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**COLLECTION OF ULTRASONIC VELOCITY DATA
AS A FUNCTION OF PRESSURE FOR
POLYCRYSTALLINE SOLIDS**

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April 10, 1974

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Contents

Introduction	1
Purpose	1
Theoretical Background	1
Experimental Technique	4
Data Format	9
References	11
Index	12

COLLECTION OF ULTRASONIC VELOCITY DATA AS A FUNCTION OF PRESSURE FOR POLYCRYSTALLINE SOLIDS

Introduction

PURPOSE

Over the past five years the Lawrence Livermore Laboratory has accumulated ultrasonic velocity data on select materials as a function of hydrostatic confining pressure. In most cases these materials are rocks associated either with the testing of nuclear devices underground, with various Plowshare projects of an economic feasibility nature, or with the detection of underground nuclear explosions. The data were obtained primarily to supplement information on quasi-static mechanical properties (pressure-volume, strength) which is used as input in computer modeling studies. As such, the velocity data serve (1) to provide information on the initial response of the material to an applied shear stress and (2) to supplement bulk moduli determined in the laboratory and velocities determined in the field. A majority of these data have been interpreted and published in LLL reports and reference is given where applicable. It is quite possible that through more general dissemination other uses of these data, such as in the reduction of shock wave and seismic data or in stress wave analysis, can be made. We expect to issue periodic supplements as more data become available. Notifica-

tion of desire to be added to the mailing list should be made to the Technical Information Department, Lawrence Livermore Laboratory, P.O. Box 808, Livermore, California 94550.

THEORETICAL BACKGROUND

The fundamental assumption of elasticity theory is that linear stress is proportional to linear strain,

$$\sigma_{ij} = C_{ijkl} \epsilon_{kl}$$

where σ is stress, ϵ is strain, C is the elastic constant, and $i, j, k,$ and l are indices on a Cartesian coordinate system. Considering the processes as reversible and reducing redundancies, the number of independent elastic constants is found to be 21.¹ Further restriction to material with orthorhombic or higher symmetry reduces the elastic constants to a symmetrical matrix with a maximum of nine independent components. In such a medium, the principal stresses are

$$\sigma_1 = C_{11}\epsilon_1 + C_{12}\epsilon_2 + C_{13}\epsilon_3 \quad (1)$$

$$\sigma_2 = C_{12}\epsilon_1 + C_{22}\epsilon_2 + C_{23}\epsilon_3 \quad (2)$$

$$\sigma_3 = C_{13}\epsilon_1 + C_{23}\epsilon_2 + C_{33}\epsilon_3 \quad (3)$$

$$\sigma_4 = C_{44}\epsilon_4 \quad (4)$$

$$\sigma_5 = C_{55}\epsilon_5 \quad (5)$$

$$\sigma_6 = C_{66}\epsilon_6 \quad (6)$$

using the simplified suffix notation $12 \rightarrow 6$, $13 \rightarrow 5$, $23 \rightarrow 4$, etc. If the material is isotropic, the matrix further reduces such that

$$C_{11} = C_{22} = C_{33}$$

$$C_{44} = C_{55} = C_{66} = 1/2(C_{11} - C_{12})$$

$$C_{12} = C_{13} = C_{23}$$

The propagation of a longitudinal wave is described by the following solution of the wave equation²:

$$V_P = (C_{11}/\rho)^{1/2}, \quad (7)$$

where V_P is the velocity of the compressional wave and ρ is density. In the case of transverse stresses, the velocity of the shear wave is

$$V_S = (C_{44}/\rho)^{1/2}. \quad (8)$$

The rigidity modulus μ is (σ_4/ϵ_4) with other stresses zero, and is therefore C_{44} . If $\sigma_2 = \sigma_3 = 0$, σ_1/ϵ_1 , from Eqs. (1)-(3), is

$$E = \frac{C_{44}(3C_{12} + 2C_{44})}{C_{12} + C_{44}}, \quad (9)$$

the definition of Young's modulus.

Poisson's ratio ν is ϵ_3/ϵ_1 for the same conditions, and

$$\nu = E/(2\mu) - 1. \quad (10)$$

The bulk modulus (reciprocal of the volume compressibility) $K = -P/\Delta$, with $P = \sigma_1 = \sigma_2 = \sigma_3$ and $\Delta = \epsilon_1 + \epsilon_2 + \epsilon_3$, where P = pressure. Therefore,

$$K = 1/3 C_{11} + 2/3 C_{12}. \quad (11)$$

Equations (11), (8), and (7) combine to give the familiar expression

$$V_P = \left\{ [K + 4/3 (\mu)]/\rho \right\}^{1/2}. \quad (12)$$

Bedded sedimentary rocks are generally quite symmetrical about the plane of bedding. In addition, their properties within the bedding plane are essentially isotropic, resulting in a principal axis of symmetry normal to the bedding plane. The elastic constant matrix, Eqs. (1)-(6), for transversely isotropic media is thus reduced by

$$C_{11} = C_{22}$$

$$C_{44} = C_{55}$$

$$C_{13} = C_{23}$$

$$C_{66} = 1/2 (C_{11} - C_{12}),$$

where the principal symmetry axis is labeled 3. C_{11} , C_{33} , C_{44} , and C_{66} may be determined from V_{P11} , V_{P33} , V_{S13} , and V_{S12} respectively, through

$$C = V^2 \rho.$$

A determination of V_P at 45° to the principal axis yields the fifth independent constant,

$$C_{13} = \left\{ \left[2\rho V_{45^\circ}^2 - 1/2(C_{11} + C_{33} + 2C_{44}) \right]^2 - \left[1/2(C_{11} - C_{33}) \right]^2 \right\}^{1/2} - C_{44}.$$

One is now in a position to determine the anisotropic variation in elastic moduli for such a media. In this case,

$$E_1 = \frac{M}{C_{11}C_{33} - C_{13}^2}$$

and

$$E_3 = \frac{M}{C_{11}^2 - C_{12}^2},$$

where M is the elastic constant matrix for normal components. For Poisson's ratio,

$$\nu_{12} = \frac{C_{12}C_{33} - C_{13}^2}{C_{11}C_{33} - C_{13}^2}$$

$$\nu_{13} = \frac{C_{13}(C_{11} - C_{12})}{C_{11}C_{33} - C_{13}^2}$$

$$\nu_{31} = \frac{C_{13}}{C_{11} + C_{12}}$$

and for compressibility,

$$\beta_1 = (C_{33} - C_{13})/D$$

$$\beta_3 = (C_{11} + C_{12} - 2C_{13})/D$$

$$\beta_{\text{vol}} = (C_{11} + C_{12} + 2C_{33} - 4C_{13})/D,$$

where

$$D = (C_{11} + C_{12})C_{33} - 2C_{13}^2.$$

Equivalent expressions are given by Nye.¹

Thus, determinations of V_P and V_S are sufficient to completely characterize the response of an elastic solid to elastic deformations. Since the wave travels through the material at some finite frequency, elastic moduli determined in

this manner are often referred to as dynamic moduli, as opposed to moduli directly determined by static methods. Birch³ has raised the question of whether the moduli that determine the wave velocities are compatible with statically determined moduli. Ide⁴ has shown from resonance work on cylinders that values for E and ν determined dynamically may differ markedly from those determined statically in noncompacted rocks. To complicate matters, many rocks show nonlinear stress-strain curves at low stress levels.⁵ In a study of this problem, Simmons and Brace⁶ compared bulk moduli determined by static methods with those calculated from velocity data. Their results show that moduli determined by acoustic methods are within a few percent of those measured directly at pressures above 0.2 to 0.3 GPa. Below this pressure the variance is generally at least 10%, the dynamic moduli being higher. Simmons and Brace ascribe this difference to the presence of cracks which affect the static moduli, but do not affect the propagation of an acoustic wave. These are cracks which close with the application of several hundred megapascals (a few kilobars) of pressure.

Birch³ gives an excellent review of measurements of compressional velocity and the frequencies at which they were measured. There appears to be no frequency dependence between 100 Hz and 10 MHz for fairly uniform dense rocks. In the case of extreme anisotropy and/or large defect concentration, nothing is known of the frequency dependence of the moduli. For shear waves, Peselnick and Outerbridge⁷ found no significant dependence of velocity over the range

4 to 10^7 Hz in Solenhofen limestone, a very fine-grained, compact rock.

EXPERIMENTAL TECHNIQUE

Numerous papers have dealt with the various techniques used to measure the compressional and shear velocity for rocks in the laboratory as a function of pressure. These are summarized and combined with existing data in the work of Birch^{3,8} and Simmons.^{9,10} The method most applicable to rocks is that of simply pulsing one end of a specimen and measuring the time taken for the pulse to reach the opposite end (pulse transmission). The short distances of travel involved in such measurements cause the results to be far less accurate than those for other methods of measurement. However, for most rocks, the increase in accuracy obtained by using multi-path or phase-comparison methods is generally more than offset by the loss of signal strength and its effect on the accuracy of the determination of a first arrival. In addition, the presence of inhomogeneities such as fractures and pores makes extremely accurate measurements unwarranted. These are generally reserved for measurements on either single crystal or compact mineral assemblages (i. e., where the effects of inhomogeneities are not pronounced).

In our laboratory, measurements are made at room temperature on cylindrical specimens approximately 19 mm in diameter and varying in length from 25 to 50 mm. In general, the cylindrical-specimen length must be less than six times the diameter for compressional velocity (V_P) determinations, or inter-

actions with the walls cause the simple plane wave to become dispersive⁸ and the first wave to arrive with a velocity $[E/\rho]^{1/2}$. At the other extreme, the distance traveled by the wave should be at least 50 times the mean grain diameter to obtain a velocity representative of the average or whole rock. For fine-grained rocks (limestones, basalts, shales, and similar aphanitic rocks) this presents no problem. However, many rocks, such as granites and tuffs, commonly have mean grain size of the order of 2 mm and over. This would necessitate specimens so large that the dimensions of any reasonable pressure-vessel would be exceeded. In this instance, ambient measurements are made, where possible, on large samples for comparison with any one smaller specimen that is used for measurements in the pressure vessel.

Plane waves are generated and received by piezoelectric transducer disks with a fundamental vibration frequency of 1 to 5 MHz. For compressional waves, a transducer of thickness-expanding, polycrystalline $Pb(Zr,Ti)O_3$ was found to produce very strong pulses at low power inputs. For shear waves, two types of transducers are used. Shear-expanding $Pb(Zr,Ti)O_3$ again produces very strong shear waves, but they are not mode-pure and at high-pressure the excellent coupling with the rock specimen sometimes produces a compressional wave that is strong enough to make an accurate determination of the first shear arrival difficult, if not impossible. In most cases, the amplitudes of the arriving compressional and shear waves are different enough to allow an unambiguous determination of the shear wave arrival. Where difficulty is

encountered, and if attenuation is small enough, ac-cut quartz is used. Since ac-cut quartz has a vibration that is mode-pure, the problem of compressional wave interference is avoided, but at the cost of a loss of received signal strength and attendant rise-time. The shear-expanding $\text{Pb}(\text{Zr}, \text{Ti})\text{O}_3$ is preferred in anticipation of loosely consolidated rocks. The frequency range for both types of transducers is chosen so that the pulse wavelength is longer than the average grain dimension, and hence wave propagation will not be biased by the grains themselves. Nor will dispersion due to scattering become a problem, as is the case if the wavelength is approximately equal to the average grain dimension. Except for extremely coarse-grained rocks (greater than 5 mm), this does not present a problem with shear waves.

The ends of the specimens are coated with a conductive silver paint that serves as an electrical ground for one side of the transducer. A thin copper strip is then attached along the length of the cylinder so that electrical continuity is maintained between the ends of the specimen. A very thin coat of a poly-

styrene resin is used to couple the transducers to the specimen. Electrodes are then applied and the whole assembly is potted in a polyurethane resin (see Fig. 1). This material has a tensile strength of 1.6 MPa, and its use in transmitting pressure while rendering the sample impervious to the pressure fluid is considered superior to previously used methods with thin copper jackets.^{3,9,10}

The sample assembly is placed in a piston-cylinder die, with four leads brought out through a plug in one end. Two of these are leads to transducers, with the plug serving as ground. The remaining two leads are to a manganin-wire resistance coil, calibrated against a 0.7 GPa Bourdon-tube gauge and the bismuth II-III transition. The pressure fluid used is a mixture of 0.75 ISOPAR-H, 0.25 UNIVIS-P (Humble Oil and Refining Company).*

The electronic equipment is shown schematically in Fig. 2. A negative

*Reference to company or product name does not imply approval or recommendation of the product by the University of California or the U.S. Atomic Energy Commission to the exclusion of others that may be suitable.

Fig. 1. Schematic representation of the specimen, transducers, and surrounding resin.

Fig. 2. Diagram of the pulse-transmission measuring system.

pulse (Pulse 1) is used to simultaneously trigger a pulsed oscillator, the sweep of a dual-beam oscilloscope, and a second pulse generator (Pulse 2). The signal from the pulsed oscillator is adjusted as to frequency, amplitude, and pulse length and is then sent to the transducer at one end of the specimen and to one input of a fast-rise preamplifier. The received signal at the other end of the sample is amplified and filtered before being sent to the other input of the preamplifier. The observed signals are then horizontally amplified and swept across the oscilloscope screen. The received signal is aligned with the negative output from the second pulse generator by adjusting its internal delay circuit (see Fig. 3). The pulsers have their positive outputs connected to the start and stop inputs of a time-interval counter, where the delay-time in the sample and attendant leads is then read out.

The electronic delay can be accounted for by measuring the delay-time through four standard samples (different lengths of 1100 aluminum) and extrapolating back to "zero" length. A separate check is made by measuring the travel time in a piece of dense Al_2O_3 , independently measured by acoustic interferometry.¹¹ The remaining time is the correction factor and is subtracted from all readings. The sweep delay of the oscilloscope is used with the expanded horizontal scale, but only as a display feature since the pulse-generator signals are set to coincide with the initial pulse and the received signal from the transducer at a "null" point on the screen. Since both pulse generators have the same risetime, the time-interval counter (TIC) has the same response to each and the precision of the measurements is theoretically related only to the accuracy of the TIC. In principle, this is the same type of

Fig. 3. Oscilloscope traces showing (1) the input pulse to the transducer, (2) the first arrival (compressional), (3) energy reflected back to the driving transducer, and (4) energy that has passed through three lengths of the specimen. View (b) is a close-up of the travel-time interval (Δt) in view (a). View (c) is a greatly enlarged close-up showing the first arrival aligned with the timing pulse.

measuring technique employed by Mattaboni and Schreiber,¹² who used a variable frequency oscillator with a frequency counter to obtain the time between pulses. Our system uses a 1-MHz crystal oscillator as a time base for the TIC, which in turn electronically integrates the time between cycles.

The accuracy of the basic travel-time measurements just described is affected by several factors. The accuracy of the TIC is stated as ± 10 ns, which should yield a precision of better than 0.2% in velocity at 0.1 MPa. The stability of the 1-MHz crystal is such that even its maximum drift, taken over a 1-yr period, is many orders of magnitude removed from the accuracy of the TIC. Initial specimen length can be easily measured to within 0.02%. It is other effects that ultimately bear on the accuracy of the measurement. A plane wave that is transmitted through a solid is attenuated and undergoes phase shifts, so that the onset of first motion recorded by the receiving crystal is often extremely gradual and, even under full amplification, is sometimes difficult to determine from the background noise [see Fig. 3(c)], even after optimizing the signal. If the wave is a shear wave and arrival is preceded by compressional energy, then the determination of first arrival is even more difficult. This task is made somewhat easier, in the case of shear wave travel-times, by the previous determination of the direction first motion as a function of transducer alignment. In addition, both the frequency at which the transducers are driven and the pulse-width can be varied to obtain a shear wave arrival that does not coincide with

a node of the preceding compressional wave-train. Interpolation can then be used to determine first shear motion. This, combined with the accuracy of the back extrapolation for outside effects on delay time, probably results in a measurement that is accurate to 1% at best, and this only in rocks with little attenuation. It is felt, however, that such factors as operator experience, careful attention to sample assembly techniques, and willingness to painstakingly optimize the electronic system tend to keep the accuracy near this level.

We have been discussing the measurement of velocity at atmospheric pressure. With increasing stress, several additional effects may influence accuracy. The effect of pressure on transducers is unknown. External stress will probably affect the frequency of vibration only slightly. The so-called "end-effect," the delay time owing to the transducer-rock bond, and phase shifts within the transducers should be investigated as a function of pressure. At present the ambient correction is applied to all readings under the assumption that the pressure effect is negligible.

A correction must be made for the change in specimen length due to compression so that observed travel-time data may be converted to velocities. As Birch has pointed out, neglecting this in the case of most rocks causes an error of only 1 or 2%. However, since some rather compressible rocks are studied, all data are corrected for this effect. One method used is the analytical procedure of Cook.¹³ The adiabatic, bulk modulus may be written as

$$K_S = \rho_0 (dP/d\rho)_S, \quad (13)$$

which gives the density change for a pressure increment dP

$$\rho/\rho_0 = 1 + dP/K_S. \quad (14)$$

If P is hydrostatic, the new specimen length

$$\ell = \ell_0/s,$$

where $s^3 \rho_0 = \rho$. Since the compression of the sample proceeds slowly, it may be considered isothermal, and a correction to Eq. (14),

$$K_S/K_T = 1 + (9\alpha^2 T K_S/\rho_0 C_p) = 1 + \Delta, \quad (15)$$

is needed. The linear coefficient of thermal expansion is α , T is the temperature, and C_p is the thermal heat capacity at constant pressure. Delta (Δ) is a function of pressure, but its dependence is small and is ignored. Substitution of Eq. (15) into Eq. (14), use of Eq. (8) and Eq. (12), and integrating over the pressure change give

$$s = 1 + \frac{1 + \Delta}{12 \rho_0} \int_{\rho_0}^{\rho=f(P)} \frac{dP}{V_p^2 - \frac{4}{3} V_s^2}. \quad (16)$$

For most rocks, $K_S/K_T \approx 1.01$, and an arbitrary $\Delta = 0.01$ is used. It should be mentioned that the integration is valid only for continuous changes in volume, thus rendering this method invalid when a phase change of unknown ΔV has taken place. Since the acoustically derived bulk

modulus has been shown in many rocks to be much different than the quasi-static value, especially at low pressures, we have also corrected the data using, when

available, measured linear strains as a function of pressure. Data computed using these corrections are noted by an asterisk (*) after the material name.

Data Format

Each data set is presented as follows:

- p. 1. An identification page giving source and ambient physical property data.

In cases where values are given for total porosity, the value is determined as $(\rho_g - \rho_0)/\rho_g$, where ρ_0 is the bulk density of the rock determined by measuring and weighing the sample and ρ_g is the grain density determined by first grinding the sample to pass a 44- μ m sieve and then using a helium densitometer. When data are given on the degree of saturation, the water loss, as determined by drying a sample in an oven at 100°C for several days and then reweighing, is used to calculate percent saturation based on an independent determination of total porosity. In some cases complete saturation is defined as the state of a rock after being placed in a partial vacuum and backfilled with water. In cases where rocks contain water in-situ they are wrapped in foil and coated with wax to prevent drying during shipment to the laboratory.

- p. 2. A table showing total porosity and initial length of the sample and listing the following calculated velocities and computed elastic moduli as a function of pressure:

pressure (MPa)
 density (Mg/m^3),
 compressional velocity (km/s)
 measured normally on a
 different piece than shear
 velocity,
 shear velocity (km/s)
 measured normally on a
 different piece than com-
 pressional velocity,
 bulk modulus (GPa),
 shear modulus (GPa),
 Poisson's ratio,
 Young's modulus (GPa),
 Lamé constant, C_{12} (GPa).
 p. 3. A table showing various com-
 puted parameters as follows:
 compressibility (GPa^{-1}),
 mean integrated velocity

$$\left[\frac{2}{3} V_s^3 + \frac{1}{V_p^3} \right]^{-1/3} \text{ (km/s),}$$
 logarithm of compressional
 velocity, $\ln V_p$,
 logarithm of shear velocity,
 $\ln V_s$,
 bulk velocity $\left[V_p^2 - \frac{4}{3} V_s^2 \right]^{1/2}$,
 (km/s),
 logarithm of ratio of density -
 original density,
 seismic parameter, $\Phi = V_p^2$
 $-(4/3) V_s^2$ (km^2/s^2),
 specific volume (dm^3/kg),
 volume change to maximum
 pressure ($\Delta V/V_0$).

- p. 4. Plot of compressional velocity
versus pressure
- p. 5. Plot of shear velocity versus
pressure

In instances where a material has been treated as transversely isotropic, p. 1 is followed by:

- p. 2. The stress strain coefficients
as a function of pressure,

C_{11} (GPa),
 C_{66} (GPa),
 C_{33} (GPa),
 C_{44} (GPa),
 C_{13} (GPa),
 C_{12} (GPa).

- p. 3. The density (ρ) and
Young's Moduli

E_{11} (GPa),
 E_{33} (GPa) as a function of
pressure.

Poisson's ratios

ν_{12} ,
 ν_{13} ,
 ν_{31} as a function of
pressure.

- p. 4. Compressibilities

β_{11} (GPa⁻¹),
 β_{33} (GPa⁻¹),
 β_{vol} (GPa⁻¹) as a function
of pressure.

- p. 5. Wave velocities

It should be noted in the case of materials treated as transversely isotropic that we are using data reduction methods normally applied to single crystal data, and since rocks do not possess perfect symmetry, some unreal values of the computed moduli may result. This effect may be compounded at low pressures where acoustic signals are often highly attenuated and accuracies in travel-time measurements are much lower than at high pressures.

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Index

<u>Index No.</u>	<u>Name</u>
69-1	Westerly granite
69-1*	Westerly granite
69-2	Solenhofen limestone
69-3	Dome Mt. andesite
69-4	Stirling quartzite, Type A.
69-5	Stirling quartzite, Type B
69-6	Stirling quartzite, Type C
69-7	Stirling quartzite, Type D
69-8	Ortho-enstatite
69-9	Polycrystalline forsterite
69-10	Grout
69-11	Climax stock granodiorite
69-12	Green River shale
70-1	Indian Trail tuff, sub-unit 3
70-2	Indian Trail tuff, sub-unit 4a(I)
70-3	Indian Trail tuff, sub-unit 4a(II)
70-4	Indian Trail tuff, sub-unit 4a(III)
70-5	Lance sandstone (I)
70-6	Lance sandstone (II)
70-7	Lance sandstone (III)
70-8	Fort Union siltstone
70-9	Timber Mt. tuff
70-10	Dry St. Peter sandstone
70-11	50% saturated St. Peter sandstone
71-1	Indian Trail tuff, sub-unit 4c (I)
71-1*	Indian Trail tuff, sub-unit 4c (I)
71-2	Indian Trail tuff, sub-unit 4c (II)
71-3	Indian Trail tuff, sub-unit 4c (III)
71-4	Indian Trail tuff, sub-unit 4c (IV)
71-5	Climax stock granodiorite
71-5*	Climax stock granodiorite
71-6	Polymethylmethacrylate
71-7	Yule marble
72-1	Dry Mesa Verde sandstone
72-1*	Dry Mesa Verde sandstone
72-2	50% saturated Mesa Verde sandstone
72-3	Hoggar granite
72-4	Blair dolomite
72-4*	Blair dolomite

Index No.Name

73-1	Nugget sandstone
73-1*	Nugget sandstone
73-2	Kayenta sandstone
73-2*	Kayenta sandstone

* Denotes velocities obtained using measured linear strain data.

Distribution

LLL Internal Distribution

Roger E. Batzel	L-1
A. Abey	L-437
G. Dorough/J. Frazer	L-401
B. Bonner	L-437
I. Borg	L-10
J. Bryan	L-51
T. Butkovich	L-43
J. Carothers	L-7
R. Chin	L-51
B. Crowley	L-42
A. Duba	L-437
D. Emerson	L-47
L. Germain	L-18
J. Hannon	L-41
B. Hudson	L-40
H. Heard	L-437
J. Hearst	L-41
R. Heckman	L-437
G. Higgins	L-41
A. Holzer	L-41
W. Isbell	L-504
J. Kahn	L-41
E. Joslyn	L-437
A. Kusubov	L-41
D. Larson	L-41
A. Lewis	L-43
E. Lilley	L-437
A. Maimoni	L-503
R. McArthur	L-777
W. McMaster	L-40
M. Nordyke	L-13
W. Nervik	L-231
D. Norris	L-90
A. Piwinski	L-437
L. Ramspott	L-44
A. Ratcliffe	L-40
H. Reynolds	L-21
H. Rodean	L-41
A. Rothman	L-41
J. Schatz	L-44
R. Schock	L-437
D. Springer	L-41
D. Stephens	L-437
R. Taylor	L-503
R. Terhune	L-47
J. Toman	L-47
M. Van Thiel	L-504
J. Vieceilli	L-71
H. Washington	L-437
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TID-4500 Distribution, UC-34
Physics-General

(114)

HLL/lh

Name

Westerly granite, 69-1

Source

Bonner Monument Company, Westerly, Rhode Island.

