The Suizhou meteorite is a stone meteorite, which fell on April 15, 1986, in Dayanpo, 12.5 km in the southeast of the Suizhou city, Hubei province, China. Right after the fall of this meteorite, a group of scientists from the China University of Geosciences and the Institute of Geochemistry, Chinese Academy of Sciences, conducted field survey and collection of Suizhou meteorite samples. A total weight of 270 kg of this meteorite was collected. The largest piece, a fragment of 56 kg in weight, is now preserved in the City Museum of Suizhou, and the smallest piece only weighs 20 g. This group of scientists headed by Professor Wang Renjing and Li Zhaohui then conducted a series of study on collected samples and published a monograph entitled “The synthesized study of the Suizhou meteorite” (in Chinese with an English abstract) in 1990. They classified this meteorite as an L6 chondrite on the basis of chemical composition and petrologic features, and evaluated it as a very weakly (S2) to weakly (S3) shock-metamorphosed meteorite. The authors of that book described in detail the mineral composition of this meteorite that consists of olivine, low-Ca pyroxene, plagioclase, kamacite, taenite, troilite, whitlockite, chlorapatite, chromite, and ilmenite. They observed some thin black melt veins in this meteorite, but no high-pressure phases were found.

Our recent studies revealed that the Suizhou meteorite is a unique chondrite with specific and unusual shock-related petrological and mineralogical features. At the first glance, this meteorite did contain very weakly shocked metal and troilite (S2) and the undulatory extinction is very weak for most olivine and pyroxene (S2-S3), indicating that the shock classification of S2 to S3 determined by previous investigators for Suizhou meteorite was reasonable according to the principles of Stöffler’s classification. However, our detailed study revealed that most of the constituent minerals in Suizhou unmelted chondritic rock have intact structure, some of olivine and pyroxene grains display a weak mosaic texture and usually contain abundant regular fractures and 3–4 sets of planar fractures, and some of the plagioclase grains have a reduced birefringence and contain abundant planar deformation features (PDFs), and many plagioclase grains display isotropic nature, indicating these grains have transformed to maskelynite, a melted plagioclase glass.
This implies that the main three rock-forming minerals in the Suizhou unmelted chondritic rock also experienced a moderate (S4) and strong (S5) shock compression according to the Stöffler’s classification for shocked chondrites. On the other hand, the thin shock melt veins in Suizhou are filled with abundant shock-produced ringwoodite, majorite and many other high-pressure mineral phases, indicating that this part of meteorite was very strongly shocked (S6). Therefore, the shock features of the Suizhou meteorite listed above match a wide range of shock stages, namely from S2 to S6, and, hence, should cover a wide range of shock-produced high pressures from 5 to >45–90 GPa and temperatures from 600 to 1750 °C. However, the results of our recent studies allowed us to come to a conclusion that the actual shock level of the Suizhou unmelted chondritic rock could be evaluated as S4-S5, and this rock experienced a shock pressure of up to 22 GPa and temperature of 1100 °C.

Locally developed thin shock veins in Suizhou were formed at pressure of 22–24 GPa that is very close to the shock pressure of the Suizhou unmelted chondritic rock but at an elevated temperature of about 1900–2200 °C. The higher temperature in melt veins than that in the unmelted chondritic rock was achieved by localized shear-friction stress caused by the collision event. Besides, the achievements in micromineralogical investigations of the Suizhou meteorite also include the following aspects:

1. Ten high-pressure mineral phases have been discovered in the shock melt veins of the Suizhou meteorite. They are as follows: ringwoodite (the high-pressure polymorph of olivine), majorite (the high-pressure polymorph of low-calcium pyroxene), akimotoite (the ilmenite-structured (Mg,Fe)SiO₃), devitrified perovskite (the CaTiO₃-structured (Mg,Fe)SiO₃), lingunite (the hollandite-structured polymorph of plagioclase), tuite (the γ-Ca₃(PO₄)₂-structured polymorph of both whitlockite and chlorapatite), xieite (the CaTi₂O₄-type polymorph of chromite), CF-phase (the CaFe₂O₄–type polymorph of chromite), garnet (majorite–pyrope in solid solution), and magnesiowüstite ((Mg, Fe)O). Among them, tuite, xieite, and the CF-phase are new high-pressure minerals, and lingunite is found for the first time in its single-phase form.

2. Two types of high-pressure mineral assemblages in shock veins were identified, namely (1) the coarse-grained mineral assemblage consisted of ringwoodite, majorite, akimotoite, perovskite, lingunite, tuite, xieite, and the CF-phase which formed directly through phase transformation in solid state upon shock, and (2) the fine-grained mineral assemblage consisted of majorite–pyrope<sub>ss</sub> (ss-solid solution), magnesiowüstite and microcrystalline ringwoodite, which crystallized from shock-induced dense melt under pressure. FeNi metal and troilite (FeS) in the veins were molten and occur as fine eutectic FeNi–FeS intergrowths in the interstices of fine-grained high-pressure minerals.

