to hope that this infestation had been conquered, I encountered three small patches of the thistle. Collection No. 52015 was made. The son of the owner (the latter was now well along in his eighties) was interviewed. He reported his success in controlling the weed, and stated that the three patches I had just seen were all that now remained. I shared his confidence that these would soon be wiped out, and added my heartiest commendation.

The second infestation of Turkestan thistle in Texas was encountered in El Paso County on May 12, 1946. A pure stand of possibly a hundred square feet lay across the highway and a short distance west of the discovery-site of *Swainsona*. Here collection No. 52939 was made. The attention of Agronomist Lee S. Stith of Substation No. 17 was called to this infestation, and he visited it with me. It was then that he told me of the presence of camelthorn near Socorro, already described.

The Elementary Dynamics of Terrestrial and Lunar Impacts[1]

John D. Boon

Many articles have been written about the origin of lunar craters and also about the origin of certain peculiar structures found in the crust of the earth. Since these craters and structures have at times been referred to the impact of giant meteorites it is well to consider the dynamics of these impacts. No effort will be made to either prove or disprove the meteorite theory. The reader must keep in mind the following laws, principles, and processes:

DYNAMIC FACTORS

I. Momentum is equal to mass multiplied by velocity. It can neither be created nor destroyed.

II. Vector quantities have both a numerical value and a directional value. Vectors may take either the positive or the negative sign.

III. Momentum is a vector quantity. A body taken as a whole may have no momentum, and yet its parts may have relatively large amounts of momentum. This is illustrated by a hot body that is at rest. Heat is random molecular motion, which means that

[1]This paper was read at a meeting of the Texas Academy of Science in Austin, December 12, 1947.

all of the molecular motions cancel, and of course the momenta cancel.

IV. Inertia is the resistance that a material body offers to any effort to change its velocity. Inertia may bring into action some of the greatest forces known.

V. When a large elastic body is given a heavy blow the energy of the impact is quickly transmitted to all parts of the body by elastic waves. When a non-elastic body is given a heavy blow, little energy is transmitted to other parts of the body by elastic waves. Heat energy is transmitted slowly in both elastic and non-elastic material.

VI. A substance is said to be a liquid when without shattering it quickly takes the form imposed by the action of external forces. Recent experiments[2] indicate that even the most rigid solids behave as liquids when these solids are subjected to very great forces.

VII. The pressure produced by the impact of a giant meteorite may be represented by the equation $F = D\ V^2$ where D is the density of the medium which receives the impact, and V is the velocity of the moving body[3]. As an illustration take the case of a meteorite having a velocity of 100,000 f.p.s. (about 19 m.p.s.) falling upon rocks that have a density of 200 pounds per cubic foot. The equation shows that the pressure produced will be about 430 million pounds per square inch. This is far greater than the pressure that man is able to produce.

VIII. If a number of processes are simultaneously active in the consumption of a given quantity of energy, those that work the faster will get the greater portion of the energy.

IX. When a solid is changed into a liquid by means of heat, both specific heat and heat of fusion are involved. When a solid is made to behave as liquid by means of pressure, neither specific heat nor heat of fusion is involved. For this reason pressure may change the state of a substance in a much shorter time than heat.

X. Wave energy is transmitted in the surface rocks of the earth more slowly than in the surface rocks of the moon for the following reasons: (1) The surface rocks of the earth are predominaantly sedimentary while the surface rocks of the moon are igneous. Sedimentary rocks are not, as a rule, as elastic as igneous rocks. (2) The sedimentary rocks of the earth are in thin layers and are often broken by faults and joints. All of these dividing planes hinder the transmission of elastic waves. The igneous rocks of the moon are not in layers and it is probable that they have few defects that would hinder the transmission of waves. (3) The surface of the earth is covered with soil and a zone of weathering that are poor conductors of waves. The moon has no soil and no zone of weathering.

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[2]Griggs, G. T., "Deformation of rocks under high confining pressure." (*Journal of Geology*, vol. 51, pp. 541-577, 1935.) See also *Science News Letter*, vol. 51, p. 105, 1947.

[3]The writer received an elegant derivation of this equation from Dr. F. R. Moulton.

We shall now discuss some conclusions which a physicist might draw, assuming that the dynamic factors listed above are true. The discussion will be limited by the nature of this paper and by the fact that the writer is not a selenologist. No effort will be made to cite the extensive literature on the subject of meteorite craters. As has been stated the view will be that of a physicist thinking only in terms of the dynamic factors.

When a giant meteorite arrives at the surface of the moon or the surface of the earth, it has a vast supply of kinetic energy that must be changed into other forms *in a moment of time.* The possible forms may be listed as follows: (1) Heat energy. (2) Energy used in excavating a crater. (3) Energy used in the production of rock-flour. (4) Energy of elastic waves. (5) Energy of electromagnetic wares. The only time that electromagnetic waves are important as energy absorbers is during the flight of a meteorite through the atmosphere. After it plunges into the solid rocks these waves are not able to escape. For this reason electromagnetic waves will be omitted from the discussion which follows. Since the processes which operate with the greater speed get the greater portion of the energy, the problem of distribution is one of arranging them in the order of their speed of action.