Physical Properties

Density - 2.63 Mg/m^3

Total porosity - unavailable

Saturation - air dry

1WESTERLY GRANITE,69-1

POROSITY=NO DATA

LENGTH=26.91 MM

DELTA=0.010

PRESSURE(MPA)	RHO(MG/CM)	VP(KM/S)	VS(KM/S)	K(GPA)	MU(GPA)	POISSONS R	YOUNGS MOD (GPA)	LAME CONST
0.	2.630	4.92	2.94	33.42	22.69	0.223	55.51	18.30
10.	2.631	5.26	3.11	38.98	25.37	0.233	62.54	22.06
20.	2.631	5.44	3.19	42.30	26.77	0.239	66.32	24.45
40.	2.633	5.61	3.25	45.81	27.79	0.248	69.34	27.28
60.	2.634	5.70	3.28	47.64	28.39	0.251	71.05	28.72
80.	2.635	5.76	3.31	48.77	28.90	0.253	72.40	29.50
100.	2.636	5.80	3.34	49.54	29.35	0.253	73.54	29.97
150.	2.639	5.90	3.39	51.36	30.25	0.254	75.86	31.19
200.	2.641	5.95	3.43	52.32	30.99	0.253	77.64	31.66
300.	2.646	6.04	3.47	54.06	31.90	0.253	79.96	32.80
400.	2.651	6.09	3.50	55.12	32.43	0.254	81.35	33.50
500.	2.656	6.12	3.51	55.88	32.72	0.255	82.13	34.07
600.	2.661	6.14	3.52	56.44	32.93	0.256	82.70	34.49
700.	2.665	6.15	3.52	56.73	33.03	0.256	82.99	34.71
800.	2.670	6.15	3.52	56.77	33.11	0.256	83.17	34.70
900.	2.675	6.14	3.52	56.80	33.14	0.256	83.24	34.70
1000.	2.680	6.14	3.52	56.83	33.16	0.256	83.29	34.72

1WESTERLY GRANITE.69-1

POROSITY=NO DATA

LENGTH=25.91 MM

DELTA=0.010

PRESSURE(MPA)	COMPRESS(GPA-1)	MEAN VEL	LNVP	LNVS	BULK VEL	LN RHO/RHOZERO	PHI(KM/S)SQ	V(DM3/KG)
0.	0.0299	3.25	1.593	1.077	3.57	0.	12.71	0.3802
10.	0.0257	3.44	1.660	1.133	3.85	0.0003	14.82	0.3801
20.	0.0236	3.54	1.695	1.160	4.01	0.0005	16.07	0.3800
40.	0.0218	3.61	1.725	1.178	4.17	0.0010	17.40	0.3799
60.	0.0210	3.65	1.740	1.189	4.25	0.0014	18.09	0.3797
80.	0.0205	3.68	1.750	1.198	4.30	0.0018	18.51	0.3795
100.	0.0202	3.71	1.758	1.205	4.34	0.0022	18.80	0.3794
150.	0.0195	3.76	1.774	1.220	4.41	0.0032	19.46	0.3790
200.	0.0191	3.80	1.784	1.231	4.45	0.0042	19.81	0.3786
300.	0.0185	3.86	1.799	1.245	4.52	0.0061	20.43	0.3779
400.	0.0181	3.89	1.807	1.252	4.56	0.0080	20.79	0.3772
500.	0.0179	3.90	1.812	1.256	4.59	0.0098	21.04	0.3765
600.	0.0177	3.91	1.815	1.258	4.61	0.0116	21.21	0.3758
700.	0.0176	3.91	1.816	1.259	4.61	0.0134	21.28	0.3752
800.	0.0176	3.91	1.816	1.259	4.61	0.0152	21.26	0.3745
900.	0.0176	3.91	1.816	1.258	4.61	0.0169	21.23	0.3738
1000.	0.0176	3.91	1.815	1.258	4.61	0.0187	21.21	0.3732

WESTERLY GRANITE, 69-1

1WESTERLY GRANITE,69-1

POROSITY=NO DATA

LENGTH=26.91 MM

DELTA=0.010

PRESSURE (MPA)	RHO (MG/CM)	VP (KM/S)	VS (KM/S)	K (GPA)	MU (GPA)	POISSONS R	YOUNGS MOD (GPA)	LAME CONST
0.	2.630	4.92	2.94	33.42	22.69	0.223	55.51	18.30
10.	2.631	5.26	3.11	38.98	25.37	0.233	62.54	22.06

WESTERLY GRANITE,69-1

PRESSURE MPa

COMPR VELOCITY KM/S

69-1-4

WESTERLY GRANITE, 69-1

Name

Westerly granite, 69-1*

Source

Bonner Monument Company, Westerly, Rhode Island.

Physical Properties

Density - 2.63 Mg/m^3

Total porosity - unavailable

Saturation - air dry

*Length changes calculated using measured linear strain data.

1WESTERLY GRANITE.69-1 *

POROSITY=NO DATA

LENGTH=26.91 MM

DELTA=0.010

PRESSURE(MPA)	RHO(MG/CM)	VP(KM/S)	VS(KM/S)	K(GPA)	MU(GPA)	POISSONS R	YOUNGS MOD (GPA)	LAME CONST
0.	2.630	4.92	2.94	33.42	22.69	0.223	55.51	18.30
10.	2.631	5.26	3.11	38.98	25.37	0.233	62.54	22.07
20.	2.632	5.44	3.19	42.30	26.77	0.239	66.33	24.45
40.	2.633	5.61	3.25	45.81	27.79	0.248	69.35	27.29
60.	2.635	5.70	3.28	47.65	28.39	0.251	71.06	28.72
80.	2.636	5.76	3.31	48.78	28.91	0.253	72.42	29.51
100.	2.637	5.80	3.34	49.55	29.36	0.253	73.55	29.98
150.	2.640	5.89	3.39	51.37	30.26	0.254	75.87	31.20
200.	2.643	5.95	3.42	52.34	31.00	0.253	77.66	31.67
300.	2.649	6.04	3.47	54.08	31.91	0.253	79.99	32.81
400.	2.654	6.09	3.50	55.14	32.45	0.254	81.38	33.51
500.	2.659	6.12	3.51	55.91	32.73	0.255	82.16	34.08
600.	2.664	6.14	3.52	56.46	32.94	0.256	82.73	34.50
700.	2.668	6.15	3.52	56.75	33.05	0.256	83.03	34.72
800.	2.673	6.15	3.52	56.80	33.13	0.256	83.21	34.71
900.	2.678	6.14	3.52	56.82	33.16	0.256	83.27	34.72
1000.	2.683	6.14	3.52	56.86	33.18	0.256	83.32	34.74

69-1*-2

1WESTERLY GRANITE.69-1 *

POROSITY=NO DATA

LENGTH=26.91 MM

DELTA=0.010

PRESSURE(MPA)	COMPRESS(GPA-1)	MEAN VEL	LNVP	LNVS	BULK VEL	LN RHO/RHOZERO	PHI(KM/S)SQ	V(DM3/KG),
0.	0.0299	3.25	1.593	1.077	3.57	0.	12.71	0.3802
10.	0.0257	3.44	1.660	1.133	3.85	0.0004	14.81	0.3801
20.	0.0236	3.54	1.694	1.160	4.01	0.0007	16.07	0.3800
40.	0.0218	3.61	1.724	1.178	4.17	0.0013	17.40	0.3797
60.	0.0210	3.65	1.740	1.189	4.25	0.0018	18.09	0.3795
80.	0.0205	3.68	1.750	1.197	4.30	0.0023	18.50	0.3794
100.	0.0202	3.71	1.758	1.205	4.33	0.0028	18.79	0.3792
150.	0.0195	3.76	1.774	1.219	4.41	0.0039	19.46	0.3787
200.	0.0191	3.80	1.784	1.231	4.45	0.0051	19.80	0.3783
300.	0.0185	3.86	1.798	1.244	4.52	0.0072	20.42	0.3775
400.	0.0181	3.88	1.807	1.252	4.56	0.0090	20.78	0.3768
500.	0.0179	3.90	1.811	1.255	4.59	0.0109	21.03	0.3761
600.	0.0177	3.91	1.815	1.258	4.60	0.0127	21.20	0.3754
700.	0.0176	3.91	1.816	1.258	4.61	0.0145	21.27	0.3748
800.	0.0176	3.91	1.816	1.259	4.61	0.0162	21.25	0.3741
900.	0.0176	3.91	1.815	1.258	4.61	0.0181	21.22	0.3734
1000.	0.0176	3.91	1.815	1.258	4.60	0.0198	21.19	0.3728

THE VOLUME CHANGE TO MAXIMUM PRESSURE IS 0.020

COMPR VELOCITY KM/S

WESTERLY GRANITE, 69-1 *

69-1*-4

WESTERLY GRANITE, 69-1 *

Name

Solenhofen limestone, 69-2

Source

Solnhofen, Germany¹

Physical Properties

Density - 2.66 Mg/m³

Total porosity - unavailable

Saturation - air dry

Note - The anomalous decrease in wave velocities in the 0.5- to 0.7-GPa region has been investigated by both Peselnick and Wilson² and Wang,³ and appears to be related to phase transformations in calcite, the principal mineral present in limestone.

1. Same block of material as in H. C. Heard, Geol. Soc. Memoir 79, Chapt. 4, pp 30-104 (1960); and H. C. Heard et al., Jour. Geophys. Res. 72, 611-640 (1967).
2. L. Peselnick and R. Wilson, J. Geophys. Res. 73, 3272 (1968).
3. C. Wang, ibid. 73, 3937 (1968).

ISOLENHOFEN LIMESTONE.69-2

POROSITY=NO DATA

LENGTH=25.44 MM

DELTA=0.010

PRESSURE(MPA)	RHO(MG/CM)	VP(KM/S)	VS(KM/S)	K(GPA)	MU(GPA)	POISSONS R	YOUNGS MOD (GPA)	LAME CONST
0.	2.660	5.94	3.14	58.91	26.21	0.306	68.47	41.43
10.	2.660	6.04	3.16	61.54	26.52	0.312	69.57	43.86
20.	2.661	6.06	3.18	62.06	26.84	0.311	70.36	44.17
30.	2.661	6.07	3.19	62.08	27.07	0.310	70.89	44.04
50.	2.662	6.09	3.20	62.29	27.31	0.309	71.48	44.08
100.	2.664	6.13	3.25	62.48	28.12	0.304	73.35	43.73
200.	2.669	6.18	3.28	63.69	28.75	0.304	74.98	44.52
300.	2.673	6.23	3.30	64.89	29.06	0.305	75.86	45.52
400.	2.677	6.26	3.30	66.05	29.19	0.307	76.32	46.59
500.	2.681	6.29	3.30	67.14	29.23	0.310	76.59	47.65
600.	2.685	6.31	3.30	68.00	29.23	0.312	76.69	48.52
700.	2.689	6.32	3.29	68.45	29.17	0.313	76.63	49.00
800.	2.693	6.30	3.28	68.28	29.01	0.314	76.24	48.94
900.	2.697	6.25	3.26	67.23	28.70	0.313	75.37	48.10
1000.	2.701	6.15	3.23	64.72	28.10	0.310	73.65	45.98

69-2-2

1SOLENHOFEN LIMESTONE,69-2

POROSITY=NO DATA

LENGTH=25.44 MM

DELTA=0.010

PRESSURE(MPA)	COMPRESS(GPA-1)	MEAN VEL	LNVP	LNVS	BULK VEL	LN RHO/RHOZERO	PHI(KM/S)SQ	V(DM3/KG).
0.	0.0170	3.51	1.782	1.144	4.71	0.	22.15	0.3759
10.	0.0162	3.53	1.798	1.150	4.81	0.0002	23.13	0.3759
20.	0.0161	3.55	1.802	1.156	4.83	0.0003	23.32	0.3758
30.	0.0161	3.57	1.804	1.160	4.83	0.0005	23.33	0.3758
50.	0.0161	3.58	1.806	1.164	4.84	0.0008	23.40	0.3756
100.	0.0160	3.63	1.812	1.178	4.84	0.0016	23.45	0.3753
200.	0.0157	3.67	1.822	1.189	4.89	0.0032	23.87	0.3747
300.	0.0154	3.69	1.829	1.193	4.93	0.0048	24.28	0.3741
400.	0.0151	3.69	1.835	1.195	4.97	0.0063	24.68	0.3736
500.	0.0149	3.69	1.839	1.195	5.00	0.0079	25.04	0.3730
600.	0.0147	3.69	1.842	1.194	5.03	0.0094	25.33	0.3724
700.	0.0146	3.69	1.843	1.192	5.05	0.0108	25.45	0.3719
800.	0.0146	3.67	1.841	1.189	5.04	0.0123	25.36	0.3713
900.	0.0149	3.65	1.833	1.182	4.99	0.0138	24.93	0.3708
1000.	0.0155	3.61	1.817	1.171	4.90	0.0153	23.96	0.3702

SOLENHOFEN LIMESTONE, 69-2

SOLENHOFEN LIMESTONE-69-2

Name

Dome Mt. andesite, 69-3

Source and Description

Chukar Mesa, Nye County, Nevada. A homogeneous, very fine grained extrusive rock, with a porosity consisting of small vesicles and minute fractures.

Physical Properties

Density — 2.640 Mg/m^3

Total porosity — approximately 12% based on pressure-volume data to 4.0 GPa.¹

Saturation — air dry

Note — Attendant report, R. N. Schock, Proc. Am. Nucl. Soc. Topical Meeting — Engr. Nucl. Expl., Las Vegas, 1970, (Am. Nucl. Soc. 1970) Vol. 1.

1. D. R. Stephens, E. M. Lilley, and H. Louis, J. Rock. Mech. Min. Sci. 7, 257 (1970).

1DOME MOUNTAIN ANDESITE,69-3

POROSITY=NO DATA

LENGTH=27.80 MM

DELTA=0.010

PRESSURE(MPA)	RHO(MG/CM)	VP(KM/S)	VS(KM/S)	K(GPA)	MU(GPA)	POISSONS R	YOUNGS MOD (GPA)	LAME CONST
0.	2.640	5.05	3.03	35.03	24.27	0.219	59.16	18.85
20.	2.642	5.11	3.06	35.82	24.77	0.219	60.40	19.31
40.	2.643	5.15	3.08	36.57	25.07	0.221	61.22	19.86
60.	2.644	5.19	3.10	37.32	25.33	0.223	61.96	20.43
80.	2.646	5.23	3.11	38.16	25.59	0.226	62.74	21.10
100.	2.647	5.27	3.12	39.09	25.83	0.229	63.51	21.86
150.	2.651	5.38	3.16	41.37	26.45	0.236	65.42	23.73
200.	2.654	5.48	3.19	43.64	27.07	0.243	67.30	25.59
300.	2.660	5.57	3.24	45.33	27.86	0.245	69.36	26.76
400.	2.666	5.57	3.25	45.33	28.08	0.243	69.82	26.61
500.	2.672	5.58	3.25	45.64	28.17	0.244	70.08	26.86
600.	2.678	5.58	3.25	45.77	28.24	0.244	70.27	26.95
700.	2.683	5.60	3.26	46.10	28.49	0.244	70.88	27.11
800.	2.689	5.63	3.27	46.81	28.73	0.245	71.55	27.66
900.	2.695	5.66	3.28	47.86	28.94	0.248	72.25	28.57
1000.	2.701	5.71	3.28	49.26	29.12	0.253	72.98	29.84

1DOME MOUNTAIN ANDESITE.69-3

POROSITY=NO DATA

LENGTH=27.80 MM

DELTA=0.010

PRESSURE(MPA)	COMPRESS(GPA-1)	MEAN VEL	LNVP	LNVS	BULK VEL	LN RHO/RHOZERO	PHI(KM/S)SQ	V(DM3/KG)
0.	0.0285	3.35	1.620	1.109	3.64	0.	13.27	0.3788
20.	0.0279	3.39	1.630	1.119	3.68	0.0006	13.56	0.3786
40.	0.0273	3.41	1.638	1.125	3.72	0.0011	13.84	0.3784
60.	0.0268	3.43	1.646	1.130	3.76	0.0017	14.11	0.3782
80.	0.0262	3.44	1.654	1.135	3.80	0.0022	14.42	0.3780
100.	0.0256	3.46	1.662	1.139	3.84	0.0027	14.77	0.3778
150.	0.0242	3.50	1.682	1.150	3.95	0.0040	15.61	0.3773
200.	0.0229	3.54	1.701	1.161	4.06	0.0052	16.44	0.3768
300.	0.0221	3.59	1.717	1.174	4.13	0.0074	17.04	0.3760
400.	0.0221	3.60	1.718	1.177	4.12	0.0097	17.00	0.3751
500.	0.0219	3.60	1.719	1.178	4.13	0.0119	17.08	0.3743
600.	0.0218	3.60	1.720	1.178	4.14	0.0141	17.10	0.3735
700.	0.0217	3.62	1.722	1.181	4.15	0.0163	17.18	0.3727
800.	0.0214	3.63	1.727	1.184	4.17	0.0185	17.41	0.3719
900.	0.0209	3.64	1.734	1.187	4.21	0.0206	17.76	0.3711
1000.	0.0203	3.65	1.742	1.189	4.27	0.0227	18.24	0.3703

69-3-3

DOME MOUNTAIN ANDESITE, 69-3

DOME MOUNTAIN ANDESITE, 69-3

Name

Stirling quartzite, Type A, 69-4

Source and Description

Emigrant Valley, Nevada. Gray, medium grained, silica cemented sedimentary quartzite, with relatively few impurities.

Physical Properties

Density - 2.580 Mg/m^3

Total porosity - Unavailable

Saturation - air dry

Note - Attendant report, R. N. Schock, Proc. Am. Nucl. Soc. Topical Meeting - Engr. Nucl Expl., Las Vegas, 1970 (Am. Nucl. Soc. 1970) Vol. 1. Travel time measured normal to ill-defined bedding.

1STIRLING QUARTZITE,TYPE A,69-4

POROSITY=NO DATA

LENGTH=30.40 MM

DELTA=0.010

PRESSURE(MPA)	RHO(MG/CM)	VP(KM/S)	VS(KM/S)	K(GPA)	MU(GPA)	POISSONS R	YOUNGS MOD (GPA)	LAME CONST
0.	2.580	5.35	3.60	29.28	33.47	0.086	72.71	6.96
20.	2.582	5.38	3.63	29.38	34.10	0.082	73.76	6.64
40.	2.584	5.41	3.65	29.60	34.44	0.081	74.45	6.64
60.	2.585	5.42	3.66	29.60	34.68	0.079	74.82	6.49
80.	2.587	5.43	3.67	29.63	34.89	0.077	75.17	6.37
100.	2.589	5.43	3.68	29.63	35.09	0.075	75.48	6.24
150.	2.593	5.45	3.70	29.75	35.51	0.073	76.21	6.07
200.	2.598	5.47	3.72	29.92	35.86	0.072	76.86	6.01
300.	2.606	5.50	3.74	30.33	36.42	0.071	78.03	6.05
400.	2.615	5.53	3.76	30.74	36.98	0.071	79.19	6.09
500.	2.624	5.56	3.78	31.06	37.54	0.069	80.27	6.03
600.	2.632	5.59	3.80	31.31	38.09	0.067	81.31	5.92
700.	2.641	5.61	3.83	31.49	38.67	0.064	82.31	5.71
800.	2.649	5.63	3.85	31.70	39.23	0.062	83.32	5.54
900.	2.657	5.65	3.87	31.77	39.86	0.058	84.32	5.19
1000.	2.666	5.68	3.90	31.90	40.46	0.054	85.31	4.93

1STIRLING QUARTZITE,TYPE A,69-4

POROSITY=NO DATA

LENGTH=30.40 MM

DELTA=0.010

PRESSURE(MPA)	COMPRESS(GPA-1)	MEAN VEL	LNVP	LNVS	BULK VEL	LN RHO/RHOZERO	PHI(KM/S)SQ	V(DM3/KG),
0.	0.0342	3.93	1.677	1.281	3.37	0.	11.35	0.3876
20.	0.0340	3.97	1.683	1.290	3.37	0.0007	11.38	0.3873
40.	0.0338	3.99	1.688	1.295	3.39	0.0014	11.46	0.3871
60.	0.0338	4.00	1.689	1.298	3.38	0.0021	11.45	0.3868
80.	0.0338	4.01	1.691	1.301	3.38	0.0027	11.45	0.3865
100.	0.0337	4.02	1.693	1.303	3.38	0.0034	11.45	0.3863
150.	0.0336	4.04	1.696	1.308	3.39	0.0051	11.47	0.3856
200.	0.0334	4.05	1.699	1.312	3.39	0.0068	11.52	0.3850
300.	0.0330	4.08	1.705	1.319	3.41	0.0102	11.64	0.3837
400.	0.0325	4.10	1.711	1.325	3.43	0.0135	11.76	0.3824
500.	0.0322	4.12	1.716	1.330	3.44	0.0167	11.84	0.3812
600.	0.0319	4.15	1.720	1.336	3.45	0.0200	11.90	0.3799
700.	0.0318	4.17	1.724	1.342	3.45	0.0232	11.93	0.3787
800.	0.0316	4.19	1.728	1.348	3.46	0.0264	11.97	0.3775
900.	0.0315	4.22	1.732	1.354	3.46	0.0296	11.95	0.3763
1000.	0.0313	4.24	1.736	1.360	3.46	0.0328	11.97	0.3751

STIRLING QUARTZITE, TYPE A-69-4

STIRLING QUARTZITE, TYPE A, 69-4

Name

Stirling quartzite, Type B, 69-5

Source and Description

Emigrant Valley, Nevada. Red, fine-grained, slightly ferruginous quartzite.

Physical Properties

Density - 2.495 Mg/m^3

Total porosity - unavailable

Saturation - air dry

Note - See Type A, 69-4.

1STIRLING QUARTZITE,TYPE B,69-5

POROSITY=NO DATA

LENGTH=28.83 MM

DELTA=0.010

PRESSURE(MPA)	RHO(MG/CM)	VP(KM/S)	VS(KM/S)	K(GPA)	MU(GPA)	POISSONS R	YOUNGS MOD (GPA)	LAME CONST
0.	2.495	4.24	2.89	17.09	20.87	0.066	44.49	3.18
20.	2.498	4.41	2.93	20.10	21.42	0.107	47.41	5.82
40.	2.500	4.44	2.94	20.44	21.57	0.110	47.87	6.06
60.	2.503	4.45	2.94	20.58	21.66	0.110	48.11	6.14
80.	2.505	4.48	2.95	21.19	21.75	0.118	48.62	6.69
100.	2.507	4.48	2.95	21.28	21.84	0.118	48.82	6.72
150.	2.513	4.52	2.96	22.05	22.03	0.125	49.58	7.36
200.	2.519	4.56	2.97	22.81	22.21	0.132	50.30	8.00
300.	2.530	4.64	2.98	24.35	22.52	0.147	51.64	9.34
400.	2.540	4.71	3.00	25.83	22.83	0.159	52.90	10.61
500.	2.550	4.78	3.01	27.29	23.15	0.169	54.14	11.86
600.	2.559	4.84	3.03	28.69	23.48	0.178	55.35	13.03
700.	2.568	4.91	3.05	30.13	23.81	0.187	56.54	14.25
800.	2.576	4.97	3.06	31.53	24.15	0.195	57.71	15.44
900.	2.584	5.04	3.08	32.93	24.48	0.202	58.85	16.62
1000.	2.592	5.10	3.09	34.33	24.81	0.209	59.98	17.79

1STIRLING QUARTZITE,TYPE B.69-5

POROSITY=NO DATA

LENGTH=28.83 MM

DELTA=0.010

PRESSURE(MPA)	COMPRESS(GPA-1)	MEAN VEL	LNVP	LNVS	BULK VEL	LN RHO/RHOZERO	PHI(KM/S)SQ	V(DM3/KG),
0.	0.0585	3.15	1.445	1.062	2.62	0.	6.85	0.4008
20.	0.0498	3.20	1.485	1.074	2.84	0.0011	8.05	0.4004
40.	0.0489	3.21	1.490	1.077	2.86	0.0021	8.17	0.4000
60.	0.0486	3.22	1.492	1.079	2.87	0.0031	8.22	0.3996
80.	0.0472	3.23	1.499	1.081	2.91	0.0040	8.46	0.3992
100.	0.0470	3.23	1.500	1.082	2.91	0.0050	8.49	0.3988
150.	0.0453	3.24	1.509	1.085	2.96	0.0073	8.77	0.3979
200.	0.0438	3.26	1.518	1.088	3.01	0.0096	9.05	0.3970
300.	0.0411	3.28	1.534	1.093	3.10	0.0139	9.63	0.3953
400.	0.0387	3.30	1.549	1.098	3.19	0.0179	10.17	0.3937
500.	0.0366	3.32	1.564	1.103	3.27	0.0217	10.70	0.3922
600.	0.0349	3.34	1.577	1.108	3.35	0.0253	11.21	0.3908
700.	0.0332	3.36	1.591	1.114	3.43	0.0287	11.73	0.3895
800.	0.0317	3.38	1.604	1.119	3.50	0.0320	12.24	0.3882
900.	0.0304	3.40	1.617	1.124	3.57	0.0351	12.74	0.3870
1000.	0.0291	3.42	1.629	1.129	3.64	0.0381	13.24	0.3858

69-5-3

STIRLING QUARTZITE, TYPE B.69-5

STIRLING QUARTZITE, TYPE B, 69-5

Name

Stirling quartzite, Type C, 69-6

Source and Description

Emigrant Valley, Nevada. Red, very fine-grained ferruginous and/or arkosic siltstone.

Physical Properties

Density — 3.630 Mg/m^3

Total porosity — unavailable

Saturation — air dry

Note — See Type A, 69-4.

