47. K-Ar DATING OF BASALTS FROM SITE 647, ODP LEG 105\(^1\)

J. C. Roddick\(^2\)

ABSTRACT

Alteration of basalt samples in the basement rocks of Site 647 produced a range of K-Ar ages from 35 to 71 Ma. Microprobe data indicate that an alteration phase contributes nearly 50% of the potassium in the samples. Thus, a component with uncertain argon-retention characteristics is considered responsible for the range of ages. While the older ages are consistent with the expected magnetic anomaly age and the fossil evidence, the presence of the alteration makes these ages unreliable for defining the age of the basaltic crust.

INTRODUCTION

The chronology of Labrador Sea evolution is not known precisely because of the difficulty of correlating the magnetic anomalies in the region to the defined anomaly pattern in the rest of the North Atlantic (Srivastava, Arthur, et al., 1987). Direct radiometric dating of basement could resolve much of the uncertainties. A previous drilling project on a basement high was unsuccessful in collecting basement basalt suitable for dating (Laughton et al., 1972), while in much of the Labrador Sea the basement is inaccessible because of a large thickness of sediment. Ocean Drilling Program (ODP) Site 647, on the southern edge of the Labrador Sea, penetrated a thick basalt sequence that appeared to be potentially suitable for K-Ar dating.

K-Ar dating was done on seven samples of basaltic rocks at Site 647 in the Labrador Sea. Basalt was recovered from 699 to 736 meters below the sea floor (mbsf), and the dated samples are from 705 to 736 mbsf. The basalts of the section are generally massive, fine- to medium-grained rocks having stockwork veins near the top of the section and minor serpentinite veins farther downsection. The section may be a single, thick flow. Petrographically, the samples are composed of pyroxene, plagioclase, and oxides, with minor alteration associated with the oxides and pyroxene grains. Whole-rock samples free of vein material were crushed and sized to between 0.5 and 0.35 mm.; 0.5 to 1.0 g of each sample was taken for argon extraction.

Methods

Whole-rock samples free of vein material were crushed and sized to between 0.5 and 0.35 mm.; 0.5 to 1.0 g was taken for argon extraction. Samples were fused with an RF induction heater in a high vacuum line. The argon was then purified and analyzed by isotope-dilution mass spectrometry. Sample aliquots were taken and ground to less than 0.10 mm for potassium determination by atomic absorption spectrometry. Further details of the analytical procedures are given in Roddick and Souther (1987), but we did not employ acid washing of the crushed and sized samples.

RESULTS

The K-Ar analytical data are given in Table 1. The determined ages range from 35 to 71 Ma and show no correlation with depth below the seafloor. Potassium contents are very low and range from 0.024% to 0.050%. These values are in the low range, but are typical of oceanic tholeiites (Hart, 1969; Melson et al., 1976). Potassium content increases with depth in the section, with samples below 719 m containing almost double the potassium of the samples higher in the section; however, there is no correlation with age of the samples.

DISCUSSION

The K-Ar ages are too variable and imprecise to define the age of the basaltic crust at this location. Clearly, from the fossil evidence, four of the ages are younger than the lower age limit of 55 Ma. The three remaining ages (61 to 71 Ma) are slightly older than the expected age range of anomaly 24, when the error limits are taken into account. The low potassium content of the samples makes them difficult to analyze but does not account for the range of ages nor the poor precision. A lack of correlation of younger ages with higher potassium contents rules out the addition of potassium as a single process responsible for the young ages. It appears that some samples have lost radiogenic argon.

The great uncertainty of the ages mostly results from high atmospheric argon in the analyses. This argon, which was corrected for extraction system blank, is from the samples themselves and is not an artifact of the analytical procedures. Extraction-line blanks are less than 10% of the measured atmospheric argon, except for the sample at 709 m (30%). High atmospheric contamination of basalts is often an indication of secondary alteration associated with interaction with seawater (Dymond and Hogan, 1973; Roddick, 1978). In this case, basalt samples lower in the section have the higher atmospheric contamination. They also have higher contents of potassium—another index of alteration of basaltic rocks (Hart, 1969). Similar degrees of minor alteration were seen in thin sections of all the samples. The deeper samples do not appear to have greater alteration. However, the alteration is patchy and minor, and the thin sections may not be totally representative of the bulk samples analyzed.

---


\(^2\) Geological Survey of Canada, 601 Booth Street, Ottawa K1A 0E8, Canada.
To characterize the main phases contributing to the K-Ar ages, electron microprobe analyses were conducted on two samples (704 and 719 m depth). The analyses (Table 2) show that the determined potassium contents of the major igneous phases (clinoxyroxene and plagioclase) are not enough to produce the bulk potassium values determined in the whole rocks without considering the potassium in the alteration phase (Table 1). For the two samples (704 and 719), the average plagioclase (0.029% and 0.025% potassium) and clinoxyroxene (0.015% and 0.012% potassium) concentrations are similar to or lower than the whole-rock values of 0.029% (704) and 0.024% (719) potassium. In contrast, the alteration, which perhaps was originally glass and is now an iron-magnesium alumino-silicate, has 10 times the potassium (0.25% and 0.29%) of the whole rocks. The samples typically are composed of about 40% clinoxyroxene, 30% plagioclase, 25% oxides, and minor orange-brown alteration. Using the measured potassium concentrations of the phases (Table 2) and whole rocks (Table 1), mass-balance calculations indicate that about 3% to 5% alteration occurred and that this alteration contributes about 45% of the potassium in both whole-rock samples. This alteration has poor radiogenic argon-retention characteristics and is also likely to be the major source of atmospheric argon in the samples. Thus, the ages and the poor precision of Table 1 can be attributed to this alteration phase.

