagranite.

INTRODUCTION

The continental margins of Northwest Africa and northeast America belong to the oldest passive oceanic margins. Rifting began in Triassic time, resulting in the formation of the present Atlantic Ocean Basin. Study of basement rocks on both sides of the Atlantic helps to document the fitting of the North American and African continents.

The main purpose of Leg 79 was to define the westward extent of the African continent and to document the early rifting history. Granitic rocks were discovered in Hole 544A, 100 km west of Casablanca at the foot of the Mazagan Escarpment (Figs. 1, 2). About 50 m of basement rocks were drilled beneath 140 m of marine and 45 m of terrigenous sediments. We have studied rocks from Cores 544A-24 to 544A-28 (184.3 m to 235. 0 m sub-bottom depth) by bulk rock chemical analysis and petrography.

ANALYTICAL METHODS

Major, minor, and trace elements were analyzed by X-ray fluorescent methods on glass fusion beads, using a fully automated Philips PW 1400. The fusion beads consist of rock powders (dried at 100°C overnight) and flux (lithium metaborate and dilithium tetraborate, Merck A 12) in the ratio of one part rock to four parts flux, melted at 1000°C for 10 min. and poured into a 34-mm-diameter pellet mold.

Fe-(II) was determined by semi-automatic potentiometric titration of the hydrofluoric acid-silver perchlorate digested sample, with standard potassium bromide solution; CO_2 by closed-system coulometric titration of a barium perchlorate solution into which were passed the gases produced by passing oxygen over the sample roasted in a tube furnace; H_2O^+ by closed-system coulometric titration of a nonaqueous Karl Fischer reagent into which was passed the inert carrier gas (here N_2) containing water stripped from the sample by heating in a Pt-crucible to 1300°C with an induction furnace.

PETROGRAPHY

The coarse granular rocks are composed of quartz (= 40 vol. %), plagioclase (oligoclase = 30 vol. %), and alkali feldspar (perthitic microcline ± orthoclase = 20 vol. %). Pleochroic red-brown biotite (size 0.4 mm,

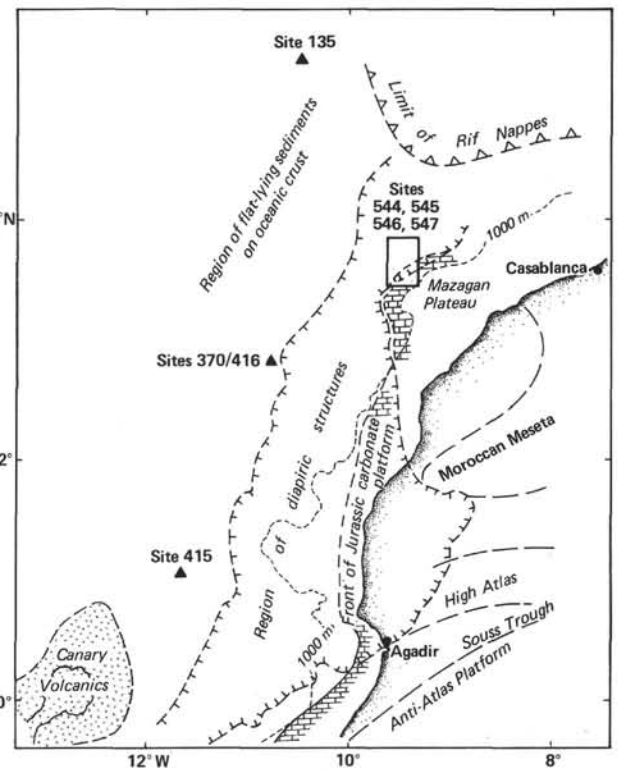

Figure 1. Location map of Leg 79 drilling area.

biotite I) zircon, and apatite occur in trace amounts interstitially as well as inclusions in quartz. Hornblende is absent. Internally highly granulated large quartz grains (size 4 mm) with rims of fine-grained recrystallized quartz (size 10–100 μm) occur as bands and indicate a mylonitic texture. Several feldspar grains are fractured. Plagioclase (size 0.6–2.5 mm, An_{20-30}) with abundant polytwining is more strongly altered than alkali feldspar and contains flakes of sericite, plates and fibers of muscovite, and abundant hypidiomorphic colorless crystals of the epidote group (size 0.4 mm). Rims of biotite I are altered to oxides and secondary pleochroic green biotite (biotite II). Intercumulus space (3 vol. %) is filled by an intergrowth of the secondary phases muscovite, biotite