If a large meteorite should strike the surface of the earth, the material which received the impact would be driven downward with terrific force; but because the crust of the earth is not, as a rule, very elastic, the chances are that the energy would be spent in a relatively small volume of matter. At the moment of impact the energy would be kinetic mass-motion, and not that cf random molecular motion of heat. This regular mass motion would continue to predominate during the impact and the violent rebound which would follow the impact, for there would be little time for regular motion to degenerate into irregular motion. Naturally the majority of the molecules would rebound in the direction opposite to that of the impact. However, there would be a thin layer of molecules lying along the interfaces of contact that must receive special consideration. These are the molecules of the opposing bodies that are brought into immediate contact. The violence of this impact of the two systems of molecules would quickly result in the random motion characteristic of heat, and thus high temperatures would be produced in a moment of time. This interfacial heating is well illustrated by the superficial high temperature produced as a meteorite plows its way through the atmosphere. It must be remembered that this heat is skin-thin[4]. Any heat which goes deeper must do so by conduction, which is always a slow process. A good illustration of the slow transfer of energy by heat conduction is found in the sun. This body is more than a thousand times hotter at its center than at its surface. This vast difference in temperature would be impossible if heat transferred energy rapidly.

The events of a terrestrial impact may be divided into three stages. In the first stage, as has been stated, the energy would be that of kinetic mass motion. In the second stage the kinetic energy would be changed into potential energy of compression. In the third stage, the stage of rebound, a crater would be formed and tensions would come into action to produce a vast amount of rock flour. Elastic waves and heat would be the minor factors in energy absorption.

The events which would characterize a lunar impact would, in general, be quite different from those of a terrestrial impact. Because of the great elasticity and the smaller damping due to structural defects, the energy would spread in all directions to a large volume of material. These outgoing pressure waves would liquify the solid rocks, and as a result of the liquefaction and the light weight and low friction, a ring of elevated material would flow outward from the locus of impact and continue to move until the pressure became too low for pressure melting. When this point was reached the elevated ring of matter *would quickly freeze to form the rim of the vast crater.* Naturally the rear part of the wave would splash upward when the rocks ceased to be a liquid, just as water waves splash upward when they strike the solid land. Perahps these splashes would freeze to form peaks on the rim of the crater, and some of them might lash out far beyond the rim. All of this is possible because pressure melting and freezing take place almost instantly.

If the reasoning given above is logical, a terrestrial meteorite would spend the greater portion of its energy in the formation of a crater and the production of rock

[4]Fath, E. A., *Elements of Astronomy*, 1928, p. 206.

flour. On the other hand a lunar impact would spend the greater portion of its energy in the displacement of the rim material and the production of elastic waves. From these statements it is obvious that a given bolide would produce a much larger crater on the moon than on the earth. It is reasonable to suppose that the floor of a lunar crater would present the appearance of having been in the liquid state, a liquid produced by pressure and interfacial heat.

The remarkable fact about Meteor Crater is not that fused quartz is found here, but rather that the quantity is not large. If we remember that the only high temperature produced is at the faces of contact, the small amount of fused material will be explained. The excavation of a crater, the production of elastic waves and the formation of rock flour are processes that may consume energy on a large scale with great rapidity. This is not true of heat. The majority of those who have written on the subject of meteorite impacts (including the writer in years past) have assumed that a vast amount of molten matter is produced. If the logic of the present paper is sound, this assumption is in error.

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HERPETOLOGICAL NOTE

THE CORAL SNAKE [*Micrurus fulvius tenere* (B. & G.)] IN DALLAS COUNTY, TEXAS.———Hitherto, it has been generally believed that the Texas Coral Snake is not found in Dallas County; but we have two authentic records, with specimens: (1) Dr. Ira E. Nash, 4702 Bryan Avenue, Dallas, on a hot August day in 1942, took a 33-inch female from under a log at the foot of a hill near the entrance of Camp Tami Babi. It is now in the formalin collection of the City of Dallas Aquarium. (2) During the summer of 1945, Rush Pierce took a 28-inch specimen from behind the mess hall of Camp Wisdom, a Boy Scout camp some five miles from the first locality. Mr. Pierce has made a skin-preparation of the snake collected. Many reports of this species have been received without specimens, from farmers and ranchers in the general area of the above. Perhaps some of these "finds" are true coral snakes, but there is a possibility that some are specimens of the non-poisonous mimic, "Cope's Milk Snake" *(Lampropeltis triangulum amaura* (Cope), which also occurs in this county.———*Pierre A. Fontaine and Lawrence Curtis, Dallas Aquarium, Dallas, Texas.*