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BY

C. RONALD SEEGER

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# Sound Wave Velocities in Some Tektites and Natural Glasses*

C. Ronald Seeger**
Department of Earth and
Planetary Sciences
University of Pittsburgh, Pennsylvania

13224

## ABSTRACT

Sound wave velocities in tektites and some other natural glasses have been measured. For tektites they show the same lack of variation as other properties; the compressional wave velocities vary by only about 6 %. The other natural glasses show slightly greater variations. This indicates the relative ordering of the internal structures. It is a further indication of the unity of origin of the tektities.

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** Presently National Academy of Sciences Resident Research Associate at the Laboratory for Theoretical Studies.

In order to see if any significant variation from one tektite field to another exists, and to compare tektites with some other glasses, sound wave velocities of compressional and surface waves have been measured in eleven representative tektites and five samples of other naturally occuring glasses, and densities obtained by Jolly balance.

The experimental apparatus consisted of two electromechanical transducers of lead zirconate titanate mounted in a stand in such a way that one acted as the source and the other as a receiver of a mechanical pulse, when the sample was placed between them. A pulse from a double pulse generator was applied to the first of these, and the signal from the receiving transducer was amplified and displayed using an oscilloscope. This was equipped with a plug-in time delay generator that allowed the direct measurement of the time associated with particular segments of the observed waveforms. The double pulse feature was used to null the source after one pulse.

The tektites were selected from the holdings of Professor Alvin J. Cohen at the University of Pittsburgh, mainly on the basis of size. Usually at least 3 cm. was required for meaningful results for compressional waves because a smaller sample would allow the signal to be lost in the radiation noise at the start of the sweep on the oscilloscope. The surface condition, homogeneity and shape were also important considerations in the selection of samples. That is to say, large spheroids with smooth surfaces and few vesicles or inclusions were favored. The glasses were selected similarly. The experiments were completely non-descructive. Table 1 presents the results which are then summarized in Table 2 and plotted in Figure 1.

The shear wave velocities should be about 5-7% faster than the surface wave velocites (Knopoff, 1952), and this was used to compute the shear velocity ($\beta$) for Table 2. Poisson's ratio was computed by the formula

$$\sigma = \frac{\alpha^2 - 2\beta^2}{2\ (\alpha^2 - \beta^2)}$$

using the above $\beta$ values. This was done only as a way to indicate the relative rigidity of the sample and no rigorous interpretation should be placed on these values, because, strictly speaking, an assumption of Poisson's ratio is made in the 6% increment. For this reason, only the average value so determined for $\sigma$ is included in Figure 1. In the case of the Moldavites and Darwin glass, a few of the compressional velocities may have been slightly slowed due to having measured the rod velocity, since these samples are about three times longer in the dimension measured than in the other dimensions. Additionally, it is considered likely that the compressional velocities found for the Moldavites from Radomilice may be low due to the small size of the samples. That is, it is likely that the first lobe that could be picked out of the initial background on the oscilloscope was possibly the second lobe of the signal, so these determinations were eliminated from the velocities in Table 2. The surface wave velocities experience considerable scatter but the method of determining the distance for these waves was imprecise, and it could be questioned whether the acutal path of the wave was found. This distance was measured by fitting a thin flexible wire around the sample until a minimum length was found. This uncertainty is reflected in estimated maximum velocity error.

## CONCLUSIONS

As can be seen in Table 2, the velocities in the tektites are similar to those in the other natural terrestrial glasses except that the velocity in obsidian is slightly higher. The velocities in the other materials are higher still, but not remarkably so.

The densities in the tektites are more constant than in the other natural glasses and materials, but there is a rather poorly defined direct dependence between density and velocity. That is to say, in general, the greater the density, the higher the velocity.

The average value of Poisson's ratio shows that tektite glass apparently is more rigid than the other natural glasses, granite or upper mantle material, but less rigid than obsidian or fused silica, although it is quite variable and the $\beta$ velocities used in computing these were determined as stated above. The other natural glasses seem to be more variable than the tektites, note Figure 1.

These results probably indicate the relative ordering of the internal structures of the tektites and the other samples. The results show, as would be expected, the same lack of variation from one type of tektite to another, as other properties, such as chemical composition or other density determinations (O'Keefe, 1963). The compressional velocities vary by only about 6%. Thus they point to the same unity of origin noted by King (1964).

