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THIRD QUARTERLY TECHNICAL PROGRESS REPORT

For the period October, November, December, 1965

DEVELOPMENT OF TECHNOLOGICAL CONCEPTS LEADING TO BENEFICIAL USE OF LUNAR MAGMA PRODUCTS

Contract NAS 7-358

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ACTIVITY LAST QUARTER AND NEW DATA

During the third quarter, 110 new determinations have been made of the solid-liquid phase transformations of igneous rocks from pressures of one atmosphere to 45 kilobars. This brings the total number of runs to date to 288.

1. Hugoton Meteorite - The Hugoton meteorite from Kansas is the chondritic meteorite we chose for comparison with the Bruderheim meteorite. Seven solid-liquid determinations have been completed so far and the final curve will be compared with that of the Bruderheim-meteorite and with those of the typical terrestrial igneous rocks.

2. Tholeiitic Basalt - A time dependence curve showing the development of ten genetic states was derived for a set of conditions and compared with a curve of the same nature derived for gabbro (see Figure 1). It is important to note that although the genetic states from one to ten do not have numerical values, they develop in a successive order. Each genetic state can be described as a physico-chemical phase, such as liquid (glass) or solid (crystalline); it can be described as a mineralogical phase (no example in this figure); or it can be described as a textural distinction, such as vesicular or pumiceous. The genetic states are descriptive and all have one common denominator - they describe distinct rocks.

Examination of the ratio of glass to crystalline material as a function of temperature and pressure suggests that the ratio increases with pressure up to a point and then decreases, a phenomenon that we reported last year (in reference to the Bruderheim meteorite). This phenomenon is being further explored now.

3. Granodiorite - Petrographic examination of the granodiorite experiments indicates a development of several mineral phases (the feldspar high-pressure transformation into the eclogite series is known to take place slightly above 30 KB).. Because of the microcrystalline nature of these phases,we are repeating the analysis with an X-ray diffractometer to clarify the data before reporting it as final and definite.

4. Serpentine - An examination of crystalline stability regions of serpentine after treatment at various temperatures and pressures was conducted by means of X-ray diffraction analysis. These analyses were conducted on small core samples which were powdered and mounted on specially-cut quartz plates. The weight of sample used in the analysis varied from 1.0 mg to 6.0 mg.

Untreated samples of this serpentine gave an X-ray diffraction pattern indicating the presence of antigorite ($Mg_6Si_4O_{16}$) only. A chemical analysis of this rock was as follows: SiO_2 - 40.0, TiO_2 - 0.04, Al_2O_3 - 1.8, Fe_2O_3 - 6.4, FeO - 1.8, MnO - 0.11, MgO - 37.2, CaO - 0.9, Na_2O - 0.08, K_2O - 0.04, P_2O_5 - 0.02, H_2O^+ - 12.5, H_2O^- - 0.3, total H_2O - 12.8, CO_2 - 0.04, S - 0.022, total - 101.2. Samples of this serpentine were analyzed after treatment at temperatures ranging up to 1400°C and pressures up to 30 KB.

Preliminary results of these analyses indicated four (4) general regions of crystalline stability at various temperatures and pressures. These stability fields have been identified from the peak positions and intensities of the X-ray diffractograms. Antigorite was the stable mineral phase at temperatures as high as 300°C and pressures up to 20 KB. Forsterite (Mg_2SiO_4) appeared to be the only mineral phase present at temperatures between 780°C and 1250°C when the pressure was generally below 12 KB. Combinations of Forsterite and Enstatite ($MgSiO_3$) became stable at temperatures over 1200°C and pressures over 14 KB. Enstatite was the only mineral phase identified in a few samples after treatment at temperatures greater than 1260°C and pressures greater than 16 KB. These stability regions have been identified in samples that have been maintained at the indicated temperatures for 5 minutes in most cases. In the few cases when the temperatures were maintained for longer periods of time or when the rate of heating varied, there appeared to be a corresponding shift in the stable crystal phase.

NEW ONE-ATMOSPHERE DETERMINATIONS

Cuts of the same range of rocks that were used previously for determination of the time dependence of genetic state developments at $1000^{\circ}C$, were used for a similar determination at $1100^{\circ}C$. Fifty experiments were repeated to determine the reproducibility of the data. Combining the data with the high pressure data, it was possible to plot genesis diagrams such as Figure 2.