1STIRLING QUARTZITE, TYPE C, 69-6

POROSITY=NO DATA

LENGTH=27.66 MM

DELTA=0.010

PRESSURE(MPA)	RHO(MG/CM)	VP(KM/S)	VS(KM/S)	K(GPA)	MU(GPA)	POISSONS R	YOUNGS MOD (GPA)	LAME CONST
0.	2.630	3.72	2.49	14.66	16.30	0.094	35.68	3.80
20.	2.633	3.97	2.64	17.07	18.36	0.104	40.55	4.83
40.	2.636	4.13	2.70	19.27	19.24	0.125	43.31	6.44
60.	2.639	4.26	2.75	21.29	19.90	0.144	45.52	8.02
80.	2.641	4.38	2.78	23.55	20.42	0.164	47.51	9.94
100.	2.643	4.50	2.81	25.74	20.86	0.181	49.27	11.83
150.	2.648	4.62	2.87	27.50	21.82	0.186	51.76	12.96
200.	2.653	4.88	2.92	32.97	22.60	0.221	55.19	17.91
300.	2.661	5.07	2.99	36.76	23.81	0.234	58.75	20.88
400.	2.668	5.20	3.04	39.27	24.63	0.241	61.11	22.85
500.	2.674	5.28	3.08	40.83	25.29	0.243	62.88	23.97
600.	2.681	5.34	3.11	41.80	25.91	0.243	64.43	24.53
700.	2.687	5.39	3.15	42.46	26.59	0.241	66.00	24.73
800.	2.694	5.43	3.18	42.98	27.30	0.238	67.58	24.78
900.	2.700	5.46	3.22	43.22	28.00	0.234	69.07	24.56
1000.	2.706	5.50	3.25	43.75	28.62	0.231	70.49	24.67

69-6-2

1STIRLING QUARTZITE,TYPE C,69-6

POROSITY=NO DATA

LENGTH=27.66 MM

DELTA=0.010

PRESSURE(MPA)	COMPRESS(GPA-1)	MEAN VEL	LNVP	LNVS	BULK VEL	LN RHO/RHOZERO	PHI(KM/S)SQ	V(DM3/KG).
0.	0.0682	2.72	1.314	0.912	2.36	0.	5.58	0.3802
20.	0.0586	2.89	1.379	0.971	2.55	0.0013	6.48	0.3797
40.	0.0519	2.96	1.418	0.994	2.70	0.0024	7.31	0.3793
60.	0.0470	3.01	1.449	1.010	2.84	0.0034	8.07	0.3789
80.	0.0425	3.06	1.478	1.022	2.99	0.0043	8.92	0.3786
100.	0.0389	3.10	1.504	1.033	3.12	0.0051	9.74	0.3783
150.	0.0364	3.16	1.531	1.054	3.22	0.0070	10.38	0.3776
200.	0.0303	3.23	1.585	1.071	3.53	0.0087	12.43	0.3769
300.	0.0272	3.32	1.624	1.096	3.72	0.0116	13.82	0.3759
400.	0.0255	3.37	1.648	1.111	3.84	0.0142	14.72	0.3749
500.	0.0245	3.41	1.664	1.123	3.91	0.0167	15.27	0.3739
600.	0.0239	3.45	1.675	1.134	3.95	0.0192	15.59	0.3730
700.	0.0236	3.49	1.684	1.146	3.98	0.0216	15.80	0.3721
800.	0.0233	3.53	1.692	1.158	3.99	0.0240	15.96	0.3712
900.	0.0231	3.57	1.698	1.169	4.00	0.0263	16.01	0.3704
1000.	0.0229	3.60	1.705	1.179	4.02	0.0286	16.17	0.3695

STIRLING QUARTZITE, TYPE C, 69-6

STIRLING QUARTZITE, TYPE C, 69-6

Name

Stirling quartzite, Type D, 69-7

Source and Description

Emigrant Valley, Nevada. Red, very fine-grained, well cemented, ferruginous and/or arkosic siltstone.

Physical Properties

Density - 2.620 Mg/m^3

Total porosity - unavailable

Saturation - air dry

Note - Treated as transversely isotropic, direction normal to bedding plane labeled 3.

1STIRLING QUARTZITE,TYPE D,69-7

PRESSURE(MPA)	C11	C66	C33	C44	C13	C12
0.	40.59	17.52	25.43	13.77	0.	5.55
20.	46.06	18.80	27.43	15.48	0.	8.47
40.	50.46	19.64	33.53	16.44	0.45	11.19
60.	54.04	20.37	40.37	17.12	4.17	13.29
80.	57.17	21.07	44.54	17.69	10.64	15.03
100.	59.77	21.67	47.98	18.13	13.28	16.43
150.	65.21	22.86	53.78	19.06	17.86	19.50
200.	69.01	23.64	57.42	19.86	21.85	21.74
300.	73.74	24.74	62.87	21.23	28.94	24.27
400.	77.16	25.13	66.75	22.41	31.09	26.91
500.	79.66	25.31	69.88	23.46	30.59	29.03
600.	81.83	25.50	72.25	24.04	31.75	30.84
700.	83.23	25.68	74.26	24.32	32.24	31.87
800.	84.48	25.87	75.78	24.50	34.72	32.74
900.	85.44	26.11	77.06	24.60	35.63	33.21
1000.	86.59	26.24	77.92	24.64	37.51	34.10

1STIRLING QUARTZITE,TYPE D.69-7

PRESSURE	RHO	E11	E33	P12	P13	P31
0.	2.62	33.35	21.29	0.14	0.	0.
20.	2.62	44.50	27.43	0.18	0.	0.
40.	2.63	47.98	33.52	0.22	0.01	0.01
60.	2.63	50.53	39.86	0.24	0.08	0.06
80.	2.63	51.77	41.40	0.23	0.18	0.15
100.	2.64	53.19	43.35	0.23	0.21	0.17
150.	2.64	56.17	46.25	0.23	0.26	0.21
200.	2.64	57.72	46.90	0.22	0.30	0.24
300.	2.65	58.44	45.78	0.18	0.38	0.30
400.	2.66	60.21	48.17	0.20	0.37	0.30
500.	2.66	62.57	52.67	0.24	0.33	0.28
600.	2.67	63.67	54.35	0.25	0.33	0.28
700.	2.67	64.62	56.20	0.26	0.32	0.28
800.	2.68	64.44	55.21	0.25	0.35	0.30
900.	2.69	64.90	55.66	0.24	0.35	0.30
1000.	2.69	64.78	54.61	0.23	0.37	0.31

1STIRLING QUARTZITE,TYPE D.69-7

PRESSURE(MPA)	B11	B33	BVOL
0.	0.02167	0.03933	0.08267
20.	0.01834	0.03646	0.07313
40.	0.01601	0.02940	0.06141
60.	0.01349	0.02198	0.04896
80.	0.01134	0.01703	0.03971
100.	0.01050	0.01503	0.03604
150.	0.00917	0.01251	0.03084
200.	0.00836	0.01106	0.02777
300.	0.00756	0.00895	0.02407
400.	0.00711	0.00835	0.02258
500.	0.00686	0.00830	0.02203
600.	0.00661	0.00803	0.02126
700.	0.00650	0.00783	0.02082
800.	0.00634	0.00738	0.02007
900.	0.00627	0.00718	0.01972
1000.	0.00613	0.00693	0.01919

1STIRLING QUARTZITE,TYPE D.69-7

PRESSURE(MPA)	VP11	VS12	VP33	VS31	VP45
0.	3.936	2.586	3.115	2.293	3.250
20.	4.190	2.676	3.233	2.429	3.551
40.	4.382	2.734	3.572	2.501	3.835
60.	4.533	2.783	3.918	2.551	4.059
80.	4.660	2.829	4.113	2.592	4.304
100.	4.763	2.867	4.267	2.623	4.442
150.	4.970	2.943	4.514	2.687	4.685
200.	5.109	2.990	4.661	2.741	4.865
300.	5.275	3.055	4.870	2.831	5.138
400.	5.389	3.076	5.013	2.904	5.279
500.	5.470	3.083	5.123	2.968	5.351
600.	5.538	3.091	5.203	3.001	5.424
700.	5.579	3.099	5.270	3.016	5.466
800.	5.615	3.107	5.318	3.023	5.532
900.	5.641	3.119	5.357	3.027	5.563
1000.	5.673	3.123	5.382	3.026	5.607

Name

Ortho-enstatite, c-axis, 69-8

Source

Bamle, Norway. Sample obtained from Prof. T. J. Ahrens, California Institute of Technology.¹

Physical Properties

Density — 3.267 Mg/m³

Note — Compressional wave travel times were measured first to 1.0 GPa, then followed by shear wave travel-time measurements on the same sample again to 1.0 GPa.

1. T. J. Ahrens, J. Geophys. Res. 76, 5504 (1971).

1ORTHONSTATITE,C-AXIS,69-8

POROSITY=NO DATA

LENGTH=27.82 MM

DELTA=0.010

PRESSURE (MPA)	RHO (MG/CM)	VP (KM/S)	VS (KM/S)	K (GPA)	MU (GPA)	POISSONS R	YOUNGS MOD (GPA)	LAME CONST
0.	3.267	7.73	3.78	132.78	46.74	0.342	125.50	101.62
10.	3.267	7.85	3.88	135.74	49.19	0.338	131.65	102.95
20.	3.267	7.86	3.89	135.90	49.32	0.338	132.00	103.02
40.	3.268	7.87	3.89	136.20	49.53	0.338	132.54	103.18
60.	3.268	7.87	3.90	136.35	49.69	0.338	132.92	103.22
80.	3.269	7.88	3.91	136.48	49.86	0.337	133.34	103.24
100.	3.269	7.89	3.91	136.68	49.97	0.337	133.64	103.36
200.	3.272	7.91	3.93	137.42	50.50	0.336	134.96	103.76
300.	3.274	7.93	3.94	138.25	50.88	0.336	135.96	104.33
400.	3.277	7.95	3.95	138.90	51.23	0.336	136.86	104.75
500.	3.279	7.97	3.96	139.49	51.53	0.336	137.65	105.14
600.	3.281	7.99	3.97	140.17	51.78	0.336	138.31	105.65
700.	3.284	8.00	3.98	140.67	51.99	0.335	138.86	106.01
800.	3.286	8.01	3.99	141.30	52.19	0.336	139.41	106.50
900.	3.288	8.02	3.99	141.82	52.39	0.336	139.93	106.90
1000.	3.291	8.03	4.00	142.25	52.56	0.335	140.40	107.20

10RTHOENSTATITE,C-AXIS,69-8

POROSITY=NO DATA

LENGTH=27.82 MM

DELTA=0.010

PRESSURE (MPA)	COMPRESS (GPA-1)	MEAN VEL	LNVP	LNVS	BULK VEL	LN RHO/RHOZERO	PHI (KM/S) SQ	V (DM3/KG),
0.	0.0075	4.25	2.045	1.330	6.38	0.	40.64	0.3061
10.	0.0074	4.36	2.060	1.356	6.45	0.0001	41.55	0.3061
20.	0.0074	4.36	2.061	1.357	6.45	0.0001	41.59	0.3060
40.	0.0073	4.37	2.063	1.359	6.46	0.0003	41.68	0.3060
60.	0.0073	4.38	2.063	1.361	6.46	0.0004	41.72	0.3060
80.	0.0073	4.38	2.064	1.362	6.46	0.0006	41.75	0.3059
100.	0.0073	4.39	2.065	1.363	6.47	0.0007	41.81	0.3059
200.	0.0073	4.41	2.068	1.368	6.48	0.0015	42.00	0.3056
300.	0.0072	4.42	2.071	1.372	6.50	0.0022	42.22	0.3054
400.	0.0072	4.44	2.073	1.375	6.51	0.0029	42.39	0.3052
500.	0.0072	4.45	2.075	1.377	6.52	0.0037	42.54	0.3050
600.	0.0071	4.46	2.078	1.379	6.54	0.0044	42.72	0.3048
700.	0.0071	4.47	2.079	1.381	6.55	0.0051	42.84	0.3045
800.	0.0071	4.47	2.081	1.383	6.56	0.0058	43.00	0.3043
900.	0.0071	4.48	2.082	1.384	6.57	0.0065	43.13	0.3041
1000.	0.0070	4.49	2.084	1.385	6.58	0.0072	43.23	0.3039

ORTHOENSTATITE-C-AXIS-69-8

ORTHOENSTATITE, C-AXIS, 69-8

Name

Polycrystalline forsterite, 69-9

Source

Synthesized from oxides and obtained from Prof. T. J. Ahrens, California Institute of Technology.¹

Physical Properties

Density - 3.13 Mg/m^3

Note - Compressional wave travel times were measured first to 1.0 GPa, then followed by shear wave travel-time measurements on the same sample, again to 1.0 GPa.

1. T. J. Ahrens, J. Geophys. Res. 76, 518 (1971).

1POLYCRYSTALLINE FORSTERITE.69-9

POROSITY=NO DATA

LENGTH=27.59 MM

DELTA=0.010

PRESSURE(MPA)	RHO(MG/CM)	VP(KM/S)	VS(KM/S)	K(GPA)	MU(GPA)	POISSONS R	YOUNGS MOD (GPA)	LAME CONST
0.	3.130	6.65	3.03	99.98	28.77	0.369	78.76	80.80
5.	3.130	6.85	3.07	107.49	29.42	0.375	80.87	87.88
10.	3.130	7.04	3.10	114.95	30.08	0.380	83.00	94.90
15.	3.130	7.24	3.15	122.65	31.12	0.383	86.08	101.90
20.	3.131	7.46	3.20	131.29	32.07	0.387	88.96	109.91
25.	3.131	7.71	3.49	135.01	38.18	0.371	104.67	109.56
30.	3.131	7.88	3.91	130.77	47.81	0.337	127.84	98.90
40.	3.131	8.03	4.00	135.02	50.19	0.335	133.98	101.56
50.	3.131	8.14	4.05	138.84	51.38	0.335	137.22	104.59
60.	3.131	8.21	4.09	141.13	52.46	0.335	140.02	106.16
70.	3.132	8.28	4.13	143.70	53.40	0.335	142.55	108.09
80.	3.132	8.34	4.16	145.49	54.21	0.334	144.67	109.35
100.	3.132	8.44	4.22	148.58	55.72	0.333	148.58	111.44
150.	3.133	8.58	4.32	152.52	58.56	0.330	155.74	113.48
200.	3.134	8.64	4.41	152.85	60.83	0.324	161.11	112.30
400.	3.139	8.71	4.54	151.77	64.72	0.313	170.01	108.62
700.	3.145	8.76	4.59	153.19	66.29	0.311	173.79	109.00
1000.	3.151	8.77	4.62	152.87	67.22	0.308	175.89	108.05

1POLYCRYSTALLINE FORSTERITE.69-9

POROSITY=NO DATA

LENGTH=27.59 MM

DELTA=0.010

PRESSURE(MPA)	COMPRESS(GPA-1)	MEAN VEL	LNVP	LNVS	BULK VEL	LN RHO/RHOZERO	PHI(KM/S)SQ	V(DM3/KG).
0.	0.0100	3.42	1.894	1.109	5.65	0.	31.94	0.3195
5.	0.0093	3.46	1.924	1.120	5.86	0.0000	34.34	0.3195
10.	0.0087	3.50	1.951	1.131	6.06	0.0001	36.72	0.3195
15.	0.0082	3.56	1.980	1.148	6.26	0.0001	39.18	0.3194
20.	0.0076	3.62	2.009	1.163	6.48	0.0002	41.94	0.3194
25.	0.0074	3.94	2.042	1.251	6.57	0.0002	43.12	0.3194
30.	0.0076	4.39	2.065	1.363	6.46	0.0003	41.77	0.3194
40.	0.0074	4.49	2.083	1.387	6.57	0.0003	43.12	0.3194
50.	0.0072	4.55	2.096	1.399	6.66	0.0004	44.34	0.3194
60.	0.0071	4.59	2.105	1.409	6.71	0.0005	45.07	0.3193
70.	0.0070	4.63	2.114	1.418	6.77	0.0005	45.88	0.3193
80.	0.0069	4.67	2.121	1.426	6.82	0.0006	46.45	0.3193
100.	0.0067	4.73	2.132	1.439	6.89	0.0008	47.44	0.3192
150.	0.0066	4.85	2.149	1.464	6.98	0.0011	48.68	0.3191
200.	0.0065	4.94	2.156	1.483	6.98	0.0014	48.76	0.3190
400.	0.0066	5.08	2.164	1.513	6.95	0.0027	48.36	0.3186
700.	0.0065	5.14	2.171	1.524	6.98	0.0047	48.71	0.3180
1000.	0.0065	5.16	2.172	1.530	6.97	0.0067	48.51	0.3174

69-9

POLYCRYSTALLINE FORSTERITE, 69-9

POLYCRYSTALLINE FORSTERITE, 69-9

Name

Grout, 69-10

Source

J. R. Hearst, Lawrence Livermore Laboratory. The material was obtained from a large block of set, but not fully cured, grout. Samples were kept immersed in water until run.

Physical Properties

Density - 1.795 Mg/m^3

Total porosity - unavailable

Saturation - 100% water

Note - The composition of the grout is (in weight fractions):

Portland cement	0.22
Gel	0.03
400 - 850 μm Monterey sand	0.19
Barite	0.30
CrF_2	0.001
Air entraining agent	0.001
Water	0.27

An apparent transition is evident at 600-700 MPa in the velocity data. This correlates with a reversible volume change observed at these pressures by D. R. Stephens and is thought to be related to pressure-induced hydration of Ca(OH)_2 .

1GR0UT.69-10

POROSITY=NO DATA

LENGTH=33.08 MM

DELTA=0.010

PRESSURE (MPA)	RHO (MG/CM)	VP (KM/S)	VS (KM/S)	K (GPA)	MU (GPA)	POISSONS R	YOUNGS MOD (GPA)	LAME CONST
0.	1.795	2.03	1.16	4.17	2.43	0.256	6.10	2.55
10.	1.798	2.31	1.18	6.24	2.52	0.322	6.67	4.56
20.	1.801	2.59	1.19	8.69	2.56	0.366	6.99	6.98
30.	1.803	2.64	1.24	8.84	2.78	0.358	7.55	6.99
50.	1.807	2.67	1.25	9.11	2.82	0.360	7.66	7.23
100.	1.817	2.73	1.26	9.64	2.90	0.363	7.92	7.71
200.	1.835	2.88	1.29	11.12	3.04	0.375	8.35	9.10
300.	1.850	3.01	1.31	12.53	3.15	0.384	8.72	10.43
400.	1.864	3.14	1.31	14.11	3.21	0.394	8.95	11.98
500.	1.877	3.23	1.32	15.25	3.25	0.401	9.10	13.09
600.	1.889	3.36	1.33	16.93	3.33	0.408	9.38	14.70
635.	1.893	3.42	1.36	17.51	3.49	0.407	9.81	15.18
640.	1.893	3.64	1.44	19.90	3.92	0.408	11.04	17.29
700.	1.899	3.79	1.60	20.80	4.84	0.392	13.48	17.57
800.	1.908	3.98	1.72	22.69	5.62	0.386	15.57	18.94
900.	1.916	4.13	1.81	24.40	6.26	0.382	17.30	20.23
1000.	1.924	4.25	1.89	25.69	6.83	0.378	18.83	21.13

69-10-2

1GROUT.69-10

POROSITY=NO DATA

LENGTH=33.08 MM

DELTA=0.010

PRESSURE(MPA)	COMPRESS(GPA-1)	MEAN VEL	LNVP	LNVS	BULK VEL	LN RHO/RHOZERO	PHI(KM/S)SQ	V(DM3/KG).
0.	0.2399	1.29	0.709	0.151	1.52	0.	2.32	0.5571
10.	0.1603	1.33	0.837	0.169	1.86	0.0019	3.47	0.5560
20.	0.1151	1.34	0.952	0.175	2.20	0.0033	4.82	0.5553
30.	0.1131	1.40	0.970	0.217	2.21	0.0044	4.90	0.5546
50.	0.1098	1.41	0.981	0.222	2.25	0.0067	5.04	0.5534
100.	0.1037	1.42	1.003	0.234	2.30	0.0121	5.31	0.5504
200.	0.0899	1.45	1.056	0.252	2.46	0.0218	6.06	0.5451
300.	0.0798	1.47	1.101	0.266	2.60	0.0304	6.77	0.5404
400.	0.0709	1.48	1.144	0.271	2.75	0.0379	7.57	0.5364
500.	0.0656	1.49	1.172	0.274	2.85	0.0448	8.12	0.5327
600.	0.0591	1.51	1.213	0.284	2.99	0.0511	8.96	0.5294
635.	0.0571	1.54	1.230	0.305	3.04	0.0531	9.25	0.5283
640.	0.0502	1.63	1.293	0.364	3.24	0.0534	10.51	0.5281
700.	0.0481	1.81	1.332	0.468	3.31	0.0564	10.95	0.5266
800.	0.0441	1.94	1.381	0.540	3.45	0.0610	11.89	0.5241
900.	0.0410	2.04	1.419	0.592	3.57	0.0653	12.73	0.5219
1000.	0.0389	2.13	1.448	0.634	3.65	0.0694	13.35	0.5198

69-10-3

GROUT, 69-10

GROUT, 69-10

Name

Climax stock granodiorite, 69-11

Source

Climax stock, Area 15, Nevada Test Site, Nye County, Nevada. Sample from near the site of Hardhat nuclear experiment.

Physical Properties

Density - 2.69 Mg/m^3

Total porosity - unavailable

Saturation - air dry

Note - The anomalous behavior in the shear velocity is neither typical nor understood. However, it has been found to be both reversible and reproducible on samples from this site.

1CLIMAX STOCK GRANODIORITE,69-11

POROSITY=NO DATA

LENGTH=28.11 MM

DELTA=0.010

PRESSURE (MPA)	RHO (MG/CM)	VP (KM/S)	VS (KM/S)	K (GPA)	MU (GPA)	POISSONS R	YOUNGS MOD (GPA)	LAME CONST
20.	2.690	6.09	3.42	57.72	31.47	0.269	79.88	36.74
40.	2.692	6.13	3.44	58.72	31.81	0.271	80.84	37.51
60.	2.693	6.16	3.45	59.28	32.07	0.271	81.50	37.90
80.	2.694	6.17	3.46	59.63	32.28	0.271	82.05	38.11
100.	2.695	6.19	3.47	59.88	32.45	0.270	82.45	38.24
150.	2.697	6.22	3.49	60.44	32.80	0.270	83.33	38.57
200.	2.699	6.24	3.50	60.97	33.08	0.270	84.05	38.92
300.	2.704	6.28	3.52	62.03	33.47	0.271	85.10	39.72
400.	2.708	6.31	3.53	63.01	33.68	0.273	85.76	40.56
500.	2.712	6.34	3.53	63.90	33.75	0.275	86.09	41.40
600.	2.717	6.36	3.52	64.84	33.72	0.278	86.22	42.35
700.	2.721	6.37	3.51	65.65	33.61	0.281	86.12	43.25
800.	2.725	6.39	3.50	66.54	33.44	0.285	85.92	44.24
900.	2.729	6.39	3.49	67.28	33.23	0.288	85.60	45.12
1000.	2.733	6.40	3.48	68.05	33.00	0.291	85.22	46.05

1CLIMAX STOCK GRANODIORITE,69-11

POROSITY=NO DATA

LENGTH=28.11 MM

DELTA=0.010

PRESSURE(MPA)	COMPRESS(GPA-1)	MEAN VEL	LNVP	LNVS	BULK VEL	LN RHO/RHOZERO	PHI(KM/S)SQ	V(DM3/KG),
20.	0.0173	3.81	1.806	1.230	4.63	0.	21.46	0.3717
40.	0.0170	3.83	1.813	1.235	4.67	0.0007	21.81	0.3715
60.	0.0169	3.84	1.817	1.239	4.69	0.0010	22.01	0.3714
80.	0.0168	3.85	1.820	1.242	4.71	0.0014	22.14	0.3712
100.	0.0167	3.86	1.822	1.244	4.71	0.0017	22.22	0.3711
150.	0.0165	3.88	1.827	1.249	4.73	0.0026	22.41	0.3708
200.	0.0164	3.90	1.831	1.253	4.75	0.0034	22.59	0.3705
300.	0.0161	3.92	1.838	1.258	4.79	0.0050	22.94	0.3699
400.	0.0159	3.93	1.843	1.260	4.82	0.0066	23.27	0.3693
500.	0.0156	3.93	1.846	1.261	4.85	0.0082	23.56	0.3687
600.	0.0154	3.93	1.850	1.259	4.89	0.0098	23.87	0.3681
700.	0.0152	3.92	1.852	1.257	4.91	0.0114	24.13	0.3676
800.	0.0150	3.91	1.854	1.254	4.94	0.0129	24.42	0.3670
900.	0.0149	3.89	1.855	1.250	4.97	0.0144	24.65	0.3664
1000.	0.0147	3.88	1.857	1.246	4.99	0.0159	24.90	0.3659

CLIMAX STOCK GRANODIORITE, 69-11

CLIMAX STOCK GRANODIORITE, 69-11

Name

Green River shale, 69-12

Source and Description

704.1-m level of wellhole CCH-3, Rifle, Colorado. A silty kerogenous marlstone, described as "poor" in its kerogen content.

Physical Properties

Density — 2.075 Mg/m^3

Total porosity — unavailable, estimated from pressure-volume work to be about
0.6%

Saturation — air dry

Note — Treated as transversely isotropic, direction normal to bedding plane labeled 3.

1GREEN RIVER SHALE.69-12

PRESSURE(MPA)	C11	C66	C33	C44	C13	C12
0.	21.43	6.51	14.31	4.29	1.51	8.41
50.	25.11	7.26	17.36	5.19	1.09	10.59
100.	27.45	7.88	19.31	5.68	2.22	11.70
200.	31.50	8.90	22.65	6.56	3.44	13.70
300.	35.03	9.73	25.80	7.33	4.33	15.57
400.	38.10	10.45	28.66	8.04	4.79	17.21
500.	40.79	11.09	31.17	8.62	5.49	18.61
600.	43.04	11.67	33.83	9.11	6.37	19.70
700.	45.02	12.21	36.14	9.52	7.31	20.61
800.	46.65	12.73	38.32	9.90	8.53	21.18
900.	48.02	13.29	40.43	10.24	9.95	21.44
1000.	49.45	13.88	43.02	10.61	11.14	21.69

1 GREEN RIVER SHALE, 69-12

PRESSURE	RHO	E11	E33	P12	P13	P31
0.	2.06	18.07	14.16	0.39	0.07	0.05
50.	2.07	20.62	17.29	0.42	0.04	0.03
100.	2.08	22.38	19.06	0.42	0.07	0.06
200.	2.10	25.37	22.13	0.43	0.09	0.08
300.	2.12	27.89	25.06	0.43	0.10	0.09
400.	2.13	30.09	27.83	0.44	0.09	0.09
500.	2.14	32.01	30.15	0.44	0.10	0.09
600.	2.15	33.66	32.53	0.44	0.11	0.10
700.	2.16	35.14	34.51	0.44	0.11	0.11
800.	2.18	36.44	36.17	0.43	0.13	0.13
900.	2.18	37.66	37.58	0.42	0.14	0.14
1000.	2.19	38.97	39.53	0.40	0.15	0.16

69-12-3

1GREEN RIVER SHALE.69-12

PRESSURE(MPA)	B11	B33	BV0L
0.	0.03029	0.06347	0.12405
50.	0.02636	0.05431	0.10703
100.	0.02290	0.04652	0.09233
200.	0.01921	0.03831	0.07672
300.	0.01693	0.03308	0.06694
400.	0.01551	0.02972	0.06073
500.	0.01434	0.02703	0.05570
600.	0.01345	0.02450	0.05141
700.	0.01273	0.02252	0.04798
800.	0.01214	0.02069	0.04497
900.	0.01168	0.01899	0.04234
1000.	0.01134	0.01737	0.04005

1 GREEN RIVER SHALE, 69-12

PRESSURE(MPA)	VP11	VS12	VP33	VS31	VP45
0.	3.225	1.777	2.636	1.443	2.652
50.	3.481	1.872	2.894	1.583	2.853
100.	3.631	1.945	3.045	1.652	3.016
200.	3.872	2.058	3.284	1.767	3.252
300.	4.069	2.145	3.492	1.862	3.443
400.	4.230	2.215	3.668	1.943	3.593
500.	4.364	2.275	3.815	2.006	3.723
600.	4.470	2.328	3.963	2.056	3.843
700.	4.560	2.375	4.086	2.097	3.947
800.	4.631	2.420	4.197	2.134	4.048
900.	4.689	2.467	4.302	2.166	4.144
1000.	4.748	2.516	4.428	2.199	4.241

Name

Indian Trail tuff, subunit 3, 70-1

Source and Description

Tunnel U-16a.05, Area 16, Nevada Test Site, Nye County, Nevada. Sample was recovered from between 8 and 12 m of instrument hole 6. A zeolitized, non-welded ash-flow tuff.