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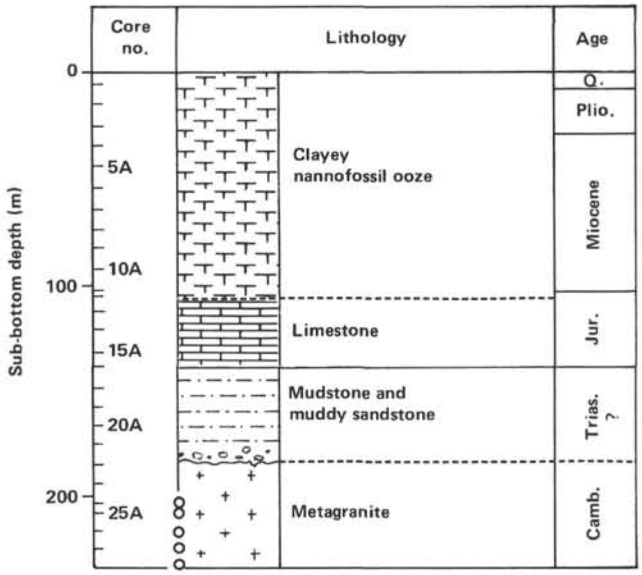

Figure 2. Schematic stratigraphy of Hole 544A. Circles indicate sample positions.

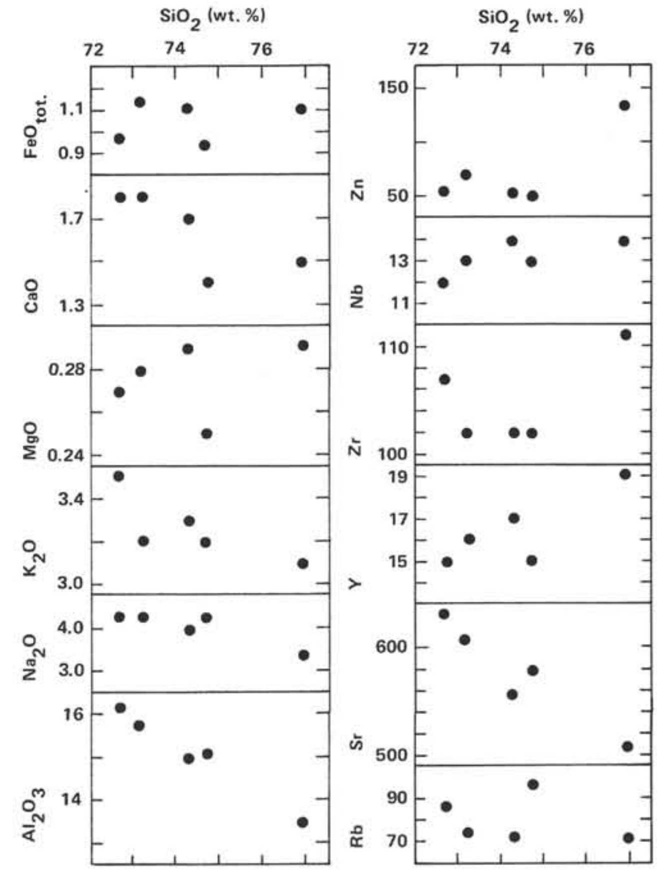

Figure 3. Major (wt.%) and trace element data (ppm) versus wt.% SiO_2.

II, "Clinozoisite," oxides, and traces of sphene as a result of deuteric magmatic processes.

Muscovite and, less often, biotite II form well-crystallized plates and fibers that are tectonically deformed. The other phases occur as xenomorphic aggregates less than 50 μm in size. Trace amounts of chlorite flakes are probably due to weak regional metamorphism. Weathering effects (?) are indicated by a reddish coating of some fractures and grain boundaries caused by hydrous iron oxides.