3. According to the results of high-pressure and high-temperature melting experiments on some chondrites and peridotite, the occurrence of shock-induced high-pressure polymorphs, such as ringwoodite, majorite,
lingunite, majorite–pyrope garnet, magnesiowüstite, and tuite in shock veins constrains the peak pressure of 20–22 GPa and temperature of 1800–2000 °C. However, the presence of akimotoite, devitrified perovskite, and xieite found inside or directly adjacent to the shock veins indicates that the maximum pressure and temperature developed in the Suizhou shock veins would be about 24 GPa and 2200 °C.

4. Although the shock melt veins in Suizhou are extremely thin, all of the high-pressure polymorphs, except devitrified perovskite, occur as mineral phases of good crystallinity, no matter how fine (<0.5 μm in size) their grains are, and no glassy phases were observed in any of the veins. This implies that the duration of shock-induced high-pressure and high-temperature regime in the Suizhou shock veins should be long enough (not microseconds, but a few seconds) for phase transformation of coarse-grained minerals in solid state and crystallization of fine-grained minerals from dense melt under pressure.

5. In comparison with many other shock-vein-bearing chondritic meteorites, the Suizhou shock melt veins are the thinnest and straightest, and they contain most abundant high-pressure mineral species (up to 10 polymorphs of different silicate, phosphate, and oxide minerals). It has been found that the cooling rate of the shock melt veins in meteorites is a main factor that controls the preservation of shock-produced high-pressure polymorphs. Since the hot melt veins are embedded in the cool meteorite body, and the heat diffusion coefficient of the chondritic mass is extremely low, the thinner of the shock melt vein the greater the cooling rate of the vein, and the more species of shock-produced high-pressure polymorphs could be preserved in veins.

6. A new explanation for the unique shock-related mineralogical features of the Suizhou meteorite has been proposed in that during a moderate-to-strong shock event with intensities of S4-S5, a longer duration of the shock pressure and temperature regime in the Suizhou meteorite plays an important role in the pervasive melting of plagioclase in the unmelted part of the meteorite, as well as in the formation of abundant high-pressure mineral phases in the thin shock melt veins as the temperature locally increased high enough. It has also been assumed that the phenomenon of numerous tiny chromite inclusions in molten plagioclase can be explained by disaggregation of fracture-rich chromite grains and subsequent in-situ mixing with intruding molten plagioclase.

7. Two types of zonal polymineralic grains have been found in the Suizhou chondrite. One is of (Mg,Fe)SiO₃ composition, and composed by three parallel zones: the inner perovskite zone, the intermediate akimotoite zone, and the outer low-Ca pyroxene zone. The other is of FeCr₂O₄ composition and composed also by three zones: the inner xieite zone, the intermediate CF-phase, and the outer chromite zone. The inner zones for both grains are just adjacent to the walls of shock melt veins. Detailed studies demonstrate that the existence of temperature gradient from the vein wall to the unmelted chondritic rock, and fast cooling of the extremely thin shock veins are regarded as essential conditions for the formation of such zonal polymineralic grains in the Suizhou meteorite.
8. Some large fragments consisted of three or two high-pressure polymorphs of silicate minerals, namely ringwoodite, majorite, and lingunite, were observed in the Suizhou shock veins. Besides, the distinct two-phase grains consisted of xieite and a high-pressure polymorph of one of the above-mentioned three silicate high-pressure minerals are also observed in veins. The interfaces between high-pressure polymorphs of silicate or oxide minerals in these fragments are quite sharp, implying that partial melting does not take place at the interface areas.

9. The different behavior of FeNi metal in the Suizhou meteorite upon shock was very well explained by using the theory of local concentration of stress at the boundaries of two phases with different densities, or at the discontinuities in rocks or minerals. While the FeNi metal in the Suizhou meteorite is “very weakly” shocked and displays no obvious shock-induced intragranular textures, some of very small rounded FeNi metal grains with higher Ni content were observed in cracks or at intersecting joints of shock-induced planar fractures in olivine and pyroxene, indicating that these tiny grains must be deposited from vapor phase produced by local stress concentration during shock event.

10. The discovery of various high-pressure phases in the Suizhou shock veins is of important significance in the study of Earth’s mantle mineralogy. While the minerals such as ringwoodite, majorite, lingunite, and majorite–pyrope garnet are main stable mineral phases for the Earth’s mantle transition zone, the perovskite, akimotoite, magnesiowüstite, and xieite are the stable mineral phases in the P–T conditions of the lower mantle.

Mineralogy is an important basic discipline of geological sciences. Mineralogical research does not have to be ended in itself. Mineralogical research should be aimed at solving geological problems. This book introduces the unique characteristics of different minerals found both in unmelted chondritic rock and in shock-induced melt veins of the Suizhou meteorite and describes the specific shock-related mineralogical features of this meteorite in an attempt to draw some conclusions on its P–T history and to enrich the contents of mineralogy and geochemistry of the Earth’s mantle. We hope that mineralogists both in foreign countries and in our homeland who are engaging in study of shock-induced mineralogical features of terrestrial or extraterrestrial rocks may find this book useful and helpful for their own undertakings.

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Xiande Xie

Ming Chen
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