TO characterize the main phases contributing to the K-Ar ages, electron microprobe analyses were conducted on two samples (704 and 719 m depth). The analyses (Table 2) show that the determined potassium contents of the major igneous phases (clinoxyroxene and plagioclase) are not enough to produce the bulk potassium values determined in the whole rocks without considering the potassium in the alteration phase (Table 1). For the two samples (704 and 719), the average plagioclase (0.029% and 0.025% potassium) and clinoxyroxene (0.015% and 0.012% potassium) concentrations are similar to or lower than the whole-rock values of 0.029% (704) and 0.024% (719) potassium. In contrast, the alteration, which perhaps was originally glass and is now an iron-magnesium alumino-silicate, has 10 times the potassium (0.25% and 0.29%) of the whole rocks. The samples typically are composed of about 40% clinoxyroxene, 30% plagioclase, 25% oxides, and minor orange-brown alteration. Using the measured potassium concentrations of the phases (Table 2) and whole rocks (Table 1), mass-balance calculations indicate that about 3% to 5% alteration occurred and that this alteration contributes about 45% of the potassium in both whole-rock samples. This alteration has poor radiogenic argon-retention characteristics and is also likely to be the major source of atmospheric argon in the samples. Thus, the ages and the poor precision of Table 1 can be attributed to this alteration phase.

CONCLUSIONS

Minor alteration of basalt samples in the basement rocks of Site 647 produced secondary minerals with poor argon retention characteristics. This alteration contributes proportionately large quantities of potassium to the total potassium in the basalt. This results in samples with a range of K-Ar ages from 35 to 71 Ma. While the older ages are consistent with the expected magmatic anomaly age of about 56 Ma, the ages are not reliable enough to constrain the tectonic evolution of the region. Plagioclase in these rocks is essentially unaltered, and it may be possible to determine a precise age by $^{40}$Ar/$^{39}$Ar analysis of this mineral.

ACKNOWLEDGMENTS

I thank S. Srivastava for selecting the initial suite of samples and B. Clarke for parting with several grams of his limited supply of core material. I thank G. LeCheminant for the microprobe analyses, while B. Cameron kindly provided petrographic descriptions of several samples. Reviews by S. Srivastava, P. Renne, and D. Janeky helped improve the manuscript; Geological Survey of Canada Contribution #48387.

REFERENCES


Date of initial receipt: 28 September 1987
Date of acceptance: 22 March 1988

Ms 105B-176
Table 2. Electron-probe analyses of some phases of two basalts for Site 647.

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Lab no. 3778</th>
<th></th>
<th></th>
<th>Lab no. 3777</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO₂</td>
<td>52.59</td>
<td>51.35</td>
<td>41.14</td>
<td>52.93</td>
<td>52.38</td>
<td>42.29</td>
</tr>
<tr>
<td>TiO₂</td>
<td>0.06</td>
<td>0.50</td>
<td>0.15</td>
<td>0.05</td>
<td>0.33</td>
<td>0.26</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>28.31</td>
<td>2.39</td>
<td>6.02</td>
<td>28.08</td>
<td>1.57</td>
<td>5.26</td>
</tr>
<tr>
<td>Fe₂O₃</td>
<td>1.26</td>
<td>11.77</td>
<td>27.32</td>
<td>1.23</td>
<td>10.74</td>
<td>22.37</td>
</tr>
<tr>
<td>MnO</td>
<td>0.00</td>
<td>0.25</td>
<td>0.15</td>
<td>0.01</td>
<td>0.27</td>
<td>0.05</td>
</tr>
<tr>
<td>MgO</td>
<td>0.16</td>
<td>16.34</td>
<td>13.55</td>
<td>0.15</td>
<td>17.71</td>
<td>13.93</td>
</tr>
<tr>
<td>CaO</td>
<td>12.31</td>
<td>17.34</td>
<td>1.81</td>
<td>12.11</td>
<td>16.95</td>
<td>2.14</td>
</tr>
<tr>
<td>Na₂O</td>
<td>4.25</td>
<td>0.25</td>
<td>0.28</td>
<td>4.42</td>
<td>0.17</td>
<td>0.29</td>
</tr>
<tr>
<td>K₂O</td>
<td>0.04</td>
<td>0.05</td>
<td>0.28</td>
<td>0.04</td>
<td>0.01</td>
<td>0.41</td>
</tr>
<tr>
<td>Total</td>
<td>98.98</td>
<td>100.24</td>
<td>90.70</td>
<td>99.02</td>
<td>100.13</td>
<td>87.00</td>
</tr>
</tbody>
</table>

²K  

1 Total iron calculated as ferric oxide.  
2 Potassium average of five analyses as a trace element. Plag. = Plagioclase, the average of three analyses; Cpx. = Clinopyroxene, average of two analyses; Alt. = Alteration, average of three analyses.