been proposed about source material and mode of transportation, such as melting of surface material and ejection of jets early in the impact process, or on condensation from a silicate vapor. The chemical composition of moldatives and Bavarian glass tuffs is markedly different from that of Ries glass bombs (Cohen, 1961, 1963; Gentner, Lippolt & Schaeffer, 1963; Gentner & Wagner, 1969; David, 1969; Engelhardt & Hörz, 1965; Engelhardt, 1967).

II. Cratering mechanics, impact metamorphism and distribution of ejected masses of the Ries structure — An introduction

By

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With 6 figures and 1 table

The following introduction is partly based on the general information about the Ries crater and its impact formations given by W. von Engelhardt in the first part of this paper. It is the aim of this section to present a brief review of some aspects of cratering mechanics, impact metamorphism, and ejecta distribution with respect to the conditions of the Ries event. This review cannot give a complete coverage of all aspects of the formation of the Ries crater. For more detailed information the reader is referred to the special literature.

Impact and excavation mechanics

Although mineralogical, petrographical, geophysical and geological data obtained mainly in the past decade (see collection of papers in Preuss & Schmidt-Kaler, 1969) have strongly and consistently proved the impact origin of the Ries crater, the exact physical impact conditions, that is the velocity, size, and nature of the cosmic body as well as its orbital parameters are not known. However celestial mechanics tells us that the impact velocities of meteorite bodies with respect to the Earth range from about 11 to 70 km/sec. Velocities in the 15—40 km/sec range have the highest probability (Millman & McKinley, 1963). Moreover we know from cratering experiments that the kinetic energy of the projectile is proportional to the size of the produced crater and that within certain limits the morphological parameters of a crater do not depend on the angle of impact at constant kinetic energy except for very oblique angles (Gault et al., 1968; Gault, 1973). These relations are exactly valid only for small-scale impact craters with energies up to some 10^{16} erg (Gault, 1973). Extrapolation of the experimental data and additional information from large-scale high-explosive and nuclear explosion craters (Cratering Symposium, 1961) result in a most probable value of the total energy of the Ries event of $E = 10^{26}$ to 10^{27} erg. Previous estimates of this energy are somewhat higher (Preuss, 1964; David, 1969). For a given impact velocity v the mass of the projectile m can be calculated according to $E = \frac{mv^2}{2}$. If this mass is then converted to the dimensions of a stony and iron meteorite sphere for an impact velocity of 20 km/sec, the diameter of this sphere would be 230 m and 317 m, respectively in the case of $E = 10^{26}$ erg, or 495 m and 683 m, respectively in the case of $E = 10^{27}$ erg.

The physical process of cratering by a meteorite impact with the conditions mentioned above can be briefly described as follows. For any detailed explanation the reader is referred to special papers (Gault et al., 1968; David, 1969; Engelhardt, 1974). Upon impact the target rocks and the projectile are compressed with approximately one half of the impact velocity (if it is a stony meteorite) through the propagation of two shock waves which proceed hemispherically into the target and the projectile with roughly 4/5 of the impact velocity (Fig. 3). From the known Hugoniot equation-of-state data for rock and meteorite material the peak pressure and temperature at the point of impact can be calculated approximately: about 4.5 megabar (ca. 4.5×10^6 atm) and 15000° for a stony meteorite with a density of 3.0 g/cm³ and an impact velocity of 20 km/sec (David, 1969). For a short period of time which is less than 0.03 sec, until the shock wave reaches the rear side of the projectile, the projectile and part of the target rocks are kept under these extreme conditions. They cause immediate vaporization of the affected material. At this point the main process of excavation starts by the propagation of rarefaction waves which run into the target from any point where the proceeding shock wave reaches the free surface. The rarefaction wave accelerates the target material in an upward direction. By the interaction of this motion with the particle motion behind

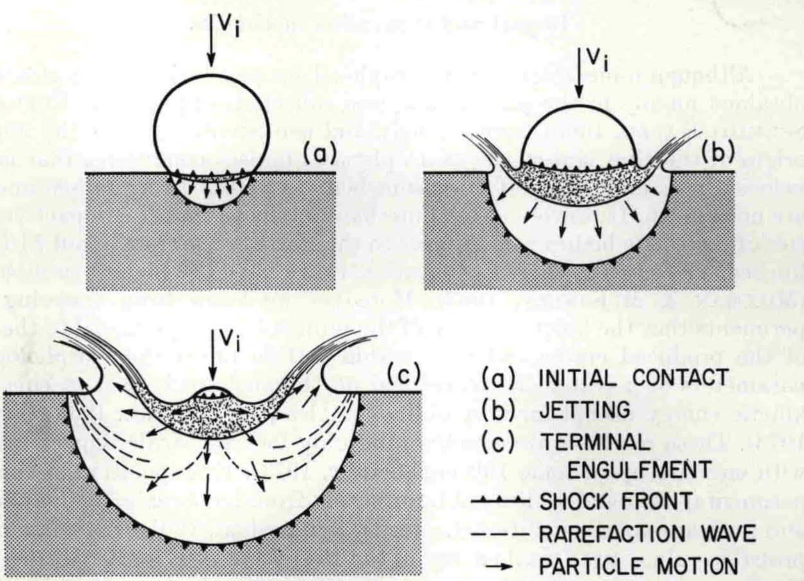

Fig. 3. Schematic representation of the shock wave propagation and particle motion at various stages of the vertical impact of a spherical body on a plane solid surface (modified after Gault et al., 1968).