CHEMICAL COMPOSITION

Five rocks were analyzed for major and trace elements (Figs. 3, 4; Tables 1, 2). Most elements have very similar concentrations that correspond to a granite. The most notable variations are an inverse correlation between SiO_2 and the elements Al, Ca, Na, and Sr (Fig. 3). This suggests that differences in chemical composition are chiefly caused by variable plagioclase content. Such differences were expected since the grain size is large (up to 3 mm) and the samples received are small.

The rocks can be classified as granodiorite by their modal and normative mineralogy. However, chemically they clearly belong to the granitic rocks proper (e.g., Le Maitre, 1976), and we prefer to use the term granite for these rocks.

Fe_2O_3/FeO ratios decrease from 3 in the top to 0.2 in the lowermost sample analyzed, suggesting increasing oxidation toward the basement surface (former weathering surface?) or decreasing seawater influx with increasing sub-bottom depth (Fig. 4). Among the mobile trace elements, Rb shows the highest concentration (97 ppm) near the top, decreasing to 74 ppm in the bottom samples, also suggesting increase in alteration upward (Fig. 4). Barium is most abundant in Section 544A-25-1 (1200 ppm), ranging from 730 to 900 ppm in other samples.

The peraluminous ($Al/[Na+Ca+K] > 1$) nature of the Mazagan metagranite is reflected in the CIPW norm (Table 2) since all rocks analyzed are corundum normative. Peraluminous granites are commonly interpreted to have formed by partial melting of sedimentary rocks. Such sediments become peraluminous due to removal of Na and K relative to Al during weathering.

Compared to S-type granites from Australia described by Chappel and White (1974), White and Chappel (1977), and Wyborn et al. (1981), the Mazagan granite (Table 3) is lower in FeO_{tot} and Rb and higher in Na, Sr, and Ba. The possibility that the latter elements are introduced by seawater cannot be discounted, but is considered unlikely because K and Rb, which are commonly increased during low-temperature seawater alteration, are not very high. Instead we interpret these elements as having been high in the granitic magma that is highly fractionated judging from the high SiO_2 and low MgO and FeO concentrations.

White and Chappel (1977) have interpreted similar compositions as minimum melt compositions generated during partial melting (Table 3). Thus, we tentatively interpret the Mazagan granite as approximately representing minimum melts generated during anatexis of crustal rocks.

The intrusion-uplift age of the Mazagan metagranite is tentatively dated as late Cambrian (Wissmann et al., 1982). Prior to Triassic rifting, the Mazagan Plateau was adjacent to rocks in the Nova Scotia area (Canada). During the late Cambrian, the sedimentation of the Megu-

Table 1. Major and trace elements of Leg 79, Hole 544A granitic rocks.

	Sample (interval in cm)				
	24-1, 23–26	25-1, 27–30	26-1, 32–36	27-1, 41–44	28-1, 27–31
Major elements (wt.%)					
SiO_2	73.80	71.60	73.40	76.60	72.30
TiO_2	0.10	0.12	0.12	0.12	0.12
Al_2O_3	14.90	15.90	14.80	13.40	15.60
Fe_2O_3	0.77	0.87	0.58	0.29	0.19
FeO	0.25	0.20	0.59	0.84	0.96
MnO	0.03	0.03	0.03	0.04	0.04
MgO	0.25	0.27	0.29	0.29	0.28
CaO	1.50	1.81	1.69	1.59	1.83
Na_2O	4.12	4.24	3.92	3.43	4.26
K_2O	3.13	3.43	3.29	3.07	3.16
P_2O_5	0.04	0.04	0.03	0.03	0.04
H_2O	0.15	0.50	0.25	0.46	0.40
CO_2	0.09	0.06	0.02	0.07	0.01
Cl	0.01	0.01	0.01	0.01	0.01
S	0.01	0.01	0.01	0.01	0.00
	99.15	99.09	99.03	100.25	99.20
Trace elements (ppm)					
Cr	5	4	2	3	5
Co	22	22	20	26	18
Ni	7	10	4	7	8
Cu	4	2	3	233	34
Zn	51	56	52	133	69
Rb	97	87	72	72	74
Sr	578	631	556	509	606
Y	15	15	17	19	16
Zr	102	107	102	111	102
Nb	13	12	14	14	13
Ba	923	1218	926	899	896

Table 2. CIPW norms for Hole 544A, assuming Fe_2O_3 = 15% total Fe.