Physical Properties

Density - 1.83 Mg/m^3

Total porosity - 27%

Saturation - ~85%, 12-16% water by weight

Note - Attendant report describing complete physical properties measurements, D. R. Stephens, H. C. Heard, and R. N. Schock, High-Pressure Mechanical Properties of Tuff from the Diamond Dust Site, Lawrence Livermore Laboratory, Rept. UCRL-50858 (1970).

1 INDIAN TRAIL, SUB-UNIT 3.70-1

POROSITY=27.00

LENGTH=26.29 MM

DELTA=0.010

PRESSURE (MPA)	RHO (MG/CM)	VP (KM/S)	VS (KM/S)	K (GPA)	MU (GPA)	POISSONS R	YOUNGS MOD (GPA)	LAME CONST
0.	1.830	2.87	1.39	10.35	3.54	0.346	9.54	7.99
5.	1.831	3.20	1.43	13.72	3.75	0.375	10.31	11.22
10.	1.831	3.22	1.45	13.81	3.86	0.372	10.60	11.23
20.	1.833	3.22	1.48	13.69	4.02	0.366	10.99	11.01
40.	1.835	3.25	1.52	13.68	4.25	0.359	11.55	10.85
60.	1.838	3.27	1.56	13.74	4.47	0.353	12.09	10.76
80.	1.841	3.30	1.59	13.78	4.67	0.348	12.58	10.67
100.	1.844	3.32	1.62	13.84	4.86	0.343	13.06	10.59
200.	1.857	3.43	1.76	14.20	5.73	0.322	15.14	10.38
400.	1.883	3.62	1.97	14.89	7.31	0.289	18.84	10.02
600.	1.908	3.77	2.10	15.90	8.40	0.276	21.42	10.30
800.	1.931	3.92	2.19	17.32	9.25	0.273	23.55	11.16
1000.	1.953	4.05	2.24	18.96	9.82	0.279	25.13	12.41

1 INDIAN TRAIL, SUB-UNIT 3.70-1

POROSITY=27.00

LENGTH=26.29 MM

DELTA=0.010

PRESSURE(MPA)	COMPRESS(GPA-1)	MEAN VEL	LNVP	LNVS	BULK VEL	LN RHO/RHOZERO	PHI(KM/S)SQ	V(DM3/KG).
0.	0.0966	1.56	1.054	0.330	2.38	0.	5.66	0.5464
5.	0.0729	1.61	1.162	0.358	2.74	0.0004	7.50	0.5462
10.	0.0724	1.64	1.168	0.373	2.75	0.0008	7.54	0.5460
20.	0.0730	1.67	1.171	0.393	2.73	0.0015	7.47	0.5456
40.	0.0731	1.71	1.178	0.420	2.73	0.0030	7.45	0.5448
60.	0.0728	1.75	1.186	0.444	2.73	0.0045	7.47	0.5440
80.	0.0726	1.79	1.193	0.465	2.74	0.0059	7.49	0.5432
100.	0.0723	1.82	1.200	0.485	2.74	0.0074	7.50	0.5424
200.	0.0704	1.97	1.232	0.563	2.77	0.0146	7.65	0.5385
400.	0.0672	2.20	1.286	0.678	2.81	0.0285	7.91	0.5311
600.	0.0629	2.34	1.327	0.741	2.89	0.0416	8.34	0.5242
800.	0.0577	2.44	1.366	0.783	3.00	0.0538	8.97	0.5178
1000.	0.0528	2.50	1.399	0.808	3.12	0.0649	9.71	0.5121

INDIAN TRAIL, SUB-UNIT 3, 70-1

INDIAN TRAIL, SUB-UNIT 3, 70-1

Name

Indian Trail tuff, subunit 4a (I), 70-2

Source and Description

Tunnel U-16a.05, Area 16, Nevada Test Site, Nye County, Nevada. Samples were recovered from 42 m, instrument hole no. 8. A thin bedded zeolitic and argillaceous ash-fall and reworked ash-fall tuff.

Physical Properties

Density - 1.975 Mg/m^3

Total porosity - unavailable, gas filled porosity estimated from pressure-volume data to be 9.7%

Note - Attendant report describing complete physical properties measurements, D. R. Stephens, H. C. Heard, and R. N. Schock, High-Pressure Mechanical Properties of Tuff from the Diamond Dust Site, Lawrence Livermore Laboratory, Rept. UCRL-50858 (1970).

1 INDIAN TRAIL TUFF, SUB-UNIT 4A(1), 70-2

POROSITY= 9.70

LENGTH=26.04 MM

DELTA=0.010

PRESSURE(MPA)	RHO(MG/CM)	VP(KM/S)	VS(KM/S)	K(GPA)	MU(GPA)	POISSONS R	YOUNGS MOD (GPA)	LAME CONST
0.	1.975	3.16	1.69	12.18	5.63	0.300	14.62	8.43
5.	1.976	3.23	1.88	11.36	6.98	0.245	17.39	6.70
10.	1.977	3.26	1.91	11.45	7.19	0.240	17.84	6.66
20.	1.978	3.27	1.92	11.47	7.30	0.238	18.06	6.61
40.	1.982	3.29	1.93	11.60	7.41	0.237	18.33	6.66
60.	1.985	3.33	1.94	12.04	7.51	0.242	18.64	7.04
80.	1.989	3.35	1.96	12.13	7.62	0.240	18.91	7.05
100.	1.992	3.37	1.97	12.37	7.71	0.242	19.15	7.24
200.	2.008	3.48	2.03	13.27	8.24	0.243	20.49	7.77
300.	2.023	3.53	2.08	13.58	8.71	0.236	21.53	7.78
400.	2.037	3.68	2.13	15.35	9.20	0.250	23.00	9.22
600.	2.062	3.85	2.20	17.33	9.98	0.258	25.11	10.68
800.	2.085	4.00	2.27	19.00	10.72	0.263	27.07	11.86
1000.	2.107	4.14	2.31	21.09	11.23	0.274	28.60	13.61

1 INDIAN TRAIL TUFF, SUB-UNIT 4A(1).70-2

POROSITY= 9.70

LENGTH=26.04 MM

DELTA=0.010

PRESSURE(MPA)	COMPRESS(GPA-1)	MEAN VEL	LNVP	LNVS	BULK VEL	LN RHO/RHOZERO	PHI(KM/S)SQ	V(DM3/KG),
0.	0.0021	1.89	1.149	0.523	2.48	0.	6.17	0.5063
5.	0.0080	2.09	1.174	0.631	2.40	0.0004	5.75	0.5061
10.	0.0073	2.12	1.182	0.646	2.41	0.0009	5.79	0.5059
20.	0.0072	2.13	1.186	0.653	2.41	0.0018	5.80	0.5054
40.	0.0062	2.14	1.192	0.659	2.42	0.0035	5.85	0.5046
60.	0.0030	2.16	1.204	0.665	2.46	0.0052	6.07	0.5037
80.	0.0025	2.17	1.208	0.672	2.47	0.0069	6.10	0.5029
100.	0.0008	2.18	1.216	0.677	2.49	0.0085	6.21	0.5020
200.	0.0754	2.25	1.246	0.706	2.57	0.0164	6.61	0.4981
300.	0.0736	2.30	1.261	0.730	2.59	0.0239	6.71	0.4944
400.	0.0651	2.36	1.303	0.754	2.75	0.0309	7.54	0.4909
600.	0.0577	2.44	1.349	0.788	2.90	0.0433	8.40	0.4849
800.	0.0526	2.52	1.385	0.818	3.02	0.0544	9.11	0.4795
1000.	0.0474	2.57	1.420	0.837	3.16	0.0645	10.01	0.4747

INDIAN TRAIL TUFF, SUB-UNIT 4A(1), 70-2

INDIAN TRAIL TUFF, SUB-UNIT 4A(I), 70-2

Name

Indian Trail tuff, subunit 4a (II), 70-3

Source and Description

Tunnel U-16a.05, Area 16, Nevada Test Site, Nye County, Nevada. Sample was recovered from 109 m, exploratory hole No. 1. A thin bedded zeolitic and argillaceous ash-fall and reworked ash-fall tuff.

Physical Properties

Density - 1.802 Mg/m^3

Total porosity - unknown

Saturation - ~85%, 17% water by weight

Note - Attendant report describing complete physical properties measurements, D. R. Stephens, H. C. Heard, and R. N. Schock, High-Pressure Mechanical Properties of Tuff from the Diamond Mine Site, Lawrence Livermore Laboratory, Rept. UCRL-50858 (1970).

1 INDIAN TRAIL TUFF, SUB-UNIT 4A(II), 70-3

POROSITY=NO DATA			LENGTH=33.95 MM			DELTA=0.010		
PRESSURE(MPA)	RHO(MG/CM)	VP(KM/S)	VS(KM/S)	K(GPA)	MU(GPA)	POISSONS R	YOUNGS MOD (GPA)	LAME CONST
0.	1.802	2.61	1.51	6.81	4.11	0.249	10.27	4.07
5.	1.803	3.00	1.64	9.81	4.84	0.288	12.48	6.58
10.	1.804	3.04	1.66	10.12	4.94	0.290	12.76	6.82
20.	1.806	3.07	1.67	10.29	5.05	0.289	13.02	6.93
40.	1.809	3.14	1.70	10.84	5.25	0.292	13.55	7.34
60.	1.813	3.20	1.73	11.33	5.40	0.294	13.97	7.73
80.	1.816	3.26	1.75	11.82	5.57	0.296	14.45	8.11
100.	1.819	3.29	1.76	12.10	5.66	0.298	14.68	8.32
200.	1.833	3.52	1.84	14.38	6.22	0.311	16.30	10.23
300.	1.845	3.66	1.89	15.93	6.60	0.318	17.40	11.53
400.	1.856	3.84	1.93	18.22	6.88	0.332	18.33	13.64
600.	1.875	3.99	1.95	20.29	7.16	0.342	19.21	15.52
800.	1.894	4.05	1.95	21.46	7.23	0.349	19.50	16.64
1000.	1.911	4.08	1.96	22.11	7.34	0.351	19.82	17.21

1 INDIAN TRAIL TUFF, SUB-UNIT 4A(II), 70-3

POROSITY=NO DATA

LENGTH=33.95 MM

DELTA=0.010

PRESSURE(MPA)	COMPRESS(GPA-1)	MEAN VEL	LNVP	LNVS	BULK VEL	LN RHO/RHOZERO	PHI(KM/S)SQ	V(DM3/KG),
0.	0.1468	1.68	0.960	0.412	1.94	0.	3.78	0.5549
5.	0.1019	1.83	1.100	0.494	2.33	0.0006	5.44	0.5546
10.	0.0988	1.85	1.113	0.504	2.37	0.0011	5.61	0.5543
20.	0.0972	1.87	1.122	0.514	2.39	0.0021	5.70	0.5538
40.	0.0923	1.90	1.144	0.532	2.45	0.0040	5.99	0.5527
60.	0.0883	1.93	1.162	0.545	2.50	0.0058	6.25	0.5517
80.	0.0846	1.96	1.181	0.561	2.55	0.0076	6.51	0.5507
100.	0.0827	1.97	1.190	0.567	2.58	0.0093	6.65	0.5498
200.	0.0696	2.06	1.257	0.611	2.80	0.0169	7.84	0.5456
300.	0.0628	2.12	1.298	0.637	2.94	0.0236	8.64	0.5420
400.	0.0549	2.16	1.346	0.655	3.13	0.0295	9.82	0.5388
600.	0.0493	2.19	1.383	0.670	3.29	0.0400	10.82	0.5332
800.	0.0466	2.20	1.399	0.670	3.37	0.0497	11.33	0.5281
1000.	0.0452	2.20	1.407	0.673	3.40	0.0589	11.57	0.5232

70-3-3

INDIAN TRAIL TUFF, SUB-UNIT 4A(II), 70-3

INDIAN TRAIL TUFF, SUB-UNIT 4A(II), 70-3

Name

Indian Trail tuff, subunit 4a (III), 70-4

Source and Description

Tunnel U-16a.05, Area 16, Nevada Test Site, Nye County, Nevada. Sample was recovered from 110 m, exploratory hole No. 1. A thin bedded zeolitic and argillaceous ash-fall and reworked ash-fall tuff.

Physical Properties

Density - 1.764 Mg/m^3

Total porosity - unavailable, gas-filled porosity estimated from pressure-volume data to be 9.4%

Saturation - ~ 85%, 16% water by weight

Note - Attendant report describing complete physical properties measurements, D. R. Stephens, H. C. Heard, and R. N. Schock, High-Pressure Mechanical Properties of Tuff from the Diamond Dust Site, Lawrence Livermore Laboratory, Rept. UCRL-50858 (1970).

1 INDIAN TRAIL TUFF, SUB-UNIT 4A(III), 70-4

POROSITY=NO DATA

LENGTH=34.28 MM

DELTA=0.010

PRESSURE(MPA)	RHO(MG/CM)	VP(KM/S)	VS(KM/S)	K(GPA)	MU(GPA)	POISSONS R	YOUNGS MOD (GPA)	LAME CONST
0.	1.764	2.40	1.20	6.76	2.53	0.334	6.75	5.08
5.	1.765	2.49	1.24	7.37	2.70	0.337	7.21	5.57
10.	1.766	2.61	1.27	8.19	2.85	0.344	7.67	6.29
20.	1.768	2.77	1.33	9.40	3.15	0.349	8.50	7.31
40.	1.772	2.92	1.36	10.75	3.26	0.362	8.87	8.58
60.	1.775	3.02	1.37	11.75	3.35	0.370	9.17	9.52
100.	1.781	3.12	1.40	12.65	3.50	0.373	9.60	10.32
200.	1.794	3.28	1.45	14.31	3.78	0.379	10.42	11.79
400.	1.818	3.51	1.53	16.75	4.27	0.383	11.80	13.90
600.	1.839	3.70	1.59	19.01	4.65	0.387	12.91	15.91
1000.	1.874	4.01	1.66	23.23	5.17	0.396	14.44	19.78

1 INDIAN TRAIL TUFF, SUB-UNIT 4A(III), 70-4

POROSITY=NO DATA

LENGTH=34.28 MM

DELTA=0.010

PRESSURE(MPA)	COMPRESS(GPA-1)	MEAN VEL	LNVP	LNVS	BULK VEL	LN RHO/RHOZERO	PHI(KM/S)SQ	V(DM3/KG).
0.	0.1479	1.34	0.874	0.180	1.96	0.	3.83	0.5669
5.	0.1357	1.39	0.913	0.212	2.04	0.0007	4.18	0.5665
10.	0.1221	1.43	0.958	0.240	2.15	0.0014	4.64	0.5661
20.	0.1063	1.50	1.020	0.288	2.31	0.0025	5.32	0.5655
40.	0.0931	1.53	1.071	0.304	2.46	0.0045	6.07	0.5643
60.	0.0851	1.55	1.106	0.317	2.57	0.0063	6.62	0.5633
100.	0.0790	1.58	1.137	0.337	2.67	0.0096	7.10	0.5615
200.	0.0699	1.64	1.189	0.372	2.82	0.0171	7.98	0.5573
400.	0.0597	1.73	1.257	0.427	3.04	0.0301	9.21	0.5501
600.	0.0526	1.80	1.309	0.464	3.22	0.0414	10.34	0.5439
1000.	0.0430	1.88	1.389	0.507	3.52	0.0606	12.39	0.5336

70-4-3

INDIAN TRAIL TUFF, SUB-UNIT 4A(III), 70-4

INDIAN TRAIL TUFF, SUB-UNIT 4A(III), 70-4

Name

Lance sandstone (I), 70-5

Source

3102-m-well depth, Wagon Wheel No. 1, NW 1/4 Section 5, T30N, R108W, Sublette County, Wyoming. A Cretaceous medium-grained, moderately sorted graywacke, low in feldspar (lithicwacke).¹

Physical Properties

Density - 2.40 Mg/m^3

Total porosity - unavailable

Saturation - air dry

Note - Travel times were measured normal to the bedding. Attendant report describing complete physical properties, R. N. Schock, H. C. Heard, and D. R. Stephens, High-Pressure Mechanical Properties of Rocks from Wagon Wheel No. 1, Pinedale, Wyoming, Lawrence Livermore Laboratory, Rept. UCRL-50963 (1970).

1. F. J. Pettijohn, P. E. Potter, and R. Siever, Sand and Sandstone (Springer Verlag, New York, 1972) p. 197.

1 LANCE SANDSTONE(I), 70-5

POROSITY=NO DATA

LENGTH=25.26 MM

DELTA=0.010

PRESSURE(MPA)	RHO(MG/CM)	VP(KM/S)	VS(KM/S)	K(GPA)	MU(GPA)	POISSONS R	YOUNGS MOD (GPA)	LAME CONST
0.	2.400	3.58	2.28	14.21	12.45	0.161	28.91	5.91
10.	2.402	3.84	2.43	16.42	14.22	0.164	33.10	6.95
20.	2.403	4.07	2.61	18.06	16.35	0.152	37.68	7.16
30.	2.404	4.31	2.70	21.30	17.49	0.178	41.19	9.64
40.	2.405	4.51	2.77	24.36	18.39	0.198	44.07	12.10
60.	2.407	4.65	2.85	26.01	19.48	0.200	46.77	13.02
80.	2.409	4.71	2.89	26.61	20.07	0.199	48.12	13.23
100.	2.411	4.75	2.91	27.13	20.45	0.199	49.03	13.49
150.	2.415	4.82	2.95	28.05	21.04	0.200	50.50	14.02
200.	2.420	4.85	2.96	28.56	21.25	0.202	51.09	14.39
300.	2.428	4.90	2.98	29.59	21.53	0.207	51.98	15.24
400.	2.436	4.94	2.99	30.51	21.76	0.212	52.74	16.00
600.	2.452	5.01	3.01	31.88	22.17	0.218	54.00	17.10
800.	2.467	5.05	3.02	32.73	22.57	0.220	55.06	17.68
1000.	2.482	5.09	3.04	33.61	22.98	0.222	56.14	18.29

70-5-2

ILANCE SANDSTONE(I),70-5

POROSITY=NO DATA

LENGTH=25.26 MM

DELTA=0.010

PRESSURE(MPA)	COMPRESS(GPA-1)	MEAN VEL	LNVP	LNVS	BULK VEL	LN RHO/RHOZERO	PHI(KM/S)SQ	V(DM3/KG),
0.	0.0704	2.50	1.276	0.823	2.43	0.	5.92	0.4167
10.	0.0609	2.68	1.345	0.889	2.62	0.0007	6.84	0.4164
20.	0.0554	2.87	1.404	0.959	2.74	0.0012	7.51	0.4161
30.	0.0469	2.97	1.460	0.992	2.98	0.0018	8.86	0.4159
40.	0.0411	3.05	1.506	1.017	3.18	0.0022	10.13	0.4158
60.	0.0384	3.14	1.536	1.046	3.29	0.0030	10.81	0.4154
80.	0.0376	3.19	1.549	1.060	3.32	0.0038	11.04	0.4151
100.	0.0369	3.22	1.558	1.069	3.35	0.0045	11.25	0.4148
150.	0.0357	3.26	1.573	1.082	3.41	0.0064	11.61	0.4140
200.	0.0350	3.27	1.579	1.086	3.44	0.0081	11.80	0.4133
300.	0.0338	3.29	1.589	1.091	3.49	0.0116	12.19	0.4119
400.	0.0328	3.30	1.598	1.095	3.54	0.0150	12.52	0.4105
600.	0.0314	3.33	1.611	1.101	3.61	0.0214	13.00	0.4078
800.	0.0306	3.35	1.619	1.107	3.64	0.0277	13.26	0.4053
1000.	0.0298	3.37	1.627	1.113	3.68	0.0338	13.54	0.4028

70-5-3

LANCE SANDSTONE(I), 70-5

LANCE SANDSTONE(I), 70-5

Name

Lance sandstone (II), 70-6

Source and Description

3120-m well depth, Wagon Wheel No. 1, NW 1/4 Section 5, T30N, R108W, Sublette County, Wyoming. A Cretaceous, fine grained, moderately sorted graywacke, low in feldspar (lithicwacke).¹

Physical Properties

Density - 2.440 Mg/m^3

Total porosity - 8.5%

Saturation - air dry

Note - Treated as transversely isotropic, direction normal to bedding plane labeled 3. Attendant report describing complete physical properties, R. N. Schock, H. C. Heard, and D. R. Stephens, High-Pressure Mechanical Properties of Rocks from Wagon Wheel No. 1, Pinedale, Wyoming, Lawrence Livermore Laboratory, Rept. UCRL-50963 (1970).

1. F. J. Pettijohn, P. E. Potter, and R. Siever, Sand and Sandstone (Springer Verlag, New York, 1972) p. 197.

1 LANCE SANDSTONE (II), 70-6

PRESSURE (MPa)	C11	C66	C33	C44	C13	C12
0.	42.82	15.53	37.90	14.83	10.56	11.76
10.	47.85	17.13	41.36	15.68	10.08	13.59
20.	51.89	18.65	45.69	17.06	9.12	14.59
30.	55.63	20.39	50.02	18.52	10.19	14.85
40.	58.09	21.35	52.81	20.09	11.94	15.39
60.	59.92	22.02	56.26	20.76	14.66	15.88
80.	61.23	22.39	58.46	21.62	14.32	16.44
100.	62.21	22.67	59.61	21.99	14.82	16.87
150.	64.01	23.07	61.56	22.54	14.75	17.87
200.	65.47	23.37	62.44	22.83	15.49	18.74
300.	67.19	23.81	64.17	23.23	16.93	19.58
400.	68.23	24.07	65.54	23.51	17.92	20.10
600.	70.29	24.50	68.18	23.87	18.76	21.30
800.	72.06	24.67	70.16	24.15	20.25	22.73
1000.	72.96	24.83	72.22	24.43	22.29	23.29

70-6-3

ILANCE SANDSTONE(II),70-6

PRESSURE	RHO	E11	E33	P12	P13	P31
0.	2.44	37.93	33.81	0.22	0.22	0.19
10.	2.44	42.66	38.05	0.25	0.18	0.16
20.	2.44	46.82	43.19	0.26	0.15	0.14
30.	2.44	50.50	47.07	0.24	0.16	0.14
40.	2.44	52.49	48.92	0.23	0.17	0.16
60.	2.45	53.51	50.60	0.22	0.20	0.19
80.	2.45	54.82	53.18	0.22	0.19	0.18
100.	2.45	55.55	54.06	0.23	0.19	0.19
150.	2.45	57.08	56.24	0.24	0.18	0.18
200.	2.46	58.03	56.75	0.24	0.19	0.18
300.	2.46	59.08	57.57	0.24	0.20	0.20
400.	2.47	59.69	58.27	0.24	0.21	0.20
600.	2.49	61.13	60.50	0.25	0.21	0.21
800.	2.50	61.91	61.51	0.26	0.22	0.21
1000.	2.51	62.00	61.90	0.25	0.23	0.23

ILANCE SANDSTONE(II),70-6

PRESSURE(MPA)	B11	B33	BVOL
0.	0.01481	0.01813	0.04775
10.	0.01338	0.01766	0.04441
20.	0.01274	0.01680	0.04228
30.	0.01201	0.01510	0.03911
40.	0.01137	0.01380	0.03653
60.	0.01085	0.01212	0.03382
80.	0.01069	0.01187	0.03325
100.	0.01048	0.01157	0.03252
150.	0.01016	0.01137	0.03170
200.	0.00983	0.01114	0.03079
300.	0.00946	0.01059	0.02951
400.	0.00925	0.01020	0.02871
600.	0.00892	0.00976	0.02760
800.	0.00856	0.00931	0.02643
1000.	0.00838	0.00867	0.02543

1 LANCE SANDSTONE (II), 70-6

PRESSURE (MPa)	VP11	VS12	VP33	VS31	VP45
0.	4.189	2.523	3.941	2.465	4.067
10.	4.427	2.649	4.116	2.534	4.203
20.	4.609	2.764	4.325	2.643	4.344
30.	4.772	2.889	4.525	2.753	4.528
40.	4.875	2.956	4.648	2.867	4.693
60.	4.950	3.000	4.796	2.913	4.834
80.	5.002	3.025	4.887	2.972	4.897
100.	5.040	3.042	4.933	2.996	4.943
150.	5.108	3.067	5.009	3.031	4.999
200.	5.162	3.084	5.041	3.048	5.045
300.	5.221	3.108	5.103	3.070	5.116
400.	5.254	3.120	5.149	3.084	5.162
600.	5.318	3.139	5.237	3.099	5.221
800.	5.369	3.141	5.298	3.108	5.282
1000.	5.388	3.144	5.361	3.118	5.344

Name

Lance sandstone (III), 70-7

Source and Description

3371-m well depth, Wagon Wheel No. 1, NW 1/4 Section 5, T30N, R108W, Sublette County, Wyoming. A Cretaceous, medium grained, moderately sorted graywacke, low in feldspar (lithicwacke).¹

Physical Properties

Density – 2.430 Mg/m³

Total porosity – unavailable

Saturation – air dry

Note – Treated as transversely isotropic, direction normal to bedding labeled 3. Attendant report describing complete physical properties, R. N. Schock, H. C. Heard, and D. R. Stephens, High-Pressure Mechanical Properties of Rocks from Wagon Wheel No. 1, Pinedale, Wyoming, Lawrence Livermore Laboratory, Rept. UCRL-50963 (1970).

