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October 4, 1968

Office of Grants and Research Contracts
Attention: Code SC
National Aeronautics and Space Administration
Washington, D. C. 20546

Subject: Semiannual Status Report for Grant NGR 38-003-009 and NGR 38-003-009 Supplement No. 1.

Gentlemen:

This report covers the period May 1967-October 1968. Instrumentation vital for implementing the proposed research (principally an electron probe microanalyzer) could not be ordered until the funds of NGR 38-003-009 Supplement No. 1 became available early this year. As a result, it is only in the last six months that we have been actively pursuing the specific lines of research outlined in our proposal.

1. <u>Instrumentation and Technical</u>

An electron probe microanalyzer was installed in May 1968 and is presently operational. Accompanying instrumentation such as vacuum coating and sample polishing facilities have also been installed and are operational. A set of reliable comparative standards for quantitative analysis have been acquired from various microprobe laboratories throughout the world, and we are currently doing quantitative analyses of experimental runs.

A high temperature quench furnace is being installed. The furnace is capable of operating in vacuum, inert gas, or controlled oxidizing atmospheres; is equipped for rapid quenching and will allow us to carry on our experimentation to higher temperatures than previously were attainable. Future equilibration runs (see below) will be carried out in this instrument to a large extent.

2. <u>Personnel</u>

Dr. Stewart McCallum (Ph.D., University of Chicago) has been working on the project since May. Dr. McCallum has been largely instrumental in helping us to achieve operational level in our microprobe laboratory in

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relatively short time. In collaboration with the principal investigator he is currently doing experimental work on melt-crystal element fractionation in basic magmatic systems (see below).

Mr. Richard Freeman has been working on the project as chief technician. A portion of his salary (summer) is financed from this grant.

Mr. Michael Drake, a Ph.D. candidate, has been working on plagioclase-silicate liquid equilibrium (see below) as a dissertation problem under the direction of the principal investigator. Mr. Drake is hired as a graduate research assistant (50% time) on this grant.

3. Progress of Research

It has been confirmed that the distribution of Na, Si, Al, and Ca between plagioclase and coexisting silicate melt can be correlated with temperature of equilibration in magmatic systems ranging from granitic to basaltic. Maximum correlation is achieved by means of the following linear regression curves which refer to the water pressures indicated in parentheses. In these equations

$$y = 10.34 \times 10^{-3}T - 17.24 \quad (P_{H_2O} = 0)$$
$$y = 11.05 \times 10^{-3}T - 17.86 \quad (P_{H_2O} = 0.5\text{ kb})$$
$$y = 11.14 \times 10^{-3}T - 17.67 \quad (P_{H_2O} = 1.0\text{ kb})$$
$$y = 12.18 \times 10^{-3}T - 16.63 \quad (P_{H_2O} = 5.0\text{ kb})$$

