TABLE I. Shock data for Shoal granite.

Exp. no.	Free surface angles (radians) [Eq. (7)][a] θ_1	Free surface angles (radians) (obs.) θ_2	Wedge angle (degrees) (meas.) α_1	Plastic wave velocities[a] (mm/μsec) (obs.) U_{s2}	Plastic wave velocities[a] (mm/μsec) [Eq. (15)] U_{p2}	Stress[a] (kbars) [Eq. (3)] P_2	Strain[a] [Eq. (4)] ϵ_2
35	0.0199	0.1304	15.00	5.182	1.481	205.6	0.281
38	0.0199	0.1644	15.00	5.791	2.047	313.2	0.352
40	0.0199	0.1672	15.00	5.425	1.965	283.3	0.359
42	0.0199	0.0964	15.00	3.932	0.898	103.8	0.210
43	0.0199	0.1155	15.00	4.481	1.171	145.6	0.250
44	0.0194	0.1200	14.50	4.663	1.291	164.9	0.268
46	0.0219	0.1497	17.00	5.822	1.672	257.0	0.286
47	0.0199	0.1054	15.00	3.993	0.985	113.9	0.230
49	0.0199	0.1819	15.00	6.126	2.380	384.1	0.389
50	0.0209	0.1065	16.00	6.035	1.296	205.1	0.215
51	0.0194	0.1225	14.50	5.334	1.471	209.5	0.272
52	0.0199	0.1006	15.00	3.566	0.870	94.7	0.221
53	0.0165	0.1112	12.00	4.968	1.500	200.9	0.295
56	0.0165	0.0887	12.00	4.572	1.128	142.8	0.236
60	0.0183	0.1171	13.50	5.029	1.431	193.9	0.278
61	0.0188	0.0902	14.00	4.054	0.916	107.8	0.209
66	0.0194	0.1112	14.50	4.663	1.195	152.4	0.248

[a] Elastic wave data taken from Ref. 7; shock velocity $(U_{p1})=5.98$ mm/μsec, strain $\epsilon_1=0.040$, material velocity $(U_{p1})=0.239$ mm/μsec, yield pt. $(P_1)=38$ kbars, and the initial density $(\rho_1)=2.65$ g/cc.

where

$$g(\nu)=[(\lambda/\mu+2)\tan^2 e+\lambda/\mu], \quad (10)$$

λ and μ are the Lamé constants, and ν is Poisson's ratio, so that $\lambda/\mu=2\nu/(1-2\nu)$. The notation in Eqs. (8) and (9) is used to correspond to that of Refs. 10 and 11, and the angles e and f are related to the shock front angles α_1 and α_2 by the equations

$$\alpha_1=\pi/2-e$$

and

$$\alpha_2=\pi/2-f, \quad (11)$$

where

$$\tan^2 f=[2(1-\nu)/(1-2\nu)](\tan^2 e+1)-1. \quad (12)$$

From Fig. 6, one can also relate the free surface angle θ_2 to the material velocity ΔU_{p2} behind the plastic wave. Thus

$$\Delta U_{p2}=U_{s2}\tan(\theta_2-\theta_1)/\sin 2(\alpha_1-\theta_1). \quad (13)$$

IV. RESULTS

By use of Eqs. (7)–(13), the measured values of θ_1, θ_2, α_1, U_{s1}, and U_{s2}, and a value of Poisson's ratio ν for granite,[12] values of U_{p1} and U_{p2} might be calculated since

$$U_{p1}=\epsilon_1 U_{s1}=\Delta U_{p1} \quad (14)$$

and

$$U_{p2}=\Delta U_{p1}+\Delta U_{p2}. \quad (15)$$

A somewhat different procedure was used however because θ_1 was small, of the order of 1 deg, so that U_{s1} was difficult to measure. Instead, values of the yield point data were taken from Ref. 7 and used to calculate θ_1 from Eqs. (7)–(12). Equation (13), with observed values of θ_2 and U_{s2} was then used to calculate U_{p2}. The stress and strain were then calculated from Eqs. (3) and (4). The results are shown in Table I. In Fig. 7, the Hugoniot for this material is shown. Results from the earlier low-pressure study[7] and higher-pressure data for shoal granite from Ref. 2 are also shown.

V. SUMMARY

The solid line in Fig. 5 represents what is considered to be the best estimate for the Hugoniot for shoal granite.[13] The scatter of the data about that line is partially attributable to the relatively large grain sizes of the mineral constituents of this material. The technique used here has one relative advantage over other methods, such as interferometric, which utilize information from very small elements of the free surface of a sample. Here the characteristic dimension of the portion of the sample, which contributes to the observed angles, is large compared to the grain size. One disadvantage of the present method is that the interaction of the reflected and incident wave fronts within the sample is neglected. That neglect is analogous to simplifying assumptions made in experimental configurations utilizing normal wave interactions as already pointed out.[14] The accuracy of the present method is determined to a large extent by the errors in measuring shock velocities and free surface angles. These are estimated as 2% and 0.15 degrees, respectively, and from Eqs. (5),