Acknowledgments: I wish to express my thanks to Professor Walter Pilant, University of Pittsburgh, for the use of his equipment and help in the determination of these results and to Professor Alvin J. Cohen of the University of Pittsburgh for discussion and the use of the tektites.

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## Table 1

Measured Seismic Velocities and Densities

| No. | Locality | | Distance(m.m.) Compression | Surface | Velocity(km/sec)* Compression | Surface | Density g/cm3 |
|---|---|---|---|---|---|---|---|
| | **TEKTITES** | | | | | | |
| | **Philippinites** | | | | | | |
| 1. | U.S. Nat. Museum 1914 (Isabella) | | 42.3 | 56. | 5.54 | 3.08 | 2.39 |
| 2. | U.S. Nat. Museum 1972 | | 34.7 | 49. | 5.45 | 2.53 | 2.39 |
| | **Indochinites** | | | | | | |
| 3. | Ile Tan Hai | | 51.0 | - | 5.23 | - | 2.36 |
| 4. | Borneo | | 32.3 | - | 5.47 | - | 2.38 |
| | **Australite** | | | | | | |
| 5. | A236 (Amer. Meteorite Museum) | | 45.8 | 63. | 5.35 | 3.37 | 2.41 |
| | **Moldavites** | | | | | | |
| | Bohemia (CSR) | | | | | | |
| 6. | (Radomilice) | | - | 36. | - | 2.87 | 2.33 |
| 7. | (Radomilice) | | 41.3 | - | 5.00 | - | 2.30 |
| 8. | (Radomilice) | | 26.6 | 34. | 4.89 | 3.04 | 2.30 |
| 9. | (Lherice) | A | 60.0 | - | 5.40 | - | 2.37 |
| | | | 53.8 | - | 5.20 | - | 2.37 |
| 10. | (Lherice) | B | 45.9 | - | 5.36 | - | 2.36 |
| | | | 52.8 | - | 5.26 | - | 2.36 |
| 11. | (Llatce) | | 46.7 | - | 5.25 | - | 2.32 |
| | | | 46.0 | - | 5.27 | - | 2.33 |
| | **"Americanite" glass** (Peru) | | | | | | |
| 12. | C116 | | 34.8 | - | 5.48 | - | 2.33 |
| | | | 34.8 | - | 5.43 | - | 2.33 |
| 13. | C117 | | 33.2 | 33.2 | 5.40 | 2.84 | 2.33 |
| | **Aouelloul Crater Glass** | | | | | | |
| 14. | C368 | | 28.4 | - | 5.11 | - | 2.06 |
| | **Darwin Glass** | | | | | | |
| 15. | C78 | | 42.4 | 42.4 | 5.31 | 2.33 | 2.06 |
| | **Libyan Desert Glass** | | | | | | |
| 16. | C2 | | 44.1 | 4.11 | 5.48 | 2.93 | 2.19 |

* The estimated maximum velocity errors are less than .2 km/sec for P waves and approximately .2 km/sec for surface waves.

Table 2

Summarized Results

| No. | Sample | V(compression) km/sec | V(surface) km/sec | Vs* km/sec | σ Poisson's ratio | ρ density g/cm³ | Reference |
|---|---|---|---|---|---|---|---|
| 1 - 11 | Tektites | (9) 5.35 | (5) 2.98 | 3.16* | .232 | 2.35 | (1) |
| 12 & 13 | Americanites | (2) 5.44 | (1) 2.84 | 3.01* | .279 | 2.33 | (1) |
| 14 | Aoulloul glass | 5.11 | | | | 2.06 | (1) |
| 15 | Darwin glass | 5.31 | 2.33 | 2.47* | .362 | 2.06 | (1) |
| 16 | Libyan Desert glass | 5.48 | 2.93 | 3.11* | .262 | 2.19 | (1) |
| 17 | Obsidian** | 5.70 | 3.22 | 3.54 | .185 | 2.40 | (2) |
| 18 | Fused Quartz | 5.90 | | 3.75 | .16 | 2.2 | (3) |
| 19 | Westerly granite | 5.76 | 2.98 | 3.23 | .270 | 2.66 | (4) |
| 20 | Average granite (at surface) | 5.96 | | 3.36 | .267 | 2.6-2.7 | (5) |
| 21 | Upper Mantle (at 33 km.) | 7.75 | | 4.35 | .269 | 3.32 | (6) |

* Computed based on V (surface), (see text).