FUTURE WORK

During the fourth quarter of this contract year, we intend to 1) obtain more data on the behavior of the Hugoton meteorite in the pressure range of 20 - 45 KB, 2) complete the analysis of all the experiments run thus far, and 3) correlate all the data and try to conglomerate the fragmental ideas into a working hypothesis on the behavior of igneous rocks.

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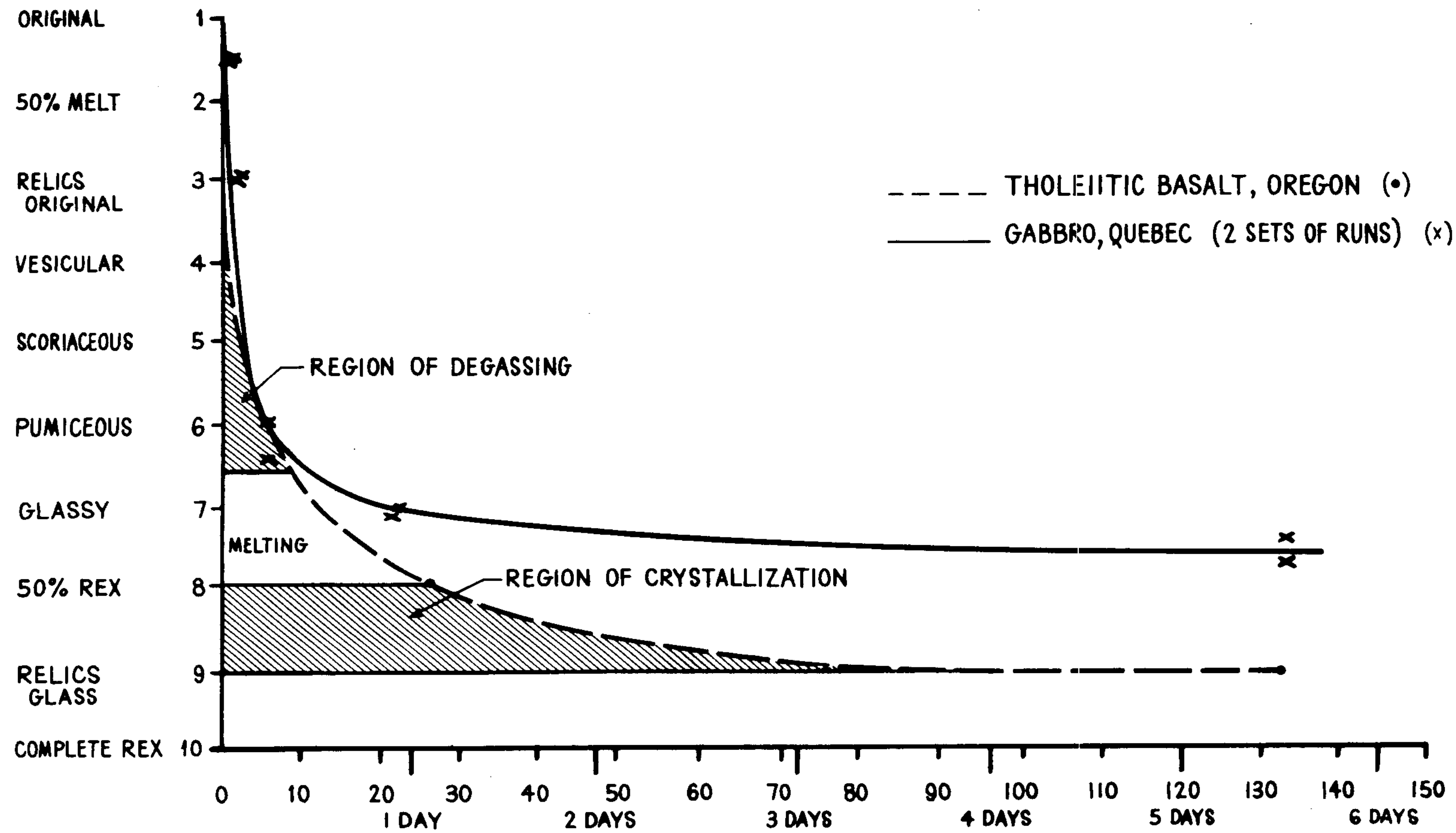