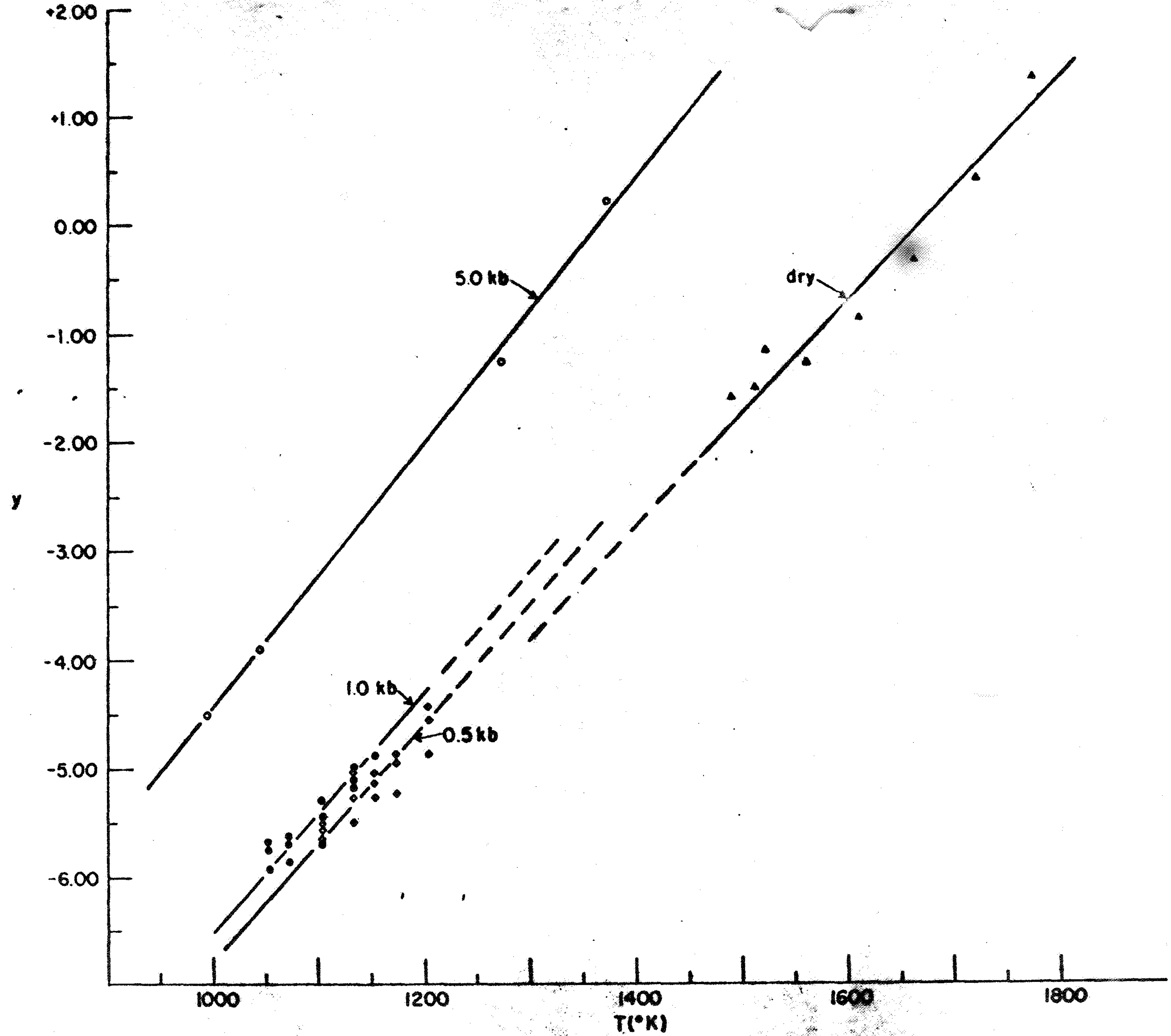
y is a function of plagioclase and liquid composition according to

$$y = \ln \frac{X_{Na}X_{Si}/X_{Ca}X_{Al}}{X_{Ab}/X_{An}} + \frac{1.29 \times 10^{4}}{T} (X_{Ca}+X_{Al}-X_{Na}-X_{Si})$$

and $X_{Na} = N_{Na}/N_{Na}+N_{Si}+N_{Al}+N_{Ca}$ (in the liquid), etc., $X_{Ab}=N_{Ab}/N_{Ab}+N_{An}$ (in plagioclase), etc., and T is given in degrees Kelvin. These curves are shown in Figure 1 where it can be seen that the dominant effect of increasing the water pressure is to shift a given plagioclase-liquid partition to lower temperatures. The mean difference between calculated temperature and experimentally measured temperature for the forty experimental points shown in Figure 1 is zero with a spread of $\pm 34^{o}$ K (standard deviation).

The greatest potential for geothermometry is for extrusive and shallow intrusive rocks. For these rocks it is likely that the high temperature equilibrium parameters will be quenched in; also the liquid composition can be directly analyzed from its glassy or fine grained quenched equivalent. Accordingly, our present efforts are directed at gathering additional data for dry (P_{H_2O}=0) systems starting with basaltic compositions. It is also expected that this work will be directly applicable to returned lunar samples provided the latter include plagioclase-bearing basalts.

Figure 1. Linear regression curves for y versus T at various water pressures. Refer to text for explanation of y. Dry, ▲; 0.5 kb, ◇; 1.0 Kb, ●; 5.0 kb, ○.


+2.00
+1.00
0.00
-1.00
-2.00
-3.00
-4.00
-5.00
-6.00
y
5.0 kb
dry
1.0 kb
0.5 kb
1000
1200
1400
1600
1800
T(°K)

We have collected a series of samples across the contact of the Stillwater layered igneous complex with the underlying basement complex. It has been postulated that this "chilled" border facies (it is in fact relatively coarse grained) may represent the initial composition of the Stillwater magma. Experiments are under way to study the crystallization history of liquids of this range of compositions. The results should be a better understanding of the details of crystallization of basic magmas and when compared to the observed mineral layering of the complex will provide limiting controls on possible primary liquid compositions. Data on the temperature dependence of the distribution of Fe and Mg between olivine, ortho and clinopyroxene, and liquid will prove a valuable addition to the plagioclase thermometry being developed.

Sincerely,

D. F. Weill

Daniel F. Weill
Principal Investigator

DFW:jmh