THE RIES CRATER AND THE INTERPRETATION OF EJECTA DEPOSITS AT IMPACT CRATERS ON MARS. T. Kenkmann¹, A. Wittmann², ¹Institut für Geowissenschaften, Albertstrasse 23-b, Universität Freiburg, 79104 Freiburg, Germany.  Thomas.kenkmann@geologie.uni-freiburg.de; ²Lunar and Planetary Institute, Houston, TX, USA.

Introduction: Terrestrial impact structures provide field evidence for cratering processes on planetary bodies with an atmosphere and volatiles in the target. The Ries crater with its preserved deposits is the ideal object on Earth to investigate the effect of atmosphere and target volaties on ejecta deposition.

Ejecta deposits of Martian craters: Martian impact craters reveal morphological characteristics like fluidized ejecta with ramparts that are different from ejecta blankets on the Moon. Ejecta morphologies such as single layer ejecta, double layer ejecta, and multiple layer ejecta [1] depend on crater size, geographic location, altitude, terrain, and time of formation [2]. The different layers have sharp boundaries. The inner layers are often sutured with radial grooves and concentric furrows and ridges. The characteristics of Martian ejecta blankets have been explained by either emphasizing the role of subsurface ice and water (‘subsurface volatile model’) [3] or atmospheric turbulences during the cratering process (‘ring vortex model’) [4].

Ries crater: The ~26 km diameter Ries crater formed ~14.3 Ma ago in a target that is composed of ~650 m of partly water-saturated and subhorizontally layered sediments (limestones, sandstones, shales) underlain by crystalline basement rocks (gneisses, granites, amphibolites).

Its continuous ejecta blanket is the Bunte Breccia, a polymict lithic breccia that is mainly composed of sedimentary target clasts and melt particles derived from local and crater derived materials are thoroughly mixed on all scales. The ratio of primary crater ejecta to local substrate components in the Bunte Breccia decreases with increasing radial range [5]. It is interpreted as a “cold”, non-cohesive impact formation [6], however, internal shear planes do occur locally within the preserved ejecta blanket. The Bunte Breccia exhibits sharp contacts to the underlying substrate, even if it is formed by unconsolidated sands [7]. Still, because no paleosols were retained, none of the contact horizons of the Bunte Breccia with the target represent the land surface prior to the impact. A radial flow of the ejecta is indicated by striations on contact surfaces and obstacles of the pre-existing paleorelief locally deflected it by up to 30°.

Upper target layers beneath the ejecta blanket around the crater were decoupled along incompetent, fluid bearing clay and marl beds. Near-surface spallation together with dragging [8] by the ejecta curtain and/or the ejecta blanket flow, induced subsequent outward shearing of target strata.

Bunte Breccia is locally overlain by 10-25 m thick patches of Suevite, which indicate far higher temperatures and degrees of shock metamorphism and are mainly composed of clasts and melt particles derived from the crystalline basement. Suevite is the dominant type of ejecta in the inner crater, where it reaches a thickness of ~300 m. Outside the crater, the bulk volume of Suevite is only 5-10% of that of the Bunte Breccia. The Suevite - Bunte Breccia contact is very sharp but locally, dm-thick transition zones with worked and mixed Suevite and Bunte Breccia occur. The contact plane has a strong relief with partly vertical walls and several meter deep grooves.

Discussion: The Ries crater’s ejecta blanket is tested for the hypothesis of fluidization during emplacement. Initial interpretations of the Bunte Breccia assumed analogies to the Moon: (I) ballistic emplacement, which triggered a ground hugging debris surge, or (II) a rolling and gliding surge under high localized confining pressures. Water saturation in the target sequence of the Ries suggests it more likely formed analogous to Martian rampart craters [8]. Sedimentological evidence from the Bunte Breccia supports this hypothesis. Near-surface volatiles may have been liberated from a variably thick cover of poorly consolidated Tertiary sediments and underlying sedimentary rocks during the impact and deposition of ejecta. This likely caused at least localized fluidization. The existence of volatiles within the Bunte Breccia can be demonstrated by the presence of ductily deformed clays and venting pipes that originate from the interface between Bunte Breccia and Suevite. These venting pipes suggest vaporization of water at the Bunte Breccia’s surface during the emplacement of Suevites.

The presence of two distinct ejecta layers is probably the most intriguing analogy between Martian impact craters and the Ries. The mechanism by which the separation of both ejecta layers occurred is still a matter of debate and will be discussed.