** Glass Mountain, Siskiyou Co., Calif.

(1) this paper

(2) Seismic Scattering Project (1957)

(3) Handbook of Chemistry and Physics

(4) Knopoff (1954)

(5) Gutenberg (1951)

(6) Jacobs, Russell and Wilson (1959)

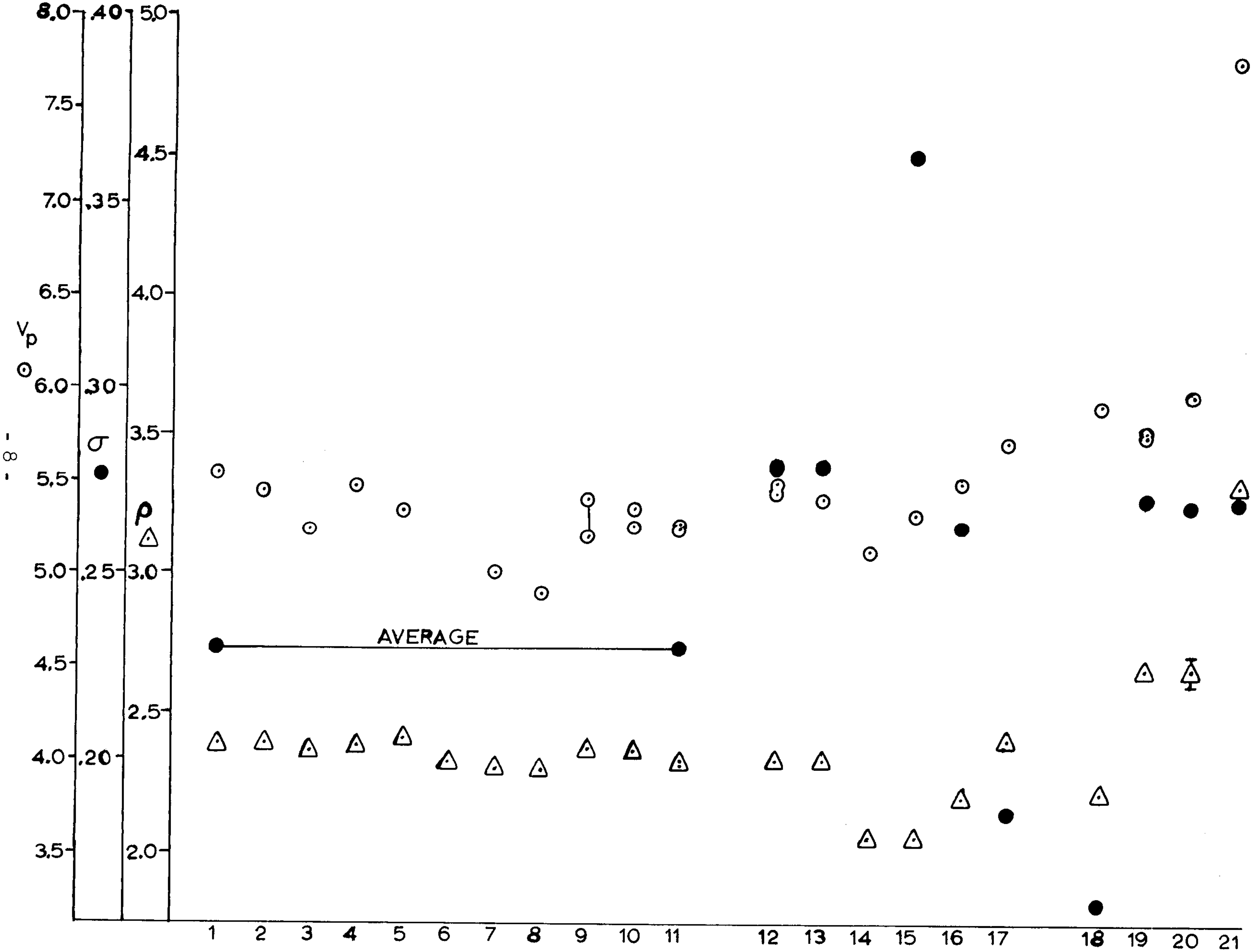


Figure 1.- This shows the relationships for the compressional wave velocity (Vp), km/sec., Poisson's ration ($\sigma$), and density ($\rho$) g/cm$^3$, among the samples listed in Tables 1 and 2.