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DEFORMATION OF YULE MARBLE: PART V—EFFECTS AT 300°C

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ABSTRACT

Yule marble has been deformed at 300°C, at 5000 atmospheres confining pressure, under conditions otherwise identical with those at room temperature and at 150°C (Parts I–IV). The important new effects are: apparent development of intergranular flow (recrystallization[1]) and development of textures closely resembling those of naturally deformed marble. Fabric measurements on the deformed material show trends nearly identical with those observed in specimens deformed at lower temperature (Parts III and IV). The effect of interstitial water is negligible except for lowering of strength similar to that observed at room temperature. Slow rates of deformation seem to favor recrystallization. Granite has been deformed plastically for the first time.

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INTRODUCTION

Parts I–IV of this series of papers (Griggs and Miller, 1951; Handin and Griggs, 1951; Turner and Ch'ih, 1951; Griggs *et al.*, 1951) described the physical properties and fabric changes in Yule marble deformed at room temperature and at 150°C under confining pressures of 5000 and 10,000 atmospheres (equivalent to depths of about 15 and 30 km in the earth's crust). The present paper describes similar observations at 300°C at 5000 atmospheres

[1] The term *recrystallization* as used in this paper follows Griggs' (1940, p. 1003) definition of recrystallization flow:—"deformation by molecular rearrangement through the medium of solutions, local melting, or solid diffusion; intergranular motion dominant".

confining pressure. In the absence of local heating 300°C is about the temperature to be expected at a depth of 30 km in the earth. Griggs and Sosoka did the experimental phase, Turner and Borg did the fabric studies.

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Experiments

Apparatus and Procedure

The apparatus and procedure have been fully described in Parts I and IV. The only difference in the work at 300°C is the method of jacketing the specimens. The solder used on the early jackets melted at 300°C. After some abortive attempts to use high-melting solder, a mechanical closure was developed which is leakproof if certain design precautions are observed [see Handin (1953) for details]. This removes one uncertainty present in former experiments—the effect of the soldering flux.

Procedure for measurements, calibrations, and reduction of data is as described in Part I. The rate of strain is the same—1.5 per cent per minute. All Yule marble specimens were cut from the same block as that used for experiments described in Parts I and IV. The temperature of the specimen was determined by calibration as in Part IV. There is a substantial temperature gradient in the test section, amounting to about 10°C in the specimen. The maximum temperature is 300°C and occurs near the middle of the specimen.

Results

Dry Yule marble.—Figure 1 shows the stress-strain curves for Yule marble dry, at 300°C, 5000 atmospheres confining pressure, for cylinders of *1*, *T*, and *d* orientation, in extension and in compression. These orientations are the same as in Parts I–IV: the axis of a *1* cylinder is normal to the foliation in the undeformed marble; that of *T* is in the foliation plane; that of *d* is at 45° to the foliation. Each curve is an average of two or more experiments. Two *1* cylinder tests and two *d* cylinder tests were discarded since the specimens in question were from 15 to 25 per cent weaker than others of the same orientation. The remaining 15 tests have an average of 2.2 per cent departure from the mean for the orientation in question as measured at 3 per cent deformation. The reproducibility is thus about the same as that of the experiments at room temperature, and much better than that at 150°C, 10,000 atmospheres confining pressure.

The stress, at 3 per cent strain, of the 300°C curves averaged 55 per cent that at room temperature. At 150°C, the stresses at 3 per cent averaged 66 per cent that at room temperature. These figures were all computed for tests at 5000 atmospheres. The effect of increasing the pressure to 10,000 atmospheres has been shown to be small at room temperature and at 150°C (Part IV, p. 1392). No experiments have been done at 300°C and 10,000 atmospheres because of strength limitations of the present apparatus.

The relative strengths for the three different orientations are markedly different from those at room temperature, but only slightly different from those at 150°C.

In Parts I and IV, it was found that differences in the stress-strain curves for the different orientations could be correlated with the stress differences to be expected from the initial fabric on the basis of a simplified treatment following Taylor's hypothesis of homogeneous deformation and assuming that deformation was dominantly twinning and translation on $\{01\bar{1}2\}$.

This method (*see* Part I, p. 860–861) was tested for its ability to correlate the relative strengths at an average shear strain of 0.1. The standard deviation of the calculated