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The Rochechouart impact geosite for research, education and training

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Abstract

In the prospect of future economic exploitation of the Moon and asteroids which are made and permanently reprocessed by impact, we address the potential for utilizing Rochechouart impact as test site for studies, and the field facilities and resources available on site and for practical "immersive" training of astronauts, administrations and industries on impact materials and processes.

1. Introduction

Following a decline since the mid 80's, the interest for terrestrial impact crater studies is now seeing a sudden revival. This is due in part to the increased awareness of the threat asteroids represent to humanity. It is also due to the renewed interest for manned missions to the Moon, and to the fact that the prospect of utilizing the Moon and near-Earth Asteroids for resource sourcing appears on the agenda of several space agencies and of private companies. In that context, terrestrial impact structures are by far the most accessible objects for ground truth data mining of impact cratering processes, and are the only sites accessible to humans **today** for "real" field training, testing and learning. Within this framework, we focus on the Rochechouart impact structure in France, one of the most interesting impact structures on European soil for research, education and training on fundamental and practical aspects of impacts on Earth and other Solar System planetary surfaces.

2. Rochechouart Impact structure

The Late Triassic Rochechouart impact structure is located at the western edge of the Massif Central in France. It involves crystalline rocks [1, 2]. Relatively "under-investigated" until recently [1], it is receiving nowadays a wide attention from the scientific community following the creation of the CIRIR facility and its research program (see next section). The Rochechouart site is very well accessible and is exposed at a unique erosion level. The crater infilling and the para-autochthonous target underneath (and thus the crater floor at the boundary) are widely exposed in a 12 km centro-symmetric zone across the center of the structure [1]. The complete sequence of crater fill deposits is represented, as well as the complete sequence of shock metamorphic effects both in the impact deposits and in the target, including melt veins and breccia dykes [1].

The recent drillings performed in 2017-2018 suggest the initial crater could have reached 50 km in diameter or more and that it belongs to the class of peak ring craters [2]. The peak ring formed beyond the 12 km diameter central deposit zone and is now completely eroded as is the annular depression further away from the center. In this context, a large zone beyond the actual central deposit exposes the target under the initial crater at a well-constrained level corresponding to the bottom of the central depression. Moreover, it eventually brings a large-sized complex crater into the analog program. Yet the Rochechouart impact structure does not give access to the proximal ejecta blanket nor to the original crater topography. Both are lost due to the erosion.

3. CIRIR facilities and resources

The idea of promoting the Rochechouart impact structure as an open international natural laboratory for ground truth data mining of impact cratering and its collateral effects on planetary surfaces was first announced in 2008 [3]. Inspired by Apollo, the two combined means for achieving this goal and mobilizing the community at Rochechouart were then presented in 2014: 1)-Realizing an extensive drilling campaign within the geosite (the first ever

scientific drillings made at Rochechouart) and 