Table 3-4.--Average values for some physical properties of units of the Oak Spring formation.

| Lithologic unit | $Tos_8$ | $Tos_7$ 1/ a | b | c | $Tos_6$ | $Tos_5$ | $Tos_4$ | $Tos_3$ | $Tos_2$ | $Tos_1$ |
|---|---|---|---|---|---|---|---|---|---|---|
| Number of samples | 31 | | 76 | | 4 | 40 | 118 | 53 | 9 | |
| Porosity (percent) K/ 2/ | 14 | -- | 36 | 28 | 19 | 40 | 39 | 38 | 35 | -- |
| No. of samples | | | | (217) | | | | | | |
| Wet bulk density (g/cc) K/ | 2.3 | -- | 1.9 | -- | 2.2 | 1.8 | 1.9 | 1.9 | 1.9 | -- |
| No. of samples | | | | | | | | | | |
| Dry bulk density (g/cc) K/ | 2.2 | -- | 1.5 | 1.65 | 2.0 | 1.4 | 1.5 | 1.5 | 1.6 | -- |
| No. of samples | | | | (181) | | | | | | |
| Grain density (g/cc) K/ | 2.6 | -- | 2.4 | 2.3 | 2.5 | 2.3 | 2.4 | 2.4 | 2.5 | -- |
| No. of samples | | | | (194) | | | | | | |
| Natural state bulk GEM/ density (g/cc) | -- | -- | -- | 1.92 | -- | -- | -- | -- | -- | -- |
| No. of samples | | | | (152) | | | | | | |
| Water content by GEM/ volume (g/cc) | -- | -- | -- | 0.286 | -- | -- | -- | -- | -- | -- |
| No. of samples | | | | (165) | | | | | | |
| Water content by GEM/ weight (percent) | -- | -- | -- | 15 | -- | -- | -- | -- | -- | -- |
| No. of samples | | | | (165) | | | | | | |
| Permeability to air K/ (millidarcies) | 0.66 | -- | 6 | -- | -- | 21.0 | 0.98 | 0.81 | 0.89 | 0.46 |
| No. of samples | (10) | | (5) | | | (9) | (9) | (4) | (12) | (3) |
| Permeability to K/ brine (millidarcies) | 0.33 | -- | 1.4 | -- | -- | 11.5 | 0.12 | 0.036 | 0.021 | 0.072 |
| No. of samples | (10) | | (5) | | | (9) | (9) | (4) | (12) | (3) |
| Wet thermal conductivity K/ (cal/deg cm sec) | 2.2 | -- | 1.6 | -- | 2.2 | 1.9 | 1.9 | 2.0 | 1.4 | -- |
| No. of samples | (30) | | (25) | | (4) | (1) | (124) | (8) | (9) | |
| Dry thermal conductivity K/ (cal/deg cm secx$10^{-3}$) | 1.8 | -- | 1.1 | -- | 2.0 | 1.2 | 1.1 | 1.4 | 1.0 | -- |
| No. of samples | (30) | | (25) | | (4) | (1) | (24) | (18) | (9) | |
| Thermal diffusivity L/ 3/ ($cm^2$/sec) | -- | -- | -- | 3.1 | -- | -- | -- | -- | -- | -- |
| Estimated accuracy | | | | (± 15 percent) | | | | | | |
| Specific heat (25°C to 100°C) RAR/ 4/ (cal/g. deg. C). | -- | -- | -- | 0.29 | -- | -- | -- | -- | -- | -- |
| Estimated accuracy | | | | (± 0.03) | | | | | | |
| Velocity /in situ/ (ft/sec) | 5/ 11,000 | 5/ 5,600 | 5/ 7,500 | 6/ 8,300 | 7/ 5,650 | 7/ 8,200 | 7/ 8,700 | 7/ 10,400 | 7/ 11,500 | 12,000 |
| Compressive strength, R/ 8/ natural state (psi) | | | | 1,200 | | | | | | |
| - No. samples | | | | (37) | | | | | | |
| - E ($10^6$ psi) | | | | 0.18 | | | | | | |
| Compressive strength R/ natural state, under hydrostatic pressure = $10^3$ (psi) | | | | 5,100 | | | | | | |
| - No. samples | | | | (25) | | | | | | |
| - E ($10^6$ psi) | | | | 0.37 | | | | | | |
| Compressive strength M/ air dry (psi) | 21,100 | | | 4,700 | | | | | 6,100 | |
| - No. samples (strength) | (6) | | | (24) | | | | | (5) | |
| - No. samples (moduli) | | | | ( 5) | | | | | | |
| - P | | | | 0.11 | | | | | | |
| - E ($10^6$ psi) | | | | 1.11 | | | | | | |
| - G* ($10^6$ psi) | | | | 0.50 | | | | | | |
| Tensile strength, M/ air dry (psi) | 330 | | | 165 | | | | | 100 | |
| - No. samples | (4) | | | (1) | | | | | (3) | |
| - P | 0.12 | | | 0.12 | | | | | 0.08 | |
| - E ($10^6$ psi) | 1.69 | | | 0.46 | | | | | 0.88 | |
| - G* ($10^6$ psi) | 0.78 | | | 0.22 | | | | | .26 | |
| Dynamic elastic M/ moduli: | | | | | | | | | | |
| - No. samples | (4) | | | (1) | | | | | (3) | |
| - E* | 1.48 | | | 0.45 | | | | | 0.66 | |
| - G* | 0.59 | | | 0.24 | | | | | 0.32 | |

1/ $Tos_7$ a. Upper indurated tuff. b. Middle friable tuff. c. Lower indurated tuff; subunit c has been further subdivided during mapping of Rainier and lateral tunnels into lithologic units designated A to Z.

2/ Measurements taken from following sources: K = G. V. Keller, L = A. H. Lachenbruch, GEM = G. E. Manger, M = U. S. Bureau of Mines, R = E. C. Robertson, RAR = R. A. Robie.

3/ Computed from thermal conductivity, specific heat and natural state density; average value for lithologic units V, W, X, Y and Z.

4/ Computed from average chemical composition assuming 16 percent water; average value for lithologic units T, U, and V.

5/ Average velocities taken from continuous velocity log (Schlumberger Well Surveying Corp.) in drill hole through $Tos_8$ and $Tos_7$, 800 feet from Rainier ground zero. The velocity near the surface is low (about 3,000 ft/sec) because of many open fractures.

6/ Average velocities from refraction measurement in Rainier tunnel.

7/ These velocities are average velocities taken from a continuous velocity log (Seismograph Service Corp.) in drill hole through the entire Oak Spring formation and 1 mile from the Rainier site. The velocities are to some extent dependent on overburden so they will not apply to the units where they are exposed or have shallow cover.

8/ All strength and elastic measurements were uniaxial in air except as noted. Symbols for elastic moduli: P = Poisson's ratio, E = Young's modulus, G = rigidity modulus; symbols are starred where calculated with elasticity theory.