1. F. J. Pettijohn, P. E. Potter and R. Siever, Sand and Sandstones (Springer Verlag, New York, 1972) p. 197.

1LANCE SANDSTONE(III),70-7

PRESSURE(MPA)	C11	C66	C33	C44	C13	C12
0.	42.87	15.91	40.01	16.02	9.81	11.06
10.	47.24	16.87	42.09	16.62	9.24	13.51
20.	51.20	17.89	45.51	17.90	7.78	15.41
40.	55.48	19.45	53.16	19.65	12.82	16.59
60.	57.50	20.37	55.94	20.50	13.16	16.76
80.	58.61	20.77	57.63	20.88	13.55	17.06
100.	59.41	21.07	58.85	21.17	14.16	17.28
200.	61.16	21.74	61.72	21.93	16.98	17.69
300.	62.92	22.14	62.99	22.34	19.45	18.63
400.	64.23	22.43	64.04	22.60	21.49	19.37
500.	65.33	22.67	64.99	22.81	23.14	20.00
600.	66.44	22.96	65.57	22.99	24.26	20.52
700.	67.45	23.20	66.16	23.15	25.55	21.05
800.	68.47	23.50	66.89	23.29	25.69	21.47
900.	69.38	23.78	67.62	23.39	25.37	21.82
1000.	70.01	24.07	68.23	23.47	24.71	21.88

ILANCE SANDSTONE(III),70-7

PRESSURE	RHO	E11	E33	P12	P13	P31
0.	2.43	38.62	36.44	0.21	0.19	0.18
10.	2.43	42.30	39.28	0.25	0.16	0.15
20.	2.43	45.89	43.69	0.28	0.12	0.12
40.	2.43	48.91	48.60	0.26	0.18	0.18
60.	2.44	50.97	51.28	0.25	0.18	0.18
80.	2.44	51.95	52.78	0.25	0.18	0.18
100.	2.44	52.57	53.62	0.25	0.18	0.18
200.	2.45	53.49	54.41	0.23	0.21	0.22
300.	2.46	54.11	53.71	0.22	0.24	0.24
400.	2.46	54.43	52.99	0.21	0.26	0.26
500.	2.47	54.67	52.44	0.21	0.28	0.27
600.	2.48	55.14	52.03	0.20	0.30	0.28
700.	2.48	55.41	51.41	0.19	0.31	0.29
800.	2.49	56.31	52.21	0.20	0.31	0.29
900.	2.50	57.34	53.51	0.21	0.30	0.28
1000.	2.50	58.33	54.94	0.21	0.29	0.27

1LANCE SANDSTONE(III),70-7

PRESSURE(MPA)	B11	B33	BV0L
0.	0.01537	0.01746	0.04820
10.	0.01377	0.01772	0.04525
20.	0.01297	0.01754	0.04347
40.	0.01152	0.01326	0.03629
60.	0.01124	0.01259	0.03506
80.	0.01104	0.01216	0.03424
100.	0.01087	0.01176	0.03350
200.	0.01043	0.01046	0.03132
300.	0.00994	0.00974	0.02962
400.	0.00960	0.00917	0.02838
500.	0.00935	0.00873	0.02743
600.	0.00913	0.00849	0.02675
700.	0.00893	0.00822	0.02607
800.	0.00877	0.00821	0.02576
900.	0.00866	0.00829	0.02561
1000.	0.00862	0.00841	0.02565

ILANCE SANDSTONE(III).70-7

PRESSURE (MPa)	VP11	VS12	VP33	VS31	VP45
0.	4.200	2.559	4.058	2.568	4.141
10.	4.408	2.634	4.161	2.614	4.236
20.	4.588	2.712	4.326	2.713	4.351
40.	4.774	2.826	4.673	2.841	4.675
60.	4.858	2.892	4.792	2.901	4.770
80.	4.903	2.919	4.862	2.926	4.823
100.	4.935	2.939	4.912	2.946	4.868
200.	4.999	2.980	5.022	2.993	4.996
300.	5.063	3.003	5.065	3.017	5.085
400.	5.108	3.018	5.100	3.030	5.152
500.	5.144	3.030	5.131	3.039	5.205
600.	5.180	3.045	5.146	3.047	5.243
700.	5.212	3.057	5.162	3.054	5.282
800.	5.245	3.073	5.184	3.059	5.300
900.	5.273	3.087	5.206	3.062	5.306
1000.	5.290	3.102	5.222	3.063	5.302

Name

Fort Union siltstone, 70-8

Source and Description

2743-m well depth, Wagon Wheel No. 1, NW 1/4 Section 5, T30N, R108W, Sublette County, Wyoming. A Paleocene, moderately sorted siltstone (graywacke).

Physical Properties

Density - 2.60 Mg/m^3

Total porosity - unavailable

Saturation - air dry

Note - Treated as transversely isotropic, direction normal to bedding labeled 3. Attendant report describing complete physical properties, R. N. Schock, H. C. Heard, and D. R. Stephens, High-Pressure Mechanical Properties of Rocks from Wagon Wheel No. 1, Pinedale, Wyoming, Lawrence Livermore Laboratory, Rept. UCRL-50963 (1970).

1FORT UNION SILTSTONE.70-8

PRESSURE(MPA)	C11	C66	C33	C44	C13	C12
0.	50.26	20.38	47.87	17.93	7.87	9.49
20.	53.12	20.97	50.35	18.99	8.60	11.18
50.	56.14	21.91	52.74	19.96	9.04	12.32
100.	60.69	23.22	56.23	21.15	9.91	14.26
200.	67.35	24.43	62.00	22.68	13.87	18.49
300.	71.39	25.09	66.32	23.63	16.36	21.22
400.	74.53	25.65	70.24	24.35	18.05	23.24
500.	77.36	26.15	73.57	24.87	20.13	25.05
600.	79.65	26.68	75.99	25.36	22.80	26.30
700.	81.67	27.18	78.20	25.85	24.71	27.32
800.	83.57	27.65	80.32	26.33	25.26	28.27
900.	85.74	28.11	82.35	26.86	25.38	29.53
1000.	87.79	28.57	80.06	27.39	27.31	30.65

1FORT UNION SILTSTONE,70-8

PRESSURE	RHO	E11	E33	P12	P13	P31
0.	2.60	47.59	45.80	0.17	0.14	0.13
20.	2.60	49.83	48.05	0.19	0.14	0.13
50.	2.61	52.46	50.35	0.20	0.14	0.13
100.	2.61	56.29	53.61	0.21	0.14	0.13
200.	2.62	60.56	57.52	0.24	0.17	0.16
300.	2.63	62.98	60.55	0.26	0.18	0.18
400.	2.64	64.94	63.58	0.27	0.19	0.18
500.	2.64	66.54	65.66	0.27	0.20	0.20
600.	2.65	67.61	66.18	0.27	0.22	0.22
700.	2.65	68.71	66.99	0.26	0.23	0.23
800.	2.66	70.17	68.91	0.27	0.23	0.23
900.	2.67	71.87	71.17	0.28	0.22	0.22
1000.	2.67	72.67	67.47	0.27	0.25	0.23

1FORT UNION SILTSTONE,70-8

PRESSURE(MPA)	B11	B33	BV0L
0.	0.01462	0.01608	0.04532
20.	0.01351	0.01525	0.04227
50.	0.01268	0.01462	0.03997
100.	0.01153	0.01372	0.03678
200.	0.00975	0.01177	0.03126
300.	0.00891	0.01068	0.02851
400.	0.00840	0.00992	0.02672
500.	0.00795	0.00924	0.02514
600.	0.00759	0.00861	0.02378
700.	0.00733	0.00816	0.02281
800.	0.00714	0.00796	0.02225
900.	0.00694	0.00786	0.02175
1000.	0.00660	0.00799	0.02119

1FORT UNION SILTSTONE,70-8

PRESSURE(MPA)	VP11	VS12	VP33	VS31	VP45
0.	4.397	2.800	4.291	2.626	4.225
20.	4.518	2.839	4.399	2.701	4.346
50.	4.642	2.900	4.499	2.767	4.454
100.	4.822	2.982	4.641	2.846	4.604
200.	5.070	3.054	4.865	2.942	4.862
300.	5.213	3.090	5.024	2.999	5.020
400.	5.318	3.120	5.163	3.040	5.137
500.	5.411	3.146	5.277	3.068	5.244
600.	5.484	3.174	5.357	3.094	5.344
700.	5.547	3.200	5.427	3.121	5.426
800.	5.605	3.224	5.494	3.146	5.480
900.	5.670	3.247	5.557	3.173	5.530
1000.	5.732	3.270	5.474	3.202	5.575

Name

Ranier Mesa member, Timber Mountain tuff, 70-9

Source and Description

120.4-m depth of hole UE19e, Area 19, Nevada Test Site, Nye County, Nevada.
A gray, dense, vitrified welded ash flow tuff.

Physical Properties

Density — 2.33 Mg/m^3

Total porosity — unavailable

Saturation — air dry

Note — Treated as transversely isotropic, direction normal to the bedding labeled 3.

IRANIER MESA MEMBER, TIMBER MOUNTAIN TUFF, 70-9

PRESSURE(MPA)	C11	C66	C33	C44	C13	C12
0.	14.83	6.71	19.30	3.90	16.61	1.42
5.	25.68	8.05	25.43	4.32	14.00	9.58
10.	29.33	9.06	29.29	4.74	16.97	11.22
20.	34.01	10.77	33.00	5.10	20.12	12.47
40.	39.11	12.28	38.19	5.66	26.54	14.55
60.	42.99	13.39	42.41	6.18	29.55	16.20
80.	46.29	14.36	45.00	6.55	31.90	17.56
100.	48.70	15.14	47.40	6.86	33.60	18.42
150.	53.61	16.73	51.97	7.54	36.28	20.16
200.	57.43	17.88	55.15	8.09	37.16	21.68
300.	62.85	19.26	59.49	8.84	39.39	24.34
400.	65.97	19.83	62.75	9.32	41.42	26.30
600.	70.49	20.57	65.67	9.67	43.79	29.36
1000.	72.96	21.16	67.97	10.00	47.30	30.64

70-6-3

IRANIER MESA MEMBER, TIMBER MOUNTAIN TUFF, 70-9

PRESSURE	RHO	E11	E33	P12	P13	P31
0.	2.33	-306.71	-14.65	-23.87	21.40	1.02
5.	2.33	17.78	14.31	0.10	0.49	0.40
10.	2.33	19.40	15.09	0.07	0.54	0.42
20.	2.33	21.74	15.58	0.01	0.60	0.43
40.	2.33	19.93	11.94	-0.19	0.83	0.50
60.	2.34	21.54	12.90	-0.20	0.83	0.50
80.	2.34	22.59	13.12	-0.21	0.86	0.50
100.	2.34	23.71	13.76	-0.22	0.86	0.50
150.	2.34	27.34	16.28	-0.18	0.83	0.49
200.	2.35	32.05	20.25	-0.10	0.74	0.47
300.	2.35	36.68	23.90	-0.05	0.69	0.45
400.	2.36	38.60	25.56	-0.03	0.68	0.45
600.	2.37	41.30	27.27	0.00	0.66	0.44
1000.	2.39	39.91	24.78	-0.06	0.74	0.46

IRANIER MESA MEMBER, TIMBER MOUNTAIN TUFF, 70-9

PRESSURE (MPa)	B11	B33	BVOL
0.	-.01132	0.07129	0.04866
5.	0.02265	0.01439	0.05969
10.	0.02013	0.01081	0.05108
20.	0.01778	0.00862	0.04418
40.	0.01819	0.00090	0.03728
60.	0.01684	0.00011	0.03379
80.	0.01564	0.00005	0.03132
100.	0.01494	-.00009	0.02980
150.	0.01306	0.00101	0.02713
200.	0.01124	0.00299	0.02546
300.	0.00965	0.00403	0.02333
400.	0.00904	0.00400	0.02208
600.	0.00804	0.00451	0.02058
1000.	0.00805	0.00350	0.01961

IRANIER MESA MEMBER, TIMBER MOUNTAIN TUFF, 70-9

PRESSURE(MPA)	VP11	VS12	VP33	VS31	VP45
0.	2.523	1.696	2.878	1.294	2.988
5.	3.319	1.858	3.303	1.362	3.215
10.	3.547	1.971	3.545	1.426	3.458
20.	3.819	2.149	3.762	1.478	3.699
40.	4.093	2.294	4.045	1.557	4.048
60.	4.290	2.394	4.261	1.627	4.255
80.	4.450	2.479	4.388	1.674	4.403
100.	4.563	2.544	4.502	1.713	4.515
150.	4.784	2.672	4.710	1.794	4.714
200.	4.948	2.761	4.849	1.857	4.832
300.	5.170	2.862	5.030	1.938	5.012
400.	5.291	2.901	5.160	1.988	5.135
600.	5.457	2.948	5.268	2.021	5.261
1000.	5.529	2.978	5.337	2.048	5.366

Name

St. Peter sandstone, dry, 70-10

Source

The sample is a well sorted quartz arenite (orthoquartzite)¹ obtained from M. E. Hopkins of the Illinois Geological Survey. The material came from a depth of 30 m in a well in Section 4, T16N, R8E, Douglas County, Illinois.

Physical Properties

Density – 2.27 Mg/m³

Total porosity – unavailable, estimated from quartz density to be about 14%

Saturation – air dry

1. F. J. Pettijohn, P. E. Potter, and R. Siever, Sand and Sandstone (Springer Verlag, New York, 1972) p. 215.

1ST. PETER SANDSTONE, DRY, 70-10

POROSITY=NO DATA

LENGTH=26.30 MM

DELTA=0.010

PRESSURE (MPA)	RHO (MG/CM)	VP (KM/S)	VS (KM/S)	K (GPA)	MU (GPA)	POISSONS R	YOUNGS MOD (GPA)	LAME CONST
0.	2.270	3.82	2.10	19.78	9.97	0.284	25.61	13.14
10.	2.271	4.34	2.49	24.06	14.03	0.256	35.24	14.70
20.	2.272	4.70	2.93	24.18	19.56	0.181	46.22	11.14
40.	2.274	4.89	3.06	25.96	21.24	0.179	50.07	11.79
60.	2.276	4.95	3.12	26.25	22.11	0.171	51.79	11.51
80.	2.277	4.98	3.15	26.25	22.60	0.166	52.68	11.19
100.	2.279	4.99	3.16	26.47	22.77	0.166	53.08	11.29
150.	2.283	5.02	3.17	26.85	23.00	0.167	53.68	11.51
200.	2.288	5.04	3.19	27.15	23.30	0.166	54.35	11.62
300.	2.296	5.09	3.21	27.87	23.67	0.169	55.34	12.09
400.	2.304	5.12	3.24	28.17	24.11	0.167	56.28	12.09
500.	2.313	5.14	3.25	28.39	24.44	0.166	56.98	12.10
600.	2.321	5.14	3.26	28.54	24.65	0.165	57.43	12.11
700.	2.329	5.15	3.28	28.53	24.99	0.161	58.03	11.87
800.	2.337	5.16	3.29	28.47	25.28	0.157	58.51	11.62
900.	2.346	5.16	3.29	28.58	25.44	0.157	58.85	11.62
1000.	2.354	5.16	3.30	28.44	25.59	0.154	59.06	11.38

70-10-2

1ST.PETER SANDSTONE.DRY.70-10

POROSITY=NO DATA

LENGTH=26.30 MM

DELTA=0.010

PRESSURE(MPA)	COMPRESS(GPA-1)	MEAN VEL	LNVP	LNVS	BULK VEL	LN RHO/RHOZERO	PHI(KM/S)SQ	V(DM3/KG),
0.	0.0505	2.34	1.339	0.740	2.95	0.	8.72	0.4405
10.	0.0416	2.76	1.468	0.910	3.26	0.0005	10.59	0.4403
20.	0.0414	3.23	1.548	1.077	3.26	0.0009	10.64	0.4401
40.	0.0385	3.37	1.586	1.117	3.38	0.0017	11.42	0.4398
60.	0.0381	3.43	1.599	1.137	3.40	0.0025	11.54	0.4394
80.	0.0381	3.47	1.605	1.147	3.40	0.0032	11.53	0.4391
100.	0.0378	3.48	1.608	1.151	3.41	0.0040	11.61	0.4388
150.	0.0373	3.49	1.613	1.155	3.43	0.0059	11.76	0.4379
200.	0.0368	3.51	1.618	1.160	3.45	0.0078	11.87	0.4371
300.	0.0359	3.53	1.627	1.167	3.48	0.0114	12.14	0.4355
400.	0.0355	3.56	1.632	1.174	3.50	0.0150	12.22	0.4340
500.	0.0352	3.58	1.636	1.179	3.50	0.0186	12.28	0.4324
600.	0.0350	3.59	1.638	1.181	3.51	0.0222	12.30	0.4309
700.	0.0351	3.60	1.640	1.187	3.50	0.0257	12.25	0.4294
800.	0.0351	3.61	1.640	1.190	3.49	0.0292	12.18	0.4278
900.	0.0350	3.62	1.641	1.192	3.49	0.0328	12.18	0.4263
1000.	0.0352	3.62	1.640	1.193	3.48	0.0363	12.08	0.4248

70-10-8

ST. PETER SANDSTONE, DRY, 70-10

ST. PETER SANDSTONE, DRY, 70-10

Name

St. Peter sandstone, 50% saturated, 70-11

Source

The sample is a well sorted quartz arenite (orthoquartzite)¹ obtained from M. E. Hopkins of the Illinois Geological Survey. The material came from a depth of 30 m in a well in Section 4, T16N, R8E, Douglas County, Illinois.

Physical Properties

Density - 2.29 Mg/m^3

Total porosity - unavailable, estimated from quartz density to be about 14%

Saturation - 50% water, 1/2 weight of total water of saturation

Note - Travel times measured normal to bedding.

1. F. J. Pettijohn, P. E. Potter, and R. Siever, Sand and Sandstone (Springer Verlag, New York, 1972) p. 215.

1ST.PETER SANDSTONE. 50 PERCENT SATURATED.70-11

POROSITY=NO DATA

LENGTH=26.33 MM

DELTA=0.010

PRESSURE(MPA)	RHO(MG/CM)	VP(KM/S)	VS(KM/S)	K(GPA)	MU(GPA)	POISSONS R	YOUNGS MOD (GPA)	LAME CONST
0.	2.290	3.94	2.63	14.39	15.81	0.098	34.72	3.85
10.	2.291	4.42	2.72	22.21	16.98	0.195	40.60	10.89
20.	2.292	4.58	2.80	24.02	18.01	0.200	43.23	12.01
40.	2.294	4.66	2.85	24.85	18.69	0.199	44.82	12.39
60.	2.296	4.69	2.88	24.98	19.06	0.196	45.59	12.27
80.	2.298	4.71	2.90	25.05	19.36	0.193	46.19	12.14
100.	2.300	4.73	2.92	25.22	19.58	0.192	46.67	12.17
150.	2.304	4.77	2.95	25.84	19.99	0.192	47.68	12.51
200.	2.309	4.82	2.95	26.74	20.14	0.199	48.30	13.31
300.	2.317	4.89	2.98	27.99	20.54	0.205	49.50	14.30
400.	2.325	4.94	2.99	29.08	20.80	0.211	50.38	15.22
500.	2.333	4.98	3.00	29.95	21.01	0.216	51.08	15.94
600.	2.341	5.01	3.01	30.46	21.18	0.218	51.58	16.34
700.	2.349	5.03	3.01	31.04	21.30	0.221	52.01	16.84
800.	2.357	5.05	3.01	31.59	21.37	0.224	52.32	17.34
900.	2.364	5.07	3.02	32.07	21.49	0.226	52.71	17.74
1000.	2.371	5.08	3.01	32.43	21.54	0.228	52.91	18.07

1ST.PETER SANDSTONE, 50 PERCENT SATURATED,70-11

POROSITY=NO DATA

LENGTH=26.33 MM

DELTA=0.010

PRESSURE(MPA)	COMPRESS(GPA-1)	MEAN VEL	LNVP	LNVS	BULK VEL	LN RHO/RHOZERO	PHI(KM/S)SQ	V(DM3/KG),
0.	0.0695	2.87	1.370	0.966	2.51	0.	6.28	0.4367
10.	0.0450	3.00	1.487	1.001	3.11	0.0006	9.69	0.4364
20.	0.0416	3.09	1.521	1.031	3.24	0.0010	10.48	0.4362
40.	0.0402	3.15	1.538	1.049	3.29	0.0018	10.83	0.4359
60.	0.0400	3.18	1.544	1.058	3.30	0.0026	10.88	0.4355
80.	0.0399	3.20	1.549	1.066	3.30	0.0034	10.90	0.4352
100.	0.0396	3.22	1.553	1.071	3.31	0.0042	10.97	0.4348
150.	0.0387	3.25	1.563	1.080	3.35	0.0062	11.21	0.4340
200.	0.0374	3.26	1.572	1.083	3.40	0.0081	11.58	0.4331
300.	0.0357	3.29	1.587	1.091	3.48	0.0118	12.08	0.4315
400.	0.0344	3.31	1.598	1.095	3.54	0.0154	12.51	0.4300
500.	0.0334	3.32	1.606	1.099	3.58	0.0188	12.83	0.4286
600.	0.0328	3.33	1.611	1.101	3.61	0.0221	13.01	0.4271
700.	0.0322	3.33	1.616	1.102	3.64	0.0254	13.21	0.4257
800.	0.0317	3.33	1.619	1.102	3.66	0.0286	13.40	0.4244
900.	0.0312	3.34	1.623	1.104	3.68	0.0318	13.57	0.4230
1000.	0.0308	3.34	1.625	1.103	3.70	0.0349	13.68	0.4217

70-11-3

ST. PETER SANDSTONE, 50 PERCENT SATURATED, 70-11

ST. PETER SANDSTONE, 50 PERCENT SATURATED, 70-11

Name

Indian Trail tuff, subunit 4C (I), 71-1

Source and Description

Tunnel U-16a.06, Area 16, Nevada Test Site, Nye County, Nevada. Material was recovered from the end of the tunnel, 6-7 m east of a large excavated cavity. A massive zeolitized ash-fall tuff.

Physical Properties

Density - 1.96 Mg/m^3

Total porosity - ~23%

Saturation - 83% saturated; ~14 wt% water

Note - Attendant report describing complete physical properties measurements, H. C. Heard, R. N. Schock, and D. R. Stephens, High-Pressure Mechanical Properties of Tuff from the Diamond Mine Site, Lawrence Livermore Laboratory, Rept. UCRL-51099 (1971).

1 INDIAN TRAIL TUFF, SUB-UNIT 4C(1), 71-1

POROSITY=23.00

LENGTH=25.36 MM

DELTA=0.010

PRESSURE(MPA)	RHO(MG/CM)	VP(KM/S)	VS(KM/S)	K(GPA)	MU(GPA)	POISSONS R	YOUNGS MOD (GPA)	LAME CONST
0.	1.960	3.17	1.72	12.05	5.77	0.294	14.93	8.20
5.	1.961	3.22	1.77	12.12	6.14	0.283	15.76	8.02
10.	1.962	3.25	1.79	12.30	6.28	0.282	16.10	8.11
20.	1.963	3.30	1.82	12.74	6.48	0.283	16.62	8.42
40.	1.966	3.36	1.86	13.23	6.77	0.281	17.36	8.71
60.	1.969	3.41	1.89	13.45	7.06	0.277	18.03	8.74
80.	1.972	3.44	1.93	13.58	7.33	0.271	18.63	8.70
100.	1.975	3.47	1.96	13.70	7.58	0.266	19.21	8.65
200.	1.989	3.62	2.08	14.58	8.60	0.254	21.55	8.85
300.	2.003	3.74	2.17	15.52	9.39	0.248	23.43	9.26
400.	2.015	3.85	2.23	16.55	10.04	0.248	25.04	9.86
500.	2.027	3.95	2.28	17.62	10.50	0.251	26.27	10.62
600.	2.039	4.03	2.31	18.65	10.85	0.256	27.26	11.42
700.	2.049	4.11	2.33	19.88	11.09	0.265	28.06	12.48
800.	2.059	4.19	2.35	20.96	11.34	0.271	28.82	13.40
900.	2.069	4.26	2.37	22.04	11.60	0.276	29.60	14.31
1000.	2.078	4.33	2.39	23.23	11.84	0.282	30.36	15.34

1 INDIAN TRAIL TUFF, SUB-UNIT 4C(1), 71-1

POROSITY=23.00

LENGTH=25.36 MM

DELTA=0.010

PRESSURE(MPA)	COMPRESS(GPA-1)	MEAN VEL	LNVP	LNVS	BULK VEL	LN RHO/RHOZERO	PHI(KM/S)SQ	V(DM3/KG),
0.	0.0830	1.92	1.155	0.540	2.48	0.	6.15	0.5102
5.	0.0825	1.97	1.169	0.571	2.49	0.0004	6.18	0.5100
10.	0.0813	1.99	1.177	0.582	2.50	0.0008	6.27	0.5098
20.	0.0785	2.03	1.194	0.597	2.55	0.0016	6.49	0.5094
40.	0.0756	2.07	1.213	0.618	2.59	0.0032	6.73	0.5086
60.	0.0743	2.11	1.226	0.639	2.61	0.0047	6.83	0.5078
80.	0.0736	2.15	1.236	0.656	2.62	0.0062	6.89	0.5070
100.	0.0730	2.18	1.245	0.673	2.63	0.0077	6.94	0.5063
200.	0.0686	2.31	1.286	0.732	2.71	0.0148	7.33	0.5027
300.	0.0645	2.40	1.319	0.772	2.78	0.0215	7.75	0.4993
400.	0.0604	2.48	1.349	0.803	2.87	0.0278	8.21	0.4962
500.	0.0568	2.53	1.373	0.822	2.95	0.0338	8.69	0.4933
600.	0.0536	2.56	1.394	0.836	3.03	0.0393	9.15	0.4905
700.	0.0503	2.59	1.414	0.844	3.11	0.0446	9.70	0.4880
800.	0.0477	2.61	1.432	0.853	3.19	0.0495	10.18	0.4856
900.	0.0454	2.64	1.449	0.862	3.26	0.0542	10.65	0.4833
1000.	0.0430	2.66	1.466	0.870	3.34	0.0587	11.18	0.4811

INDIAN TRAIL TUFF, SUB-UNIT 4C(I), 71-1

INDIAN TRAIL TUFF, SUB-UNIT 4C(I), 71-1

Name

Indian Trail tuff, subunit 4C (I), 71-1*

Source and Description

Tunnel U-16a.06, Area 16, Nevada Test Site, Nye County, Nevada. Material was recovered from the end of the tunnel 6-7 m east of a large excavated cavity. A massive zeolitized ash-fall tuff.

Physical Properties

Density - 1.96 Mg/m^3

Total porosity - ~23%

Saturation - 83% saturated; ~14 wt% water

Note - Attendant report describing complete physical properties measurements, H. C. Heard, R. N. Schock, and D. R. Stephens, High-Pressure Mechanical Properties of Tuff from the Diamond Mine Site, Lawrence Livermore Laboratory, Rept. UCRL-51099 (1971).

*Length changes calculated using measured strain data.

INDIAN TRAIL TUFF.SUB-UNIT 4C(I),71-1 *

POROSITY=23.00

LENGTH=25.36 MM

DELTA=0.010

PRESSURE(MPA)	RHO(MG/CM)	VP(KM/S)	VS(KM/S)	K(GPA)	MU(GPA)	POISSONS R	YOUNGS MOD (GPA)	LAME CONST
0.	1.960	3.17	1.72	12.05	5.77	0.294	14.93	8.20
5.	1.963	3.22	1.77	12.12	6.14	0.283	15.76	8.03
10.	1.965	3.24	1.79	12.31	6.28	0.282	16.11	8.12
20.	1.968	3.30	1.82	12.75	6.49	0.283	16.64	8.43
40.	1.984	3.35	1.85	13.26	6.79	0.281	17.41	8.74
60.	2.004	3.39	1.88	13.53	7.11	0.277	18.14	8.80
80.	2.046	3.40	1.90	13.75	7.42	0.271	18.87	8.81
100.	2.062	3.42	1.93	13.91	7.70	0.266	19.50	8.78
200.	2.091	3.56	2.05	14.84	8.75	0.254	21.93	9.00
300.	2.114	3.68	2.13	15.82	9.57	0.248	23.89	9.44
400.	2.135	3.78	2.19	16.90	10.25	0.248	25.57	10.07
500.	2.154	3.87	2.23	18.01	10.73	0.251	26.86	10.86
600.	2.171	3.95	2.26	19.09	11.10	0.256	27.90	11.69
700.	2.187	4.03	2.28	20.37	11.37	0.265	28.75	12.79
800.	2.207	4.10	2.30	21.51	11.64	0.271	29.59	13.75
900.	2.222	4.16	2.32	22.65	11.92	0.276	30.42	14.71
1000.	2.236	4.24	2.33	23.89	12.18	0.282	31.23	15.77

1 INDIAN TRAIL TUFF, SUB-UNIT 4C(1), 71-1 *

POROSITY=23.00

LENGTH=25.36 MM

DELTA=0.010

PRESSURE(MPA)	COMPRESS(GPA-1)	MEAN VEL	LNVP	LNVS	BULK VEL	LN RHO/RHOZERO	PHI(KM/S)SQ	V(DM3/KG)
0.	0.0830	1.92	1.155	0.540	2.48	0.	6.15	0.5102
5.	0.0825	1.97	1.168	0.570	2.49	0.0016	6.18	0.5094
10.	0.0813	1.99	1.177	0.581	2.50	0.0025	6.26	0.5089
20.	0.0784	2.02	1.193	0.596	2.55	0.0042	6.48	0.5081
40.	0.0754	2.06	1.210	0.615	2.59	0.0121	6.69	0.5041
60.	0.0739	2.10	1.220	0.633	2.60	0.0222	6.75	0.4990
80.	0.0727	2.12	1.224	0.644	2.59	0.0429	6.72	0.4888
100.	0.0719	2.15	1.231	0.658	2.60	0.0509	6.74	0.4849
200.	0.0674	2.27	1.270	0.716	2.66	0.0645	7.10	0.4783
300.	0.0632	2.36	1.302	0.755	2.74	0.0757	7.48	0.4730
400.	0.0592	2.43	1.331	0.784	2.81	0.0854	7.92	0.4684
500.	0.0555	2.48	1.354	0.803	2.89	0.0943	8.36	0.4643
600.	0.0524	2.51	1.374	0.816	2.97	0.1020	8.80	0.4607
700.	0.0491	2.54	1.394	0.824	3.05	0.1098	9.31	0.4571
800.	0.0465	2.56	1.410	0.831	3.12	0.1188	9.75	0.4531
900.	0.0441	2.58	1.427	0.840	3.19	0.1256	10.19	0.4500
1000.	0.0419	2.60	1.444	0.847	3.27	0.1317	10.69	0.4472

THE VOLUME CHANGE TO MAXIMUM PRESSURE IS 0.123

INDIAN TRAIL TUFF, SUB-UNIT 4C(I), 71-1 *

INDIAN TRAIL TUFF, SUB-UNIT 4C(I), 71-1 *

Name

Indian Trail tuff, subunit 4C (II), 71-2

Source and Description

Tunnel U-16a.06, Area 16, Nevada Test Site, Nye County, Nevada. Material was recovered from 10-15 m in instrument hole PI-3. A massive zeolitized ash-fall tuff.

Physical Properties

Density - 1.905 Mg/m^3

Total porosity - unavailable

Saturation - ~80% saturated; ~15 wt% water

Note - Attendant report describing complete physical properties measurements, H. C. Heard, R. N. Schock, and D. R. Stephens, High-Pressure Mechanical Properties of Tuff from the Diamond Mine Site, Lawrence Livermore Laboratory, Rept. UCRL-51099 (1971).

1 INDIAN TRAIL TUFF, SUB-UNIT 4C(II), 71-2

POROSITY=NO DATA

LENGTH=25.41 MM

DELTA=0.010

PRESSURE(MPA)	RHO(MG/CM)	VP(KM/S)	VS(KM/S)	K(GPA)	MU(GPA)	POISSONS R	YOUNGS MOD (GPA)	LAME CONST
0.	1.905	3.10	1.67	11.27	5.28	0.297	13.71	7.75
5.	1.906	3.17	1.73	11.51	5.71	0.287	14.70	7.71
10.	1.907	3.20	1.75	11.64	5.87	0.284	15.07	7.73
20.	1.908	3.23	1.78	11.90	6.02	0.284	15.45	7.88
40.	1.912	3.28	1.81	12.29	6.24	0.283	16.01	8.13
60.	1.915	3.32	1.83	12.55	6.38	0.283	16.36	8.30
80.	1.918	3.35	1.84	12.80	6.49	0.283	16.66	8.47
100.	1.921	3.37	1.85	13.02	6.59	0.283	16.92	8.63
200.	1.935	3.50	1.90	14.39	7.00	0.291	18.07	9.72
300.	1.948	3.62	1.95	15.67	7.38	0.297	19.13	10.75
400.	1.960	3.72	1.99	16.76	7.75	0.300	20.14	11.60
500.	1.972	3.81	2.03	17.84	8.11	0.303	21.12	12.44
600.	1.982	3.89	2.07	18.78	8.46	0.304	22.06	13.14
700.	1.993	3.97	2.10	19.62	8.80	0.305	22.97	13.76
800.	2.003	4.04	2.14	20.44	9.15	0.305	23.89	14.34
900.	2.013	4.10	2.18	21.08	9.52	0.304	24.83	14.73
1000.	2.022	4.15	2.21	21.66	9.90	0.302	25.77	15.06

1 INDIAN TRAIL TUFF, SUB-UNIT 4C(II), 71-2

POROSITY=NO DATA

LENGTH=25.41 MM

DELTA=0.010

PRESSURE(MPA)	COMPRESS(GPA-1)	MEAN VEL	LNVP	LNVS	BULK VEL	LN RHO/RHOZERO	PHI(KM/S)SQ	V(DM3/KG)
0.	0.0887	1.86	1.132	0.510	2.43	0.	5.92	0.5249
5.	0.0868	1.93	1.153	0.549	2.46	0.0004	6.04	0.5247
10.	0.0859	1.96	1.162	0.562	2.47	0.0009	6.11	0.5245
20.	0.0841	1.98	1.173	0.574	2.50	0.0017	6.23	0.5240
40.	0.0814	2.01	1.189	0.591	2.54	0.0034	6.43	0.5231
60.	0.0797	2.03	1.199	0.602	2.56	0.0050	6.56	0.5223
80.	0.0781	2.05	1.207	0.610	2.58	0.0066	6.67	0.5215
100.	0.0768	2.07	1.215	0.616	2.60	0.0082	6.78	0.5207
200.	0.0695	2.12	1.253	0.643	2.73	0.0156	7.43	0.5168
300.	0.0638	2.17	1.286	0.666	2.84	0.0223	8.05	0.5134
400.	0.0597	2.22	1.313	0.687	2.92	0.0285	8.55	0.5102
500.	0.0560	2.27	1.338	0.707	3.01	0.0344	9.05	0.5072
600.	0.0533	2.31	1.359	0.725	3.08	0.0399	9.47	0.5044
700.	0.0510	2.35	1.378	0.743	3.14	0.0451	9.85	0.5018
800.	0.0489	2.39	1.395	0.760	3.19	0.0502	10.20	0.4992
900.	0.0474	2.43	1.410	0.777	3.24	0.0550	10.47	0.4968
1000.	0.0462	2.47	1.423	0.794	3.27	0.0598	10.71	0.4945

INDIAN TRAIL TUFF, SUB-UNIT 4C(II), 71-2

INDIAN TRAIL TUFF, SUB-UNIT 4C(II), 71-2

Name

Indian Trail tuff, subunit 4C (III), 71-3

Source and Description

Tunnel U-16a.06, Area 16, Nevada Test Site, Nye County, Nevada. Material was recovered from 10-15 m in instrument hole GGA-1. A massive zeolitized ash-fall tuff.

Physical Properties

Density - 1.850 Mg/m^3

Total porosity - unavailable

Saturation - ~80% saturated; ~15 wt% water

Note - Attendant report describing complete physical properties measurements, H. C. Heard, R. N. Schock, and D. R. Stephens, High-Pressure Mechanical Properties of Tuff from the Diamond Mine Site, Lawrence Livermore Laboratory, Rept. UCRL-51099 (1971).

1 INDIAN TRAIL TUFF, SUB-UNIT 4C(III), 71-3

POROSITY=NO DATA

LENGTH=25.36 MM

DELTA=0.010

PRESSURE (MPA)	RHO (MG/CM)	VP (KM/S)	VS (KM/S)	K (GPA)	MU (GPA)	POISSONS R	YOUNGS MOD (GPA)	LAME CONST
0.	1.850	3.21	1.62	12.57	4.87	0.328	12.94	9.32
5.	1.851	3.26	1.64	12.94	5.00	0.329	13.30	9.60
10.	1.851	3.28	1.66	13.12	5.10	0.328	13.54	9.72
20.	1.853	3.31	2.09	9.48	8.10	0.167	18.92	4.08
40.	1.856	3.36	1.71	13.69	5.40	0.326	14.32	10.09
60.	1.859	3.40	1.73	14.12	5.56	0.326	14.75	10.41
80.	1.862	3.45	1.75	14.62	5.68	0.328	15.08	10.83
100.	1.864	3.50	1.76	15.11	5.78	0.330	15.39	11.25
200.	1.876	3.69	1.81	17.27	6.15	0.341	16.50	13.17
300.	1.886	3.82	1.85	18.88	6.46	0.347	17.39	14.58
400.	1.896	3.92	1.88	20.22	6.73	0.350	18.18	15.73
500.	1.905	4.02	1.91	21.57	6.97	0.354	18.88	16.92
600.	1.914	4.05	1.94	21.78	7.22	0.351	19.51	16.97
700.	1.923	4.20	1.97	23.93	7.50	0.358	20.36	18.94
800.	1.931	4.29	2.01	25.10	7.76	0.360	21.11	19.92
900.	1.938	4.37	2.03	26.28	7.99	0.362	21.76	20.96
1000.	1.946	4.45	2.05	27.52	8.20	0.365	22.37	22.05

71-3-2

1 INDIAN TRAIL TUFF, SUB-UNIT 4C(III), 71-3

POROSITY=NO DATA

LENGTH=25.36 MM

DELTA=0.010

PRESSURE(MPA)	COMPRESS(GPA-1)	MEAN VEL	LNVP	LNVS	BULK VEL	LN RHO/RHOZERO	PHI(KM/S)SQ	V(DM3/KG),
0.	0.0796	1.82	1.166	0.484	2.61	0.	6.80	0.5405
5.	0.0773	1.84	1.180	0.497	2.64	0.0004	6.99	0.5403
10.	0.0762	1.86	1.188	0.506	2.66	0.0008	7.09	0.5401
20.	0.1054	2.30	1.197	0.738	2.26	0.0017	5.12	0.5396
40.	0.0730	1.91	1.210	0.534	2.72	0.0034	7.38	0.5387
60.	0.0708	1.94	1.225	0.548	2.76	0.0049	7.59	0.5379
80.	0.0684	1.96	1.239	0.558	2.80	0.0063	7.85	0.5372
100.	0.0662	1.98	1.252	0.566	2.85	0.0076	8.10	0.5364
200.	0.0579	2.03	1.304	0.594	3.03	0.0139	9.21	0.5331
300.	0.0530	2.08	1.340	0.615	3.16	0.0195	10.01	0.5301
400.	0.0495	2.12	1.367	0.633	3.27	0.0246	10.66	0.5274
500.	0.0464	2.15	1.392	0.648	3.36	0.0295	11.32	0.5248
600.	0.0459	2.18	1.399	0.664	3.37	0.0341	11.38	0.5224
700.	0.0418	2.22	1.435	0.680	3.53	0.0385	12.45	0.5201
800.	0.0398	2.26	1.455	0.696	3.61	0.0427	13.00	0.5180
900.	0.0380	2.29	1.474	0.708	3.68	0.0466	13.56	0.5159
1000.	0.0363	2.31	1.492	0.719	3.76	0.0503	14.14	0.5140

71-3-3

INDIAN TRAIL TUFF, SUB-UNIT 4C(III), 71-3

Name

Indian Trail tuff, subunit 4C (IV), 71-4

Source

Tunnel U-16a.06, Area 16, Nevada Test Site, Nye County, Nevada. Material was recovered from 10-15 m in instrument hole GGA-2.

Physical Properties

Density — 1.925 Mg/m^3

Total porosity — unavailable

Saturation — ~80%; ~15 wt% water

Note — Attendant report describing complete physical properties measurements, H. C. Heard, R. N. Schock, and D. R. Stephens, High-Pressure Mechanical Properties of Tuff from the Diamond Mine Site, Lawrence Livermore Laboratory, Rept. UCRL-51099 (1971).

1 INDIAN TRAIL TUFF, SUB-UNIT 4C(IV), 71-4

POROSITY=NO DATA		LENGTH=25.44 MM				DELTA=0.010		
PRESSURE(MPA)	RHO(MG/CM)	VP(KM/S)	VS(KM/S)	K(GPA)	MU(GPA)	POISSONS R	YOUNGS MOD (GPA)	LAME CONST
0.	1.925	3.14	1.60	12.40	4.94	0.324	13.08	9.11
5.	1.926	3.26	1.70	13.02	5.54	0.314	14.55	9.33
10.	1.927	3.29	1.72	13.18	5.72	0.310	14.99	9.36
20.	1.928	3.31	1.76	13.21	5.96	0.304	15.55	9.24
40.	1.931	3.35	1.80	13.34	6.27	0.297	16.27	9.16
60.	1.934	3.39	1.83	13.63	6.46	0.295	16.73	9.33
80.	1.937	3.43	1.85	13.95	6.61	0.295	17.13	9.54
100.	1.939	3.46	1.87	14.24	6.75	0.295	17.49	9.74
200.	1.952	3.63	1.92	16.14	7.16	0.307	18.72	11.37
300.	1.964	3.77	1.96	17.79	7.55	0.314	19.84	12.76
400.	1.975	3.88	2.00	19.12	7.93	0.318	20.89	13.84
500.	1.985	3.98	2.04	20.37	8.28	0.321	21.87	14.85
600.	1.995	4.07	2.08	21.47	8.65	0.322	22.89	15.70
700.	2.004	4.14	2.12	22.35	9.02	0.322	23.86	16.34
800.	2.013	4.22	2.16	23.35	9.37	0.323	24.78	17.11
900.	2.021	4.29	2.20	24.14	9.74	0.322	25.76	17.64
1000.	2.030	4.35	2.23	24.87	10.11	0.321	26.71	18.14

1 INDIAN TRAIL TUFF, SUB-UNIT 4C(IV), 71-4

POROSITY=NO DATA

LENGTH=25.44 MM

DELTA=0.010

PRESSURE(MPA)	COMPRESS(GPA-1)	MEAN VEL	LNVP	LNVS	BULK VEL	LN RHO/RHOZERO	PHI(KM/S)SQ	V(DM3/KG),
0.	0.0806	1.80	1.144	0.471	2.54	0.	6.44	0.5195
5.	0.0768	1.90	1.180	0.528	2.60	0.0004	6.76	0.5193
10.	0.0759	1.93	1.190	0.544	2.62	0.0008	6.84	0.5191
20.	0.0757	1.97	1.198	0.564	2.62	0.0015	6.85	0.5187
40.	0.0750	2.01	1.210	0.589	2.63	0.0031	6.91	0.5179
60.	0.0734	2.04	1.221	0.603	2.66	0.0046	7.05	0.5171
80.	0.0717	2.06	1.232	0.614	2.68	0.0060	7.20	0.5164
100.	0.0702	2.08	1.242	0.624	2.71	0.0075	7.34	0.5156
200.	0.0619	2.14	1.289	0.650	2.88	0.0141	8.27	0.5122
300.	0.0562	2.19	1.326	0.673	3.01	0.0201	9.06	0.5092
400.	0.0523	2.24	1.355	0.695	3.11	0.0255	9.68	0.5064
500.	0.0491	2.29	1.381	0.714	3.20	0.0307	10.26	0.5038
600.	0.0466	2.33	1.403	0.734	3.28	0.0355	10.77	0.5014
700.	0.0447	2.38	1.421	0.752	3.34	0.0401	11.16	0.4991
800.	0.0428	2.42	1.440	0.769	3.41	0.0445	11.60	0.4969
900.	0.0414	2.46	1.455	0.786	3.46	0.0488	11.94	0.4948
1000.	0.0402	2.50	1.469	0.803	3.50	0.0529	12.26	0.4927

INDIAN TRAIL TUFF, SUB-UNIT 4C(IV), 71-4

INDIAN TRAIL TUFF, SUB-UNIT 4C(IV), 71-4

Name

Climax stock granodiorite, 71-5

Source

Climax stock, Area 15, Nevada Test Site, Nye County, Nevada. Sample from near the site of Piledriver nuclear experiment.

Physical Properties

Density - 2.665 Mg/m^3

Total porosity - unavailable

Saturation - air dry

Note - Attendant report describing complete physical properties, R. N. Schock, H. C. Heard, and D. R. Stephens, J. Geophys. Res. 78, 5922 (1973).

1CLIMAX STOCK GRANODIORITE.71-5

POROSITY=NO DATA

LENGTH=26.61 MM

DELTA=0.010

PRESSURE(MPA)	RHO(MG/CM)	VP(KM/S)	VS(KM/S)	K(GPA)	MU(GPA)	POISSONS R	YOUNGS MOD (GPA)	LAME CONST
0.	2.665	5.70	3.19	50.54	27.13	0.272	69.04	32.45
10.	2.666	5.91	3.26	55.50	28.27	0.282	72.51	36.65
20.	2.666	6.06	3.30	59.29	28.98	0.290	74.76	39.97
30.	2.666	6.16	3.31	62.11	29.27	0.296	75.89	42.59
40.	2.667	6.21	3.33	63.48	29.49	0.299	76.61	43.81
60.	2.668	6.27	3.35	64.83	29.94	0.300	77.84	44.87
80.	2.669	6.31	3.37	65.78	30.25	0.301	78.69	45.61
100.	2.669	6.34	3.38	66.49	30.48	0.301	79.33	46.17
200.	2.673	6.41	3.43	68.12	31.37	0.300	81.59	47.21
300.	2.677	6.45	3.46	68.62	31.96	0.298	82.99	47.32
400.	2.681	6.47	3.47	69.24	32.23	0.299	83.69	47.76
600.	2.689	6.51	3.47	70.75	32.43	0.301	84.39	49.13
800.	2.697	6.54	3.47	72.11	32.50	0.304	84.76	50.44
1000.	2.704	6.56	3.47	72.87	32.57	0.305	85.04	51.15

1CLIMAX STOCK GRANODIORITE,71-5

POROSITY=NO DATA

LENGTH=26.61 MM

DELTA=0.010

PRESSURE(MPA)	COMPRESS(GPA-1)	MEAN VEL	LNVP	LNVS	BULK VEL	LN RHO/RHOZERO	PHI(KM/S)SQ	V(DM3/KG),
0.	0.0198	3.55	1.741	1.160	4.36	0.	18.96	0.3752
10.	0.0180	3.63	1.777	1.181	4.56	0.0002	20.82	0.3752
20.	0.0169	3.68	1.802	1.193	4.72	0.0004	22.24	0.3751
30.	0.0161	3.70	1.818	1.198	4.83	0.0005	23.29	0.3750
40.	0.0158	3.71	1.826	1.202	4.88	0.0007	23.80	0.3750
60.	0.0154	3.74	1.835	1.209	4.93	0.0010	24.30	0.3749
80.	0.0152	3.76	1.841	1.214	4.97	0.0013	24.65	0.3747
100.	0.0150	3.78	1.846	1.218	4.99	0.0016	24.91	0.3746
200.	0.0147	3.83	1.858	1.231	5.05	0.0031	25.48	0.3741
300.	0.0146	3.86	1.863	1.240	5.06	0.0046	25.63	0.3735
400.	0.0144	3.87	1.867	1.243	5.08	0.0061	25.83	0.3730
600.	0.0141	3.88	1.873	1.245	5.13	0.0090	26.31	0.3719
800.	0.0139	3.88	1.878	1.245	5.17	0.0118	26.74	0.3708
1000.	0.0137	3.88	1.881	1.244	5.19	0.0146	26.95	0.3698

CLIMAX STOCK GRANODIORITE, 71-5

CLIMAX STOCK GRANODIORITE, 71-5

Name

Climax stock granodiorite, 71-5*

Source

Climax stock, Area 15, Nevada Test Site, Nye County, Nevada. Sample from near the site of Piledriver nuclear experiment.

Physical Properties

Density — 2.665 Mg/m^3

Total porosity — unavailable

Saturation — air dry

Note — Attendant report describing complete physical properties, R. N. Schock, H. C. Heard, and D. R. Stephens, J. Geophys. Res. 78, 5922 (1973).

*Length changes calculated using measured physical property data.

1CLIMAX STOCK GRANODIORITE,71-5 *

POROSITY=NO DATA			LENGTH=26.61 MM			DELTA=0.010		
PRESSURE(MPA)	RHO(MG/CM)	VP(KM/S)	VS(KM/S)	K(GPA)	MU(GPA)	POISSONS R	YOUNGS MOD (GPA)	LAME CONST
0.	2.665	5.70	3.19	50.54	27.13	0.272	69.04	32.45
10.	2.666	5.91	3.26	55.50	28.27	0.282	72.51	36.65
20.	2.667	6.06	3.30	59.29	28.98	0.290	74.76	39.97
30.	2.667	6.16	3.31	62.11	29.27	0.296	75.90	42.60
40.	2.668	6.21	3.33	63.48	29.50	0.299	76.62	43.82
60.	2.669	6.27	3.35	64.85	29.95	0.300	77.86	44.88
80.	2.670	6.30	3.37	65.79	30.26	0.301	78.71	45.62
100.	2.671	6.33	3.38	66.51	30.49	0.301	79.35	46.18
200.	2.677	6.41	3.42	68.15	31.38	0.300	81.62	47.23
300.	2.682	6.44	3.45	68.66	31.98	0.298	83.05	47.34
400.	2.688	6.46	3.46	69.30	32.25	0.299	83.76	47.80
600.	2.697	6.50	3.47	70.82	32.46	0.301	84.48	49.18
800.	2.707	6.53	3.47	72.21	32.54	0.304	84.88	50.51
1000.	2.717	6.55	3.47	72.99	32.63	0.305	85.19	51.24

1CLIMAX STOCK GRANODIORITE.71-5 *

POROSITY=NO DATA			LENGTH=26.61 MM			DELTA=0.010		
PRESSURE(MPA)	COMPRESS(GPA-1)	MEAN VEL	LNVP	LNVS	BULK VEL	LN RHO/RHOZERO	PHI(KM/S)SQ	V(DM3/KG).
0.	0.0198	3.55	1.741	1.160	4.36	0.	18.96	0.3752
10.	0.0180	3.63	1.777	1.181	4.56	0.0003	20.82	0.3751
20.	0.0169	3.68	1.802	1.193	4.72	0.0006	22.24	0.3750
30.	0.0161	3.70	1.818	1.198	4.83	0.0009	23.29	0.3749
40.	0.0158	3.71	1.826	1.201	4.88	0.0011	23.80	0.3748
60.	0.0154	3.74	1.835	1.209	4.93	0.0016	24.29	0.3746
80.	0.0152	3.76	1.841	1.214	4.96	0.0020	24.64	0.3745
100.	0.0150	3.77	1.846	1.217	4.99	0.0024	24.90	0.3743
200.	0.0147	3.83	1.858	1.231	5.05	0.0044	25.46	0.3736
300.	0.0146	3.86	1.863	1.239	5.06	0.0064	25.60	0.3728
400.	0.0144	3.87	1.866	1.242	5.08	0.0084	25.79	0.3721
600.	0.0141	3.88	1.872	1.244	5.12	0.0121	26.26	0.3707
800.	0.0138	3.88	1.877	1.243	5.16	0.0157	26.67	0.3694
1000.	0.0137	3.87	1.879	1.243	5.18	0.0194	26.86	0.3680

THE VOLUME CHANGE TO MAXIMUM PRESSURE IS 0.019

CLIMAX STOCK GRANODIORITE, 71-5 *

CLIMAX STOCK GRANODIORITE, 71-5 #

71-5*-5

Name

Polymethylmethacrylate, 71-6

Source

Rohm and Haas Co.