Figure 1. Time Dependence of Genetic States
(1000°C at 1 atm)

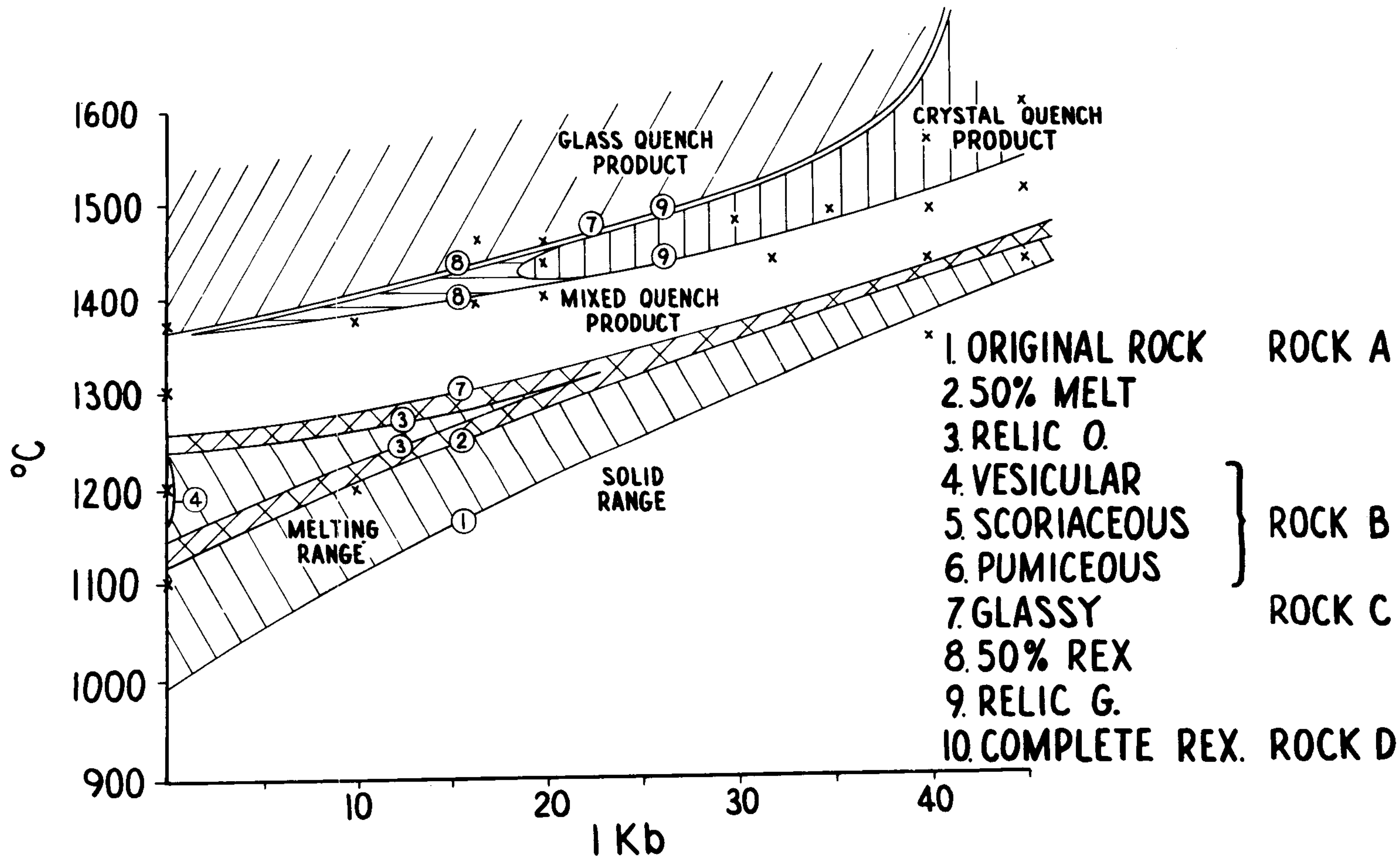

Figure 2. Genesis Diagram--Gabbro (Quebec), T° vs. P at ~ 1 min. Stay at T°, Then Quench