	Sample (interval in cm)				
CIPW norm	24-1, 23–26	25-1, 27–30	26-1, 32–36	27-1, 41–44	28-1, 27–31
Q	34.51	29.72	33.88	40.84	30.93
C	2.35	2.20	1.87	1.80	2.00
Or	18.74	20.60	19.70	18.21	18.91
Ab	35.26	36.42	33.56	29.08	36.44
An	6.70	8.48	8.17	7.28	8.86
Hl	0.01	0.01	0.01	0.01	0.01
En	0.63	0.68	0.73	0.73	0.71
Fs	1.32	1.35	1.55	1.53	1.60
Mt	0.18	0.19	0.22	0.21	0.22
Il	0.19	0.23	0.23	0.23	0.23
Ap	0.10	0.10	0.07	0.07	0.10
Pr	0.01	0.01	0.01	0.01	0.01

ma Formation, Nova Scotia, started with graywackes that are believed to have been derived from a granodioritic source area in the southeast (Schenk, 1980). The Mazagan metagranite could have been a potential source rock for the Meguma graywackes.

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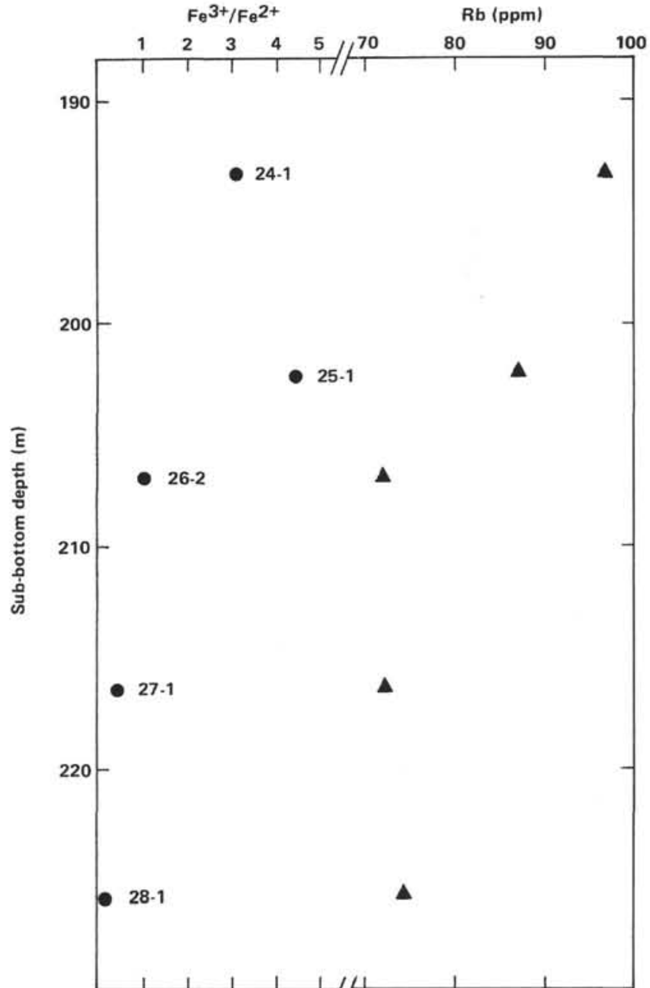

Figure 4. Fe^{3+}/Fe^{2+} and Rb versus sub-bottom depth for analyzed samples. Numbers indicate cores and sections. ▲, Rb values; ●, Fe^{3+}/Fe^{2+} ratios.

Table 3. Comparison between Leg 79 granite and minimum S-type melt.

Element	Leg 79, Section 544A-27-1	Minimum melt (S-type)
SiO_2	76.83	75.71
TiO_2	0.12	0.28
Al_2O_3	13.44	12.96
Fe_2O_3	0.29	0.24
FeO	0.84	1.32
MnO	0.04	0.03
MgO	0.29	0.31
CaO	1.59	1.12
Na_2O	3.44	3.11
K_2O	3.08	4.85
P_2O_5	0.03	0.06

Note: Minimum melt from White and Chappel (1977) (recalculated to a volatile-free basis).

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