Physical Properties

Density - 1.185 Mg/m^3

1POLYMETHYLMETHACRYLATE,71-6

POROSITY=NO DATA

LENGTH=25.81 MM

DELTA=0.010

PRESSURE(MPA)	RHO(MG/CM)	VP(KM/S)	VS(KM/S)	K(GPA)	MU(GPA)	POISSONS R	YOUNGS MOD (GPA)	LAME CONST
0.	1.185	2.76	1.40	5.92	2.32	0.327	6.15	4.37
50.	1.195	2.87	1.44	6.53	2.46	0.333	6.56	4.89
100.	1.204	2.97	1.47	7.13	2.59	0.338	6.92	5.41
200.	1.219	3.15	1.53	8.33	2.84	0.347	7.66	6.43
300.	1.233	3.33	1.59	9.49	3.11	0.353	8.40	7.42
400.	1.246	3.47	1.64	10.51	3.35	0.356	9.09	8.27
500.	1.257	3.60	1.69	11.51	3.58	0.359	9.74	9.13
600.	1.268	3.72	1.73	12.50	3.80	0.362	10.35	9.97
700.	1.278	3.84	1.77	13.47	4.00	0.365	10.93	10.80
800.	1.287	3.94	1.81	14.35	4.21	0.366	11.51	11.54
900.	1.296	4.04	1.85	15.28	4.41	0.368	12.07	12.34
1000.	1.304	4.13	1.88	16.11	4.62	0.369	12.65	13.02

1POLYMETHYLMETHACRYLATE.71-6

POROSITY=NO DATA

LENGTH=25.81 MM

DELTA=0.010

PRESSURE(MPA)	COMPRESS(GPA-1)	MEAN VEL	LNVP	LNVS	BULK VEL	LN RHO/RHOZERO	PHI(KM/S)SQ	V(DM3/KG),
0.	0.1690	1.57	1.014	0.336	2.24	0.	4.99	0.8439
50.	0.1531	1.61	1.053	0.362	2.34	0.0081	5.47	0.8371
100.	0.1402	1.65	1.087	0.382	2.43	0.0155	5.93	0.8309
200.	0.1201	1.72	1.148	0.423	2.61	0.0286	6.83	0.8201
300.	0.1053	1.79	1.201	0.462	2.77	0.0399	7.70	0.8109
400.	0.0952	1.85	1.243	0.495	2.90	0.0500	8.44	0.8027
500.	0.0869	1.90	1.281	0.524	3.03	0.0592	9.16	0.7954
600.	0.0800	1.95	1.314	0.549	3.14	0.0676	9.86	0.7887
700.	0.0742	1.99	1.345	0.571	3.25	0.0754	10.54	0.7826
800.	0.0697	2.04	1.371	0.593	3.34	0.0826	11.15	0.7770
900.	0.0655	2.08	1.396	0.612	3.43	0.0895	11.79	0.7717
1000.	0.0621	2.12	1.419	0.633	3.51	0.0959	12.35	0.7667

POLYMETHYLMETHACRYLATE, 71-6

POLYMETHYLMETHACRYLATE, 71-6

Name

Yule marble, 71-7

Source

Yule Creek, Gunnison County, Colorado¹

Physical Properties

Density — 2.70 Mg/m³

Total porosity — unavailable

Saturation — air dry

Note — Treated as transversely isotropic, direction of the principal axis of foliation labeled 3.

1. Same block of material as in H. C. Heard, J. Geol. 71, 162-196 (1963); and H. C. Heard and C. B. Raleigh, Geol. Soc. Amer. Bull. 83, 935-956 (1972).

1YULE MARBLE, 71-7

PRESSURE(MPA)	C11	C66	C33	C44	C13	C12
0.	72.75	24.58	45.64	18.35	40.90	23.59
10.	81.33	26.78	63.52	21.78	52.20	27.77
20.	99.24	29.44	84.21	25.46	58.04	40.37
40.	117.68	31.41	100.19	26.77	64.58	54.87
60.	127.71	32.25	106.29	27.37	65.72	63.21
80.	131.12	32.78	109.41	27.71	67.36	65.57
100.	132.88	33.04	110.49	27.91	68.69	66.79
150.	136.54	33.23	112.15	28.13	68.80	70.07
200.	138.43	33.38	112.99	28.27	68.43	71.67
300.	140.80	33.49	113.31	28.35	70.95	73.82
400.	141.65	33.62	113.43	28.39	71.76	74.42
500.	142.11	33.65	113.61	28.42	71.84	74.81
600.	142.19	33.68	113.62	28.44	72.10	74.83
800.	143.16	33.82	114.26	28.54	72.00	75.53
1000.	143.70	33.96	114.56	28.68	72.39	75.78

1YULE MARBLE, 71-7

PRESSURE	RHO	E11	E33	P12	P13	P31
0.	2.70	31.36	10.91	-0.36	1.22	0.42
10.	2.70	32.47	13.56	-0.39	1.15	0.48
20.	2.70	59.23	35.95	0.01	0.69	0.42
40.	2.70	73.75	51.85	0.17	0.53	0.37
60.	2.70	81.22	61.04	0.26	0.46	0.34
80.	2.70	83.17	63.28	0.27	0.45	0.34
100.	2.70	83.74	63.23	0.27	0.46	0.34
150.	2.71	86.10	66.33	0.30	0.43	0.33
200.	2.71	87.56	68.41	0.31	0.42	0.33
300.	2.71	87.41	66.41	0.31	0.44	0.33
400.	2.71	87.50	65.76	0.30	0.44	0.33
500.	2.72	87.75	66.02	0.30	0.44	0.33
600.	2.72	87.67	65.71	0.30	0.44	0.33
800.	2.73	88.49	66.84	0.31	0.44	0.33
1000.	2.73	88.75	66.81	0.31	0.44	0.33

1YULE MARBLE, 71-7

PRESSURE (MPA)	B11	B33	BVOL
0.	0.00451	0.01383	0.02285
10.	0.00765	0.00317	0.01847
20.	0.00521	0.00469	0.01512
40.	0.00398	0.00485	0.01281
60.	0.00348	0.00510	0.01207
80.	0.00338	0.00498	0.01174
100.	0.00331	0.00493	0.01156
150.	0.00316	0.00504	0.01136
200.	0.00310	0.00510	0.01130
300.	0.00297	0.00510	0.01105
400.	0.00293	0.00511	0.01097
500.	0.00292	0.00511	0.01095
600.	0.00291	0.00511	0.01093
800.	0.00289	0.00511	0.01089
1000.	0.00288	0.00509	0.01085

71-7-4

1YULE MARBLE, 71-7

PRESSURE (MPa)	VP11	VS12	VP33	VS31	VP45
0.	5.191	3.017	4.111	2.607	5.061
10.	5.488	3.149	4.850	2.840	5.589
20.	6.061	3.301	5.584	3.070	6.100
40.	6.600	3.409	6.090	3.148	6.488
60.	6.874	3.455	6.271	3.182	6.637
80.	6.965	3.482	6.362	3.202	6.713
100.	7.011	3.496	6.393	3.213	6.756
150.	7.104	3.505	6.439	3.224	6.799
200.	7.151	3.512	6.461	3.232	6.815
300.	7.208	3.515	6.466	3.234	6.867
400.	7.226	3.520	6.466	3.235	6.882
500.	7.234	3.520	6.468	3.235	6.885
600.	7.231	3.519	6.464	3.234	6.886
800.	7.248	3.523	6.475	3.236	6.889
1000.	7.254	3.526	6.477	3.240	6.897

Name

Mesa Verde sandstone, 72-1

Source and Description

1963.5 m well depth, RB-E-01, Section 14, T3S, R98W, Rio Blanco County, Colorado. A medium- to fine-grained graywacke.

Physical Properties

Density - 2.44 Mg/m^3

Total porosity - 6.8%

Saturation - air dry

Note - Travel times measured normal to bedding.

1MESA VERDE SANDSTONE,72-1

POROSITY= 6.80

LENGTH=24.46 MM

DELTA=0.010

PRESSURE(MPA)	RHO(MG/CM)	VP(KM/S)	VS(KM/S)	K(GPA)	MU(GPA)	POISSONS R	YOUNGS MOD (GPA)	LAME CONST
0.	2.440	3.37	2.13	13.03	11.06	0.169	25.86	5.66
10.	2.442	3.60	2.32	13.99	13.19	0.141	30.11	5.19
20.	2.443	3.90	2.48	17.15	15.00	0.161	34.84	7.15
40.	2.446	4.40	2.70	23.59	17.88	0.197	42.82	11.67
60.	2.448	4.61	2.83	25.95	19.55	0.199	46.89	12.92
80.	2.450	4.74	2.93	27.15	20.97	0.193	50.03	13.17
100.	2.451	4.84	2.95	28.90	21.33	0.204	51.35	14.68
200.	2.460	4.95	3.07	29.47	23.16	0.189	55.06	14.03
300.	2.468	5.00	3.09	30.32	23.51	0.192	56.04	14.64
400.	2.476	5.04	3.10	31.10	23.84	0.195	56.96	15.21
500.	2.484	5.07	3.11	31.80	23.95	0.199	57.44	15.83
600.	2.492	5.08	3.11	32.26	24.07	0.201	57.82	16.21
700.	2.500	5.08	3.11	32.29	24.19	0.200	58.07	16.17
800.	2.508	5.09	3.11	32.65	24.28	0.202	58.37	16.47
900.	2.516	5.09	3.11	32.65	24.33	0.202	58.46	16.43
1000.	2.523	5.09	3.11	32.88	24.42	0.202	58.71	16.60

1MESA VERDE SANDSTONE,7Z-1

POROSITY= 6.80

LENGTH=24.46 MM

DELTA=0.010

PRESSURE(MPA)	COMPRESS(GPA-1)	MEAN VEL	LNVP	LNVS	BULK VEL	LN RHO/RHOZERO	PHI(KM/S)SQ	V(DM3/KG)
0.	0.0767	2.34	1.216	0.756	2.31	0.	5.34	0.4098
10.	0.0715	2.55	1.280	0.844	2.39	0.0007	5.73	0.4095
20.	0.0583	2.72	1.361	0.907	2.65	0.0014	7.02	0.4093
40.	0.0424	2.98	1.482	0.995	3.11	0.0024	9.64	0.4089
60.	0.0385	3.12	1.528	1.039	3.26	0.0032	10.60	0.4085
80.	0.0368	3.23	1.557	1.074	3.33	0.0040	11.08	0.4082
100.	0.0346	3.26	1.576	1.082	3.43	0.0047	11.79	0.4079
200.	0.0339	3.38	1.600	1.121	3.46	0.0081	11.98	0.4065
300.	0.0330	3.40	1.609	1.127	3.50	0.0115	12.28	0.4051
400.	0.0322	3.42	1.617	1.132	3.54	0.0148	12.56	0.4038
500.	0.0314	3.43	1.622	1.133	3.58	0.0180	12.80	0.4025
600.	0.0310	3.43	1.626	1.134	3.60	0.0212	12.94	0.4012
700.	0.0310	3.43	1.626	1.135	3.59	0.0243	12.92	0.4000
800.	0.0306	3.44	1.628	1.135	3.61	0.0274	13.02	0.3988
900.	0.0306	3.43	1.627	1.135	3.60	0.0305	12.98	0.3975
1000.	0.0304	3.44	1.628	1.135	3.61	0.0336	13.03	0.3963

MESA VERDE SANDSTONE, 72-1

Name

Mesa Verde sandstone, 72-1*

Source and Description

1963.5 m well depth, RB-E 01, Section 14, T3S, R98W, Rio Blanco County, Colorado. A medium- to fine-grained graywacke.

Physical Properties

Density - 2.44 Mg/m³

Total porosity - 6.8%

Saturation - air dry

Note - Travel times measured normal to bedding.

* Length changes calculated using measured linear strain data.

1MESA VERDE SANDSTONE.72-1 *

POROSITY= 6.80

LENGTH=24.46 MM

DELTA=0.010

PRESSURE(MPA)	RHO(MG/CM)	VP(KM/S)	VS(KM/S)	K(GPA)	MU(GPA)	POISSONS R	YOUNGS MOD (GPA)	LAME CONST
0.	2.440	3.37	2.13	13.03	11.06	0.169	25.86	5.66
10.	2.454	3.59	2.32	14.01	13.22	0.141	30.16	5.20
20.	2.460	3.89	2.47	17.19	15.03	0.161	34.92	7.17
40.	2.466	4.39	2.70	23.65	17.93	0.197	42.94	11.70
60.	2.470	4.60	2.82	26.03	19.61	0.199	47.03	12.96
80.	2.473	4.73	2.92	27.24	21.04	0.193	50.19	13.22
100.	2.476	4.82	2.94	29.00	21.40	0.204	51.52	14.73
200.	2.488	4.93	3.06	29.58	23.25	0.189	55.27	14.08
300.	2.500	4.98	3.07	30.45	23.61	0.192	56.29	14.71
400.	2.511	5.02	3.09	31.25	23.95	0.195	57.24	15.29
500.	2.523	5.04	3.09	31.97	24.08	0.199	57.75	15.92
600.	2.533	5.05	3.09	32.44	24.21	0.201	58.15	16.31
700.	2.544	5.05	3.09	32.49	24.34	0.200	58.43	16.27
800.	2.553	5.06	3.09	32.86	24.43	0.202	58.74	16.57
900.	2.563	5.06	3.09	32.87	24.49	0.202	58.86	16.55
1000.	2.573	5.06	3.09	33.11	24.59	0.202	59.13	16.72

1MESA VERDE SANDSTONE.72-1 *

POROSITY= 6.88

LENGTH=24.46 MM

DELTA=0.010

PRESSURE(MPA)	COMPRESS(GPA-1)	MEAN VEL	LNVP	LNVS	BULK VEL	LN RHO/RHOZERO	PHI(KM/S)SQ	V(DM3/KG).
0.	0.0767	2.34	1.216	0.756	2.31	0.	5.34	0.4098
10.	0.0714	2.55	1.278	0.842	2.39	0.0058	5.71	0.4075
20.	0.0582	2.72	1.359	0.905	2.64	0.0080	6.99	0.4066
40.	0.0423	2.98	1.480	0.992	3.10	0.0107	9.59	0.4055
60.	0.0384	3.11	1.525	1.036	3.25	0.0121	10.54	0.4049
80.	0.0367	3.22	1.554	1.070	3.32	0.0136	11.01	0.4043
100.	0.0345	3.25	1.573	1.078	3.42	0.0147	11.71	0.4039
200.	0.0338	3.37	1.596	1.117	3.45	0.0196	11.89	0.4019
300.	0.0328	3.39	1.605	1.123	3.49	0.0243	12.18	0.4000
400.	0.0320	3.41	1.613	1.128	3.53	0.0288	12.45	0.3982
500.	0.0313	3.41	1.617	1.128	3.56	0.0333	12.67	0.3964
600.	0.0308	3.41	1.620	1.128	3.58	0.0376	12.81	0.3947
700.	0.0308	3.42	1.620	1.129	3.57	0.0416	12.77	0.3932
800.	0.0304	3.42	1.622	1.129	3.59	0.0454	12.87	0.3916
900.	0.0304	3.41	1.621	1.129	3.58	0.0492	12.83	0.3902
1000.	0.0302	3.41	1.622	1.129	3.59	0.0531	12.87	0.3886

THE VOLUME CHANGE TO MAXIMUM PRESSURE IS 0.052

MESA VERDE SANDSTONE, 72-1 *

MESA VERDE SANDSTONE, 72-1 *

Name

Mesa Verde sandstone, 50% saturated, 72-2

Source and Description

1963.5-m well depth, RB-E-01, Section 14, T3S, R98W, Rio Blanco County, Colorado. A medium- to fine-grained graywacke.

Physical Properties

Density — 2.474 Mg/m³

Total porosity — 6.8%

Saturation — 50% water, one-half weight of total water of saturation.

Note — Travel times measured normal to bedding.

1MESA VERDE SANDSTONE,50 PERCENT SATURATED,72-2

POROSITY= 6.80

LENGTH=24.76 MM

DELTA=0.010

PRESSURE(MPA)	RHO(MG/CM)	VP(KM/S)	VS(KM/S)	K(GPA)	MU(GPA)	POISSONS R	YOUNGS MOD (GPA)	LAME CONST
0.	2.474	3.40	2.12	13.77	11.08	0.183	26.21	6.38
10.	2.475	4.02	2.34	21.98	13.50	0.245	33.62	12.98
20.	2.476	4.50	2.63	27.41	17.06	0.242	42.39	16.03
40.	2.478	4.70	2.90	26.98	20.91	0.192	49.84	13.04
60.	2.480	4.79	3.08	25.40	23.54	0.146	53.96	9.71
80.	2.482	4.83	3.18	24.47	25.09	0.118	56.09	7.75
100.	2.484	4.88	3.18	25.54	25.16	0.129	56.82	8.77
200.	2.494	4.99	3.27	26.49	26.68	0.123	59.92	8.71
300.	2.503	5.14	3.28	30.09	27.00	0.155	62.34	12.09
400.	2.511	5.24	3.30	32.48	27.39	0.171	64.14	14.22
500.	2.518	5.33	3.31	34.63	27.64	0.185	65.49	16.21
600.	2.526	5.40	3.32	36.68	27.81	0.197	66.61	18.14
700.	2.532	5.50	3.32	39.28	27.91	0.213	67.70	20.67
800.	2.539	5.60	3.32	42.39	28.01	0.229	68.87	23.72
900.	2.545	5.64	3.32	43.43	28.11	0.234	69.36	24.69
1000.	2.550	5.67	3.33	44.39	28.28	0.237	69.99	25.53

IMESA VERDE SANDSTONE, 50 PERCENT SATURATED, 72-2

POROSITY= 6.80

LENGTH=24.76 MM

DELTA=0.010

PRESSURE(MPA)	COMPRESS(GPA-1)	MEAN VEL	LNVP	LNVS	BULK VEL	LN RHO/RHOZERO	PHI(KM/S)SQ	V(DM3/KG),
0.	0.0726	2.33	1.223	0.750	2.36	0.	5.56	0.4042
10.	0.0455	2.59	1.391	0.848	2.98	0.0006	8.88	0.4040
20.	0.0365	2.91	1.504	0.965	3.33	0.0010	11.07	0.4038
40.	0.0371	3.20	1.549	1.066	3.30	0.0017	10.89	0.4035
60.	0.0394	3.38	1.566	1.125	3.20	0.0025	10.24	0.4032
80.	0.0409	3.48	1.575	1.157	3.14	0.0033	9.86	0.4029
100.	0.0391	3.49	1.585	1.158	3.21	0.0041	10.28	0.4025
200.	0.0377	3.58	1.607	1.185	3.26	0.0080	10.62	0.4010
300.	0.0332	3.61	1.637	1.189	3.47	0.0116	12.02	0.3996
400.	0.0308	3.64	1.657	1.195	3.60	0.0148	12.94	0.3983
500.	0.0289	3.65	1.673	1.198	3.71	0.0178	13.75	0.3971
600.	0.0273	3.66	1.687	1.200	3.81	0.0206	14.53	0.3960
700.	0.0255	3.67	1.704	1.200	3.94	0.0233	15.51	0.3949
800.	0.0236	3.68	1.724	1.201	4.09	0.0258	16.70	0.3939
900.	0.0230	3.68	1.730	1.201	4.13	0.0281	17.07	0.3930
1000.	0.0225	3.69	1.736	1.203	4.17	0.0304	17.40	0.3921

72-2-3

MESA VERDE SANDSTONE, 50 PERCENT SATURATED, 72-2

MESA VERDE SANDSTONE, 50 PERCENT SATURATED, 72-2

Name

Hoggar granite, 72-3

Source

Taourirt Tan Afella Massif, Algeria. From the French Hoggar test site.

Physical Properties

Density - 2.61 Mg/m^3

Total porosity - unavailable

Saturation - air dry

Note - Attendant report describing complete physical properties, R. N. Schock, A. E. Abey, H. C. Heard, and H. Louis, Mechanical Properties of Granite from the Taourirt Tan Afella Massif, Algeria, Lawrence Livermore Laboratory, Rept. UCRL-51296 (1972).

1HOGGAR GRANITE.72-3

POROSITY=NO DATA

LENGTH=25.63 MM

DELTA=0.010

PRESSURE(MPA)	RHO(MG/CM)	VP(KM/S)	VS(KM/S)	K(GPA)	MU(GPA)	POISSONS R	YOUNGS MOD (GPA)	LAME CONST
0.	2.610	5.18	3.00	38.63	23.51	0.247	58.63	22.00
4.	2.610	5.33	3.07	41.40	24.65	0.252	61.70	24.96
10.	2.611	5.54	3.19	44.70	26.59	0.252	66.57	26.98
14.	2.611	5.68	3.26	47.01	27.83	0.253	69.72	28.46
20.	2.611	5.88	3.37	50.79	29.69	0.255	74.54	31.00
26.	2.611	6.04	3.43	54.41	30.73	0.262	77.59	33.92
30.	2.612	6.15	3.46	56.86	31.32	0.267	79.38	35.99
36.	2.612	6.27	3.50	60.10	32.01	0.274	81.54	38.76
40.	2.612	6.33	3.52	61.29	32.45	0.275	82.74	39.66
45.	2.612	6.38	3.55	62.52	32.90	0.276	83.97	40.59
50.	2.613	6.41	3.57	63.10	33.27	0.276	84.89	40.92
60.	2.613	6.46	3.60	63.82	33.83	0.275	86.26	41.27
80.	2.614	6.50	3.64	64.25	34.56	0.272	87.92	41.21
120.	2.615	6.53	3.67	64.65	35.16	0.270	89.30	41.21
200.	2.619	6.56	3.70	65.13	35.79	0.268	90.75	41.26
400.	2.627	6.63	3.72	66.85	36.35	0.270	92.32	42.61
600.	2.635	6.65	3.73	67.77	36.65	0.271	93.16	43.33
800.	2.642	6.66	3.73	68.23	36.85	0.271	93.69	43.66
1000.	2.650	6.68	3.73	68.84	36.94	0.272	94.01	44.21

72-3-2

1HOGGAR GRANITE,72-3

POROSITY=NO DATA

LENGTH=25.63 MM

DELTA=0.010

PRESSURE(MPA)	COMPRESS(GPA-1)	MEAN VEL	LNVP	LNVS	BULK VEL	LN RHO/RHOZERO	PHI(KM/S)SQ	V(DM3/KG)
0.	0.0259	3.33	1.644	1.099	3.85	0.	14.80	0.3831
4.	0.0242	3.41	1.674	1.123	3.98	0.0001	15.86	0.3831
10.	0.0224	3.54	1.712	1.160	4.14	0.0002	17.12	0.3830
14.	0.0213	3.63	1.736	1.183	4.24	0.0003	18.01	0.3830
20.	0.0197	3.75	1.772	1.215	4.41	0.0005	19.45	0.3830
26.	0.0184	3.81	1.799	1.233	4.56	0.0006	20.84	0.3829
30.	0.0176	3.85	1.816	1.242	4.67	0.0006	21.77	0.3829
36.	0.0166	3.90	1.836	1.253	4.80	0.0007	23.01	0.3829
40.	0.0163	3.92	1.845	1.260	4.84	0.0008	23.46	0.3828
45.	0.0160	3.95	1.853	1.267	4.89	0.0009	23.93	0.3828
50.	0.0158	3.97	1.858	1.272	4.91	0.0010	24.15	0.3828
60.	0.0157	4.01	1.865	1.280	4.94	0.0011	24.43	0.3827
80.	0.0156	4.05	1.871	1.291	4.96	0.0014	24.58	0.3826
120.	0.0155	4.08	1.876	1.299	4.97	0.0021	24.72	0.3823
200.	0.0154	4.11	1.882	1.308	4.99	0.0033	24.87	0.3819
400.	0.0150	4.14	1.891	1.314	5.05	0.0064	25.45	0.3807
600.	0.0148	4.15	1.895	1.316	5.07	0.0094	25.72	0.3796
800.	0.0147	4.16	1.897	1.318	5.08	0.0124	25.82	0.3784
1000.	0.0145	4.16	1.898	1.317	5.10	0.0153	25.97	0.3773

72-3-3

72-3-4

HOGGAR GRANITE, 72-3

Name

Blair dolomite (dolostone), 72-4

Source

Berkeley County, West Virginia

Physical Properties

Density - 2.85 Mg/m^3

Total porosity - unavailable, estimated from pressure-volume data to be about 0.2%

Saturation - air dry

Note - Attendant report describing complete physical properties measurements, H. C. Heard, A. Duba, A. E. Abey, and R. N. Schock, Mechanical Properties of Blair Dolomite, Lawrence Livermore Laboratory, Rept. UCRL-51465 (1973).

1BLAIR DOLOMITE(DOLOSTONE).72-4

POROSITY=NO DATA

LENGTH=25.72 MM

DELTA=0.010

PRESSURE(MPA)	RHO(MG/CM)	VP(KM/S)	VS(KM/S)	K(GPA)	MU(GPA)	POISSONS R	YOUNGS MOD (GPA)	LAME CONST
0.	2.850	5.02	3.02	37.37	25.91	0.218	63.14	20.10
10.	2.851	5.32	3.10	44.33	27.37	0.244	68.09	26.08
20.	2.851	5.47	3.16	47.51	28.39	0.251	71.02	28.58
30.	2.852	5.59	3.20	50.13	29.25	0.256	73.45	30.63
40.	2.852	5.74	3.23	54.18	29.84	0.267	75.63	34.29
50.	2.853	5.90	3.26	59.05	30.30	0.281	77.61	38.85
60.	2.853	6.14	3.29	66.31	30.84	0.299	80.11	45.75
70.	2.854	6.43	3.31	76.23	31.24	0.320	82.46	55.40
80.	2.854	6.55	3.33	80.13	31.73	0.325	84.09	58.98
100.	2.855	6.68	3.41	83.14	33.09	0.324	87.65	61.08
150.	2.857	6.87	3.51	88.07	35.12	0.324	92.99	64.66
200.	2.858	7.00	3.55	92.11	36.00	0.327	95.56	68.11
300.	2.861	7.18	3.60	97.92	37.03	0.332	98.66	73.24
400.	2.864	7.27	3.62	101.46	37.57	0.335	100.32	76.41
600.	2.870	7.36	3.65	104.75	38.13	0.338	102.01	79.33
800.	2.875	7.40	3.66	106.19	38.48	0.338	103.00	80.53
1000.	2.881	7.42	3.68	106.58	38.95	0.337	104.15	80.61

1BLAIR DOLOMITE(DOLOSTONE),72-4

POROSITY=NO DATA

LENGTH=25.72 MM

DELTA=0.010

PRESSURE(MPA)	COMPRESS(GPA-1)	MEAN VEL	LNVP	LNVS	BULK VEL	LN RHO/RHOZERO	PHI(KM/S)SQ	V(DM3/KG),
0.	0.0268	3.34	1.614	1.104	3.62	0.	13.11	0.3509
10.	0.0226	3.44	1.672	1.131	3.94	0.0002	15.55	0.3508
20.	0.0210	3.50	1.700	1.149	4.08	0.0005	16.66	0.3507
30.	0.0200	3.56	1.721	1.164	4.19	0.0007	17.58	0.3506
40.	0.0185	3.60	1.747	1.174	4.36	0.0009	18.99	0.3506
50.	0.0169	3.63	1.776	1.181	4.55	0.0010	20.70	0.3505
60.	0.0151	3.67	1.814	1.190	4.82	0.0012	23.24	0.3505
70.	0.0131	3.71	1.861	1.197	5.17	0.0013	26.71	0.3504
80.	0.0125	3.74	1.879	1.204	5.30	0.0015	28.07	0.3504
100.	0.0120	3.82	1.899	1.225	5.40	0.0017	29.12	0.3503
150.	0.0114	3.93	1.927	1.255	5.55	0.0023	30.83	0.3501
200.	0.0109	3.98	1.946	1.267	5.68	0.0029	32.23	0.3499
300.	0.0102	4.04	1.971	1.280	5.85	0.0039	34.22	0.3495
400.	0.0099	4.06	1.984	1.287	5.95	0.0050	35.42	0.3491
600.	0.0095	4.09	1.996	1.293	6.04	0.0069	36.50	0.3485
800.	0.0094	4.11	2.002	1.297	6.08	0.0088	36.93	0.3478
1000.	0.0094	4.13	2.004	1.302	6.08	0.0107	37.00	0.3471

BLAIR DOLOMITE(DOLOSTONE), 72-4

BLAIR DOLOMITE(DOLOSTONE), 72-4

Name

Blair dolomite (dolostone), 72-4*

Source

Berkeley County, West Virginia

Physical Properties

Density - 2.85 Mg/m^3

Total porosity - unavailable, estimated from pressure-volume data to be
about 0.2%

Saturation - air dry

Note - Attendant report describing complete physical properties measurements,
H. C. Heard, A. Duba, A. E. Abey, and R. N. Schock, Mechanical Properties of
Blair Dolomite, Lawrence Livermore Laboratory, Rept. UCRL-51465 (1973).

*Length changes calculated using measured linear strain data.

1BLAIR DOLOMITE(DOLOSTONE).72-4*

POROSITY=NO DATA

LENGTH=25.72 MM

DELTA=0.010

PRESSURE(MPA)	RHO(MG/CM)	VP(KM/S)	VS(KM/S)	K(GPA)	MU(GPA)	POISSONS R	YOUNGS MOD (GPA)	LAME CONST
0.	2.850	5.02	3.02	37.37	25.91	0.218	63.14	20.10
10.	2.853	5.32	3.10	44.34	27.38	0.244	68.11	26.09
20.	2.854	5.47	3.15	47.53	28.40	0.251	71.04	28.59
30.	2.873	5.58	3.19	50.25	29.32	0.256	73.63	30.70
40.	2.856	5.74	3.23	54.20	29.85	0.267	75.67	34.30
50.	2.857	5.90	3.26	59.08	30.31	0.281	77.65	38.87
60.	2.858	6.13	3.29	66.35	30.86	0.299	80.15	45.77
70.	2.859	6.42	3.31	76.28	31.26	0.320	82.51	55.44
80.	2.861	6.54	3.33	80.19	31.76	0.325	84.16	59.02
100.	2.864	6.67	3.40	83.23	33.13	0.324	87.74	61.14
150.	2.867	6.86	3.50	88.17	35.16	0.324	93.10	64.73
200.	2.871	6.99	3.54	92.25	36.06	0.327	95.70	68.21
300.	2.875	7.16	3.59	98.08	37.09	0.332	98.82	73.36
400.	2.883	7.26	3.61	101.69	37.65	0.335	100.55	76.59
600.	2.890	7.35	3.64	105.00	38.22	0.338	102.25	79.52
800.	2.896	7.38	3.65	106.44	38.57	0.338	103.25	80.73
1000.	2.850	7.44	3.69	106.20	38.81	0.337	103.78	80.32

72-4*-2

1BLAIR DOLOMITE(DOLOSTONE),72-4*

POROSITY=NO DATA			LENGTH=25.72 MM			DELTA=0.010		
PRESSURE(MPA)	COMPRESS(GPA-1)	MEAN VEL	LNVP	LNVS	BULK VEL	LN RHO/RHOZERO	PHI(KM/S)SQ	V(DM3/KG).
0.	0.0268	3.34	1.614	1.104	3.62	0.	13.11	0.3509
10.	0.0226	3.44	1.672	1.131	3.94	0.0010	15.54	0.3505
20.	0.0210	3.50	1.699	1.149	4.08	0.0015	16.65	0.3504
30.	0.0199	3.55	1.719	1.161	4.18	0.0079	17.49	0.3481
40.	0.0184	3.60	1.747	1.173	4.36	0.0022	18.98	0.3501
50.	0.0169	3.63	1.775	1.181	4.55	0.0026	20.68	0.3500
60.	0.0151	3.67	1.814	1.190	4.82	0.0029	23.21	0.3499
70.	0.0131	3.70	1.860	1.196	5.17	0.0032	26.68	0.3498
80.	0.0125	3.73	1.879	1.203	5.29	0.0038	28.03	0.3495
100.	0.0120	3.81	1.898	1.224	5.39	0.0048	29.06	0.3492
150.	0.0113	3.92	1.926	1.253	5.55	0.0058	30.76	0.3488
200.	0.0108	3.97	1.945	1.265	5.67	0.0074	32.13	0.3483
300.	0.0102	4.03	1.969	1.279	5.84	0.0088	34.11	0.3478
400.	0.0098	4.06	1.982	1.285	5.94	0.0116	35.27	0.3468
600.	0.0095	4.08	1.994	1.291	6.03	0.0139	36.33	0.3460
800.	0.0094	4.10	1.999	1.295	6.06	0.0159	36.76	0.3453
1000.	0.0094	4.14	2.007	1.306	6.10	0.	37.26	0.3509

THE VOLUME CHANGE TO MAXIMUM PRESSURE IS 0.

BLAIR DOLOMITE(DOLOSTONE), 72-4*

72-4*-4

BLAIR DOLOMITE(DOLOSTONE), 72-4*

Name

Nugget sandstone, 73-1

Source

Source unknown. Based on a reported quartz content of 99%,¹ the rock is classified as a quartz arenite (orthoquartzite).²

Physical Properties

Density - 2.56 Mg/m^3

Total porosity - unavailable

Saturation - air dry

Note - Attendant report describing complete physical properties measurements, R. N. Schock, A. E. Abey, B. P. Bonner, A. Duba, and H. C. Heard, Mechanical Properties of Nugget Sandstone, Lawrence Livermore Laboratory, Rept. UCRL-51447 (1973). Travel times measured perpendicular to the ill defined bedding.

1. W. F. Brace and D. K. Riley, Int. J. Rock. Mech. Min. Sci. 9, 271 (1972).
2. F. J. Pettijohn, P. E. Potter, and R. Siever, Sand and Sandstone (Springer Verlag, New York, 1972).

1NUGGET SANDSTONE.73-1

POROSITY=NO DATA

LENGTH=25.67 MM

DELTA=0.010

PRESSURE(MPA)	RHO(MG/CM)	VP(KM/S)	VS(KM/S)	K(GPA)	MU(GPA)	POISSONS R	YOUNGS MOD (GPA)	LAME CONST
0.	2.560	3.44	2.34	11.66	13.99	0.071	29.98	2.33
10.	2.562	4.14	2.73	18.38	19.14	0.114	42.62	5.62
20.	2.563	4.46	2.89	22.44	21.45	0.138	48.80	8.14
40.	2.565	4.92	3.08	29.67	24.39	0.177	57.43	13.42
60.	2.567	5.16	3.18	33.70	25.99	0.193	62.02	16.37
80.	2.568	5.30	3.25	35.83	27.20	0.197	65.11	17.70
100.	2.570	5.46	3.41	36.64	29.87	0.179	70.46	16.73
200.	2.576	5.71	3.45	42.91	30.70	0.211	74.37	22.44
300.	2.582	5.82	3.52	44.82	31.92	0.212	77.39	23.54
400.	2.588	5.91	3.54	46.99	32.48	0.219	79.19	25.34
500.	2.593	5.99	3.59	48.48	33.33	0.220	81.34	26.27
600.	2.599	6.05	3.62	49.85	34.01	0.222	83.13	27.17
700.	2.604	6.08	3.64	50.27	34.43	0.221	84.08	27.32
800.	2.609	6.12	3.67	50.77	35.15	0.219	85.67	27.34
900.	2.614	6.14	3.69	51.20	35.58	0.218	86.66	27.48
1000.	2.619	6.15	3.72	50.87	36.23	0.212	87.83	26.72

1NUGGET SANDSTONE,73-1

POROSITY=NO DATA

LENGTH=25.67 MM

DELTA=0.010

PRESSURE(MPA)	COMPRESS(GPA-1)	MEAN VEL	LNVP	LNVS	BULK VEL	LN RHO/RHOZERO	PHI(KM/S)SQ	V(DM3/KG),
0.	0.0858	2.55	1.236	0.849	2.13	0.	4.55	0.3906
10.	0.0544	2.99	1.421	1.005	2.68	0.0007	7.17	0.3904
20.	0.0446	3.17	1.496	1.062	2.96	0.0012	8.76	0.3902
40.	0.0337	3.40	1.594	1.126	3.40	0.0019	11.57	0.3899
60.	0.0297	3.51	1.641	1.158	3.62	0.0026	13.13	0.3896
80.	0.0279	3.59	1.667	1.180	3.74	0.0032	13.95	0.3894
100.	0.0273	3.76	1.697	1.227	3.78	0.0037	14.26	0.3892
200.	0.0233	3.82	1.741	1.239	4.08	0.0063	16.66	0.3882
300.	0.0223	3.89	1.761	1.257	4.17	0.0086	17.36	0.3873
400.	0.0213	3.92	1.776	1.265	4.26	0.0108	18.16	0.3864
500.	0.0206	3.97	1.789	1.277	4.32	0.0129	18.70	0.3856
600.	0.0201	4.00	1.801	1.286	4.38	0.0149	19.18	0.3848
700.	0.0199	4.02	1.805	1.291	4.39	0.0169	19.31	0.3841
800.	0.0197	4.06	1.811	1.300	4.41	0.0189	19.46	0.3833
900.	0.0195	4.08	1.815	1.305	4.43	0.0209	19.59	0.3825
1000.	0.0197	4.11	1.817	1.313	4.41	0.0229	19.42	0.3818

73-1-3

NUGGET SANDSTONE, 73-1

NUGGET SANDSTONE, 73-1

Name

Nugget sandstone, 73-1*

Source

Source unknown. Based on a reported quartz content of 99%,¹ the rock is classified as a quartz arenite (orthoquartzite).²

Physical Properties

Density — 2.56 Mg/m³

Total porosity — unavailable

Saturation — air dry

Note — Attendant report describing complete physical properties measurements, R. N. Schock, A. E. Abey, B. P. Bonner, A. Duba, and H. C. Heard, Mechanical Properties of Nugget Sandstone, Lawrence Livermore Laboratory, Rept. UCRL-51447 (1973). Travel-times measured perpendicular to the ill defined bedding.

1. W. F. Brace and D. K. Riley, Int. J. Rock. Mech. Min. Sci. 9, 271 (1972).

2. F. J. Pettijohn, P. E. Potter, and R. Siever, Sand and Sandstone (Springer Verlag, New York, 1972).

*Length changes calculated using measured linear strain data.

INUGGET SANDSTONE.73-1 *

POROSITY=NO DATA

LENGTH=25.67 MM

DELTA=0.010

PRESSURE(MPA)	RHO(MG/CM)	VP(KM/S)	VS(KM/S)	K(GPA)	MU(GPA)	POISSONS R	YOUNGS MOD (GPA)	LAME CONST
0.	2.560	3.44	2.34	11.66	13.99	0.071	29.98	2.33
10.	2.568	4.14	2.73	18.39	19.15	0.114	42.65	5.63
20.	2.573	4.46	2.89	22.47	21.48	0.138	48.87	8.15
40.	2.578	4.92	3.08	29.72	24.43	0.177	57.52	13.44
60.	2.580	5.15	3.18	33.76	26.04	0.193	62.14	16.40
80.	2.583	5.29	3.25	35.90	27.25	0.197	65.24	17.73
100.	2.587	5.44	3.40	36.72	29.94	0.179	70.62	16.76
200.	2.598	5.69	3.44	43.04	30.79	0.211	74.59	22.51
300.	2.607	5.80	3.51	44.97	32.03	0.212	77.65	23.62
400.	2.616	5.89	3.53	47.17	32.60	0.219	79.48	25.44
500.	2.626	5.96	3.57	48.69	33.47	0.220	81.69	26.38
600.	2.635	6.03	3.60	50.09	34.18	0.222	83.53	27.30
700.	2.644	6.05	3.62	50.54	34.61	0.221	84.53	27.47
800.	2.651	6.09	3.65	51.05	35.34	0.219	86.15	27.49
900.	2.659	6.11	3.67	51.51	35.79	0.218	87.18	27.65
1000.	2.668	6.12	3.70	51.21	36.46	0.212	88.40	26.90

73-1*-2

1NUGGET SANDSTONE.73-1 *

POROSITY=NO DATA

LENGTH=25.67 MM

DELTA=0.010

PRESSURE(MPA)	COMPRESS(GPA-1)	MEAN VEL	LNVP	LNVS	BULK VEL	LN RHO/RHOZERO	PHI(KM/S)SQ	V(DM3/KG).
0.	0.0858	2.55	1.236	0.849	2.13	0.	4.55	0.3906
10.	0.0544	2.99	1.420	1.005	2.68	0.0032	7.16	0.3894
20.	0.0445	3.17	1.494	1.061	2.96	0.0052	8.73	0.3886
40.	0.0336	3.39	1.592	1.124	3.40	0.0068	11.53	0.3880
60.	0.0296	3.50	1.639	1.156	3.62	0.0079	13.08	0.3875
80.	0.0279	3.58	1.665	1.178	3.73	0.0089	13.90	0.3871
100.	0.0272	3.75	1.694	1.224	3.77	0.0106	14.19	0.3865
200.	0.0232	3.81	1.739	1.236	4.07	0.0147	16.57	0.3849
300.	0.0222	3.87	1.758	1.254	4.15	0.0184	17.25	0.3835
400.	0.0212	3.91	1.773	1.261	4.25	0.0216	18.03	0.3823
500.	0.0205	3.95	1.785	1.273	4.31	0.0253	18.55	0.3809
600.	0.0200	3.99	1.796	1.281	4.36	0.0288	19.01	0.3795
700.	0.0198	4.00	1.800	1.286	4.37	0.0321	19.12	0.3783
800.	0.0196	4.04	1.806	1.295	4.39	0.0350	19.26	0.3772
900.	0.0194	4.06	1.810	1.300	4.40	0.0381	19.37	0.3760
1000.	0.0195	4.09	1.811	1.308	4.38	0.0412	19.19	0.3748

THE VOLUME CHANGE TO MAXIMUM PRESSURE IS 0.040

NUGGET SANDSTONE, 73-1 *

NUGGET SANDSTONE, 73-1 *

Name

Kayenta sandstone, 73-2

Source and Description

Sec. 10-12, T12S, R103W, Mesa County, Colorado. A poorly cemented, very porous, quartz arenite.

Physical Properties

Density — 2.04 Mg/m^3

Total porosity — $24\%^{\dagger}$

Saturation — air dry

† Based on a measured grain density of 2.688 Mg/m^3 .

1KAYENTA SANDSTONE.73-2

POROSITY=NO DATA

LENGTH=25.86 MM

DELTA=0.010

PRESSURE(MPA)	RHO(MG/CM)	VP(KM/S)	VS(KM/S)	K(GPA)	MU(GPA)	POISSONS R	YOUNGS MOD (GPA)	LAME CONST
0.	2.030	2.98	1.51	11.84	4.64	0.327	12.30	8.74
5.	2.031	3.46	1.75	16.06	6.21	0.329	16.50	11.92
10.	2.031	3.38	1.86	13.81	7.00	0.283	17.96	9.15
15.	2.032	3.40	1.95	13.23	7.71	0.256	19.37	8.09
20.	2.033	3.40	1.99	12.75	8.02	0.240	19.90	7.40
25.	2.034	3.47	2.06	12.98	8.62	0.228	21.18	7.23
30.	2.035	3.54	2.08	13.71	8.84	0.235	21.82	7.82
40.	2.036	3.64	2.16	14.35	9.45	0.230	23.25	8.05
50.	2.037	3.72	2.19	15.18	9.78	0.235	24.15	8.66
60.	2.039	3.79	2.22	15.85	10.03	0.239	24.86	9.16
70.	2.040	3.84	2.23	16.54	10.18	0.245	25.33	9.76
80.	2.041	3.88	2.25	17.02	10.30	0.248	25.72	10.15
100.	2.044	3.95	2.28	17.68	10.60	0.250	26.50	10.61
150.	2.049	4.09	2.30	19.86	10.84	0.269	27.51	12.64
200.	2.054	4.22	2.32	21.85	11.08	0.283	28.44	14.46
300.	2.063	4.40	2.35	24.70	11.38	0.300	29.60	17.12
400.	2.071	4.59	2.34	28.44	11.36	0.324	30.07	20.87
500.	2.078	4.70	2.33	30.87	11.27	0.337	30.13	23.36
600.	2.084	4.87	2.33	34.35	11.36	0.351	30.70	26.78
700.	2.090	4.98	2.36	36.36	11.65	0.355	31.57	28.60
800.	2.096	5.07	2.41	37.61	12.14	0.354	32.89	29.52
900.	2.102	5.16	2.47	39.02	12.77	0.352	34.54	30.51
1000.	2.107	5.21	2.54	39.10	13.61	0.344	36.58	30.03

73-2-2

1KAYENTA SANDSTONE, 73-2

POROSITY=NO DATA

LENGTH=25.86 MM

DELTA=0.010

PRESSURE(MPA)	COMPRESS(GPA-1)	MEAN VEL	LNVP	LNVS	BULK VEL	LN RHO/RHOZERO	PHI(KM/S)SQ	V(DM3/KG),
0.	0.0845	1.69	1.092	0.413	2.41	0.	5.83	0.4926
5.	0.0623	1.96	1.242	0.559	2.81	0.0004	7.91	0.4924
10.	0.0724	2.07	1.216	0.618	2.61	0.0007	6.80	0.4923
15.	0.0756	2.16	1.224	0.667	2.55	0.0011	6.51	0.4921
20.	0.0784	2.20	1.223	0.686	2.51	0.0015	6.27	0.4919
25.	0.0771	2.28	1.244	0.722	2.53	0.0019	6.38	0.4917
30.	0.0729	2.31	1.264	0.734	2.60	0.0022	6.74	0.4915
40.	0.0697	2.39	1.292	0.768	2.66	0.0030	7.05	0.4912
50.	0.0659	2.43	1.314	0.784	2.73	0.0036	7.45	0.4908
60.	0.0631	2.46	1.331	0.797	2.79	0.0043	7.77	0.4905
70.	0.0604	2.48	1.346	0.804	2.85	0.0049	8.11	0.4902
80.	0.0588	2.49	1.356	0.809	2.89	0.0055	8.34	0.4899
100.	0.0566	2.53	1.373	0.823	2.94	0.0067	8.65	0.4893
150.	0.0503	2.56	1.409	0.833	3.11	0.0094	9.69	0.4880
200.	0.0458	2.59	1.440	0.843	3.26	0.0118	10.64	0.4868
300.	0.0405	2.62	1.481	0.854	3.46	0.0161	11.98	0.4847
400.	0.0352	2.62	1.523	0.851	3.71	0.0199	13.73	0.4829
500.	0.0324	2.61	1.547	0.845	3.85	0.0233	14.86	0.4812
600.	0.0291	2.63	1.584	0.848	4.06	0.0264	16.48	0.4798
700.	0.0275	2.66	1.606	0.859	4.17	0.0293	17.40	0.4784
800.	0.0266	2.71	1.623	0.878	4.24	0.0320	17.94	0.4771
900.	0.0256	2.77	1.642	0.902	4.31	0.0347	18.57	0.4758
1000.	0.0256	2.86	1.651	0.933	4.31	0.0372	18.56	0.4746

73-2-3

KAYENTA SANDSTONE, 73-2

KAYENTA SANDSTONE, 73-2

Name

Kayenta sandstone, 73-2*

Source and Description

Sec. 10-12, T12S, R103W, Mesa County, Colorado. A poorly cemented, very porous, quartz arenite.

Physical Properties

Density - 2.04 Mg/m^3

Total porosity - $24\%^{\ddagger}$

Saturation - air dry

*Length changes calculated using measured linear strain data.

$\ddagger$ Based on a measured grain density of 2.688 Mg/m^3 .

1KAYENTA SANDSTONE,73-2 *

POROSITY=NO DATA

LENGTH=25.86 MM

DELTA=0.010

PRESSURE(MPA)	RHO(MG/CM)	VP(KM/S)	VS(KM/S)	K(GPA)	MU(GPA)	POISSONS R	YOUNGS MOD (GPA)	LAME CONST
0.	2.030	2.98	1.51	11.84	4.64	0.327	12.30	8.74
5.	2.047	3.45	1.74	16.10	6.22	0.329	16.54	11.95
10.	2.051	3.36	1.85	13.86	7.02	0.283	18.02	9.18
15.	2.054	3.39	1.94	13.28	7.74	0.256	19.44	8.12
20.	2.057	3.38	1.98	12.80	8.06	0.240	19.98	7.43
25.	2.059	3.46	2.05	13.03	8.66	0.228	21.27	7.26
30.	2.060	3.53	2.08	13.77	8.87	0.235	21.91	7.86
40.	2.062	3.62	2.15	14.42	9.49	0.230	23.35	8.09
50.	2.064	3.71	2.18	15.25	9.82	0.235	24.26	8.70
60.	2.067	3.77	2.21	15.92	10.08	0.239	24.97	9.20
70.	2.074	3.82	2.22	16.64	10.23	0.245	25.47	9.81
80.	2.076	3.86	2.23	17.12	10.36	0.248	25.86	10.21
100.	2.080	3.92	2.26	17.79	10.66	0.250	26.66	10.68
150.	2.091	4.07	2.28	20.00	10.91	0.269	27.70	12.72
200.	2.099	4.19	2.31	22.02	11.17	0.283	28.65	14.57
300.	2.148	4.34	2.32	25.06	11.55	0.300	30.03	17.36
400.	2.261	4.46	2.28	29.35	11.72	0.324	31.04	21.54
500.	2.276	4.57	2.26	31.91	11.65	0.337	31.15	24.15
600.	2.331	4.71	2.25	35.81	11.84	0.351	31.99	27.91
700.	2.360	4.80	2.27	38.05	12.19	0.355	33.03	29.93
800.	2.380	4.87	2.31	39.46	12.74	0.354	34.50	30.96
900.	2.402	4.95	2.37	41.05	13.44	0.352	36.34	32.10
1000.	2.431	4.99	2.43	41.30	14.38	0.344	38.64	31.72

73-2*-2

1KAYENTA SANDSTONE.73-2 *

POROSITY=NO DATA		LENGTH=25.86 MM				DELTA=0.010		
PRESSURE(MPA)	COMPRESS(GPA-1)	MEAN VEL	LNVP	LNVS	BULK VEL	LN RHO/RHOZERO	PHI(KM/S)SQ	V(DM3/KG).
0.	0.0845	1.69	1.092	0.413	2.41	0.	5.83	0.4926
5.	0.0621	1.96	1.239	0.556	2.80	0.0082	7.87	0.4886
10.	0.0722	2.06	1.213	0.615	2.60	0.0104	6.76	0.4875
15.	0.0753	2.16	1.221	0.663	2.54	0.0117	6.46	0.4869
20.	0.0781	2.20	1.219	0.683	2.50	0.0130	6.23	0.4863
25.	0.0768	2.27	1.240	0.718	2.52	0.0141	6.33	0.4857
30.	0.0726	2.30	1.260	0.730	2.59	0.0146	6.69	0.4855
40.	0.0694	2.38	1.287	0.763	2.64	0.0156	6.99	0.4850
50.	0.0656	2.42	1.310	0.780	2.72	0.0165	7.39	0.4845
60.	0.0628	2.45	1.327	0.792	2.78	0.0182	7.70	0.4837
70.	0.0601	2.47	1.341	0.798	2.83	0.0212	8.02	0.4823
80.	0.0584	2.48	1.351	0.804	2.87	0.0222	8.25	0.4818
100.	0.0562	2.51	1.367	0.817	2.92	0.0243	8.55	0.4808
150.	0.0500	2.54	1.402	0.826	3.09	0.0294	9.57	0.4783
200.	0.0454	2.57	1.433	0.836	3.24	0.0336	10.49	0.4764
300.	0.0399	2.59	1.468	0.841	3.42	0.0566	11.67	0.4655
400.	0.0341	2.55	1.495	0.823	3.60	0.1076	12.99	0.4424
500.	0.0313	2.54	1.519	0.816	3.75	0.1143	14.02	0.4394
600.	0.0279	2.53	1.549	0.813	3.92	0.1381	15.36	0.4291
700.	0.0263	2.56	1.568	0.821	4.02	0.1508	16.12	0.4236
800.	0.0253	2.60	1.583	0.839	4.07	0.1590	16.58	0.4202
900.	0.0244	2.66	1.600	0.861	4.13	0.1684	17.09	0.4163
1000.	0.0242	2.73	1.607	0.889	4.12	0.1803	16.99	0.4113

THE VOLUME CHANGE TO MAXIMUM PRESSURE IS 0.165

KAYENTA SANDSTONE, 73-2 *

KAYENTA SANDSTONE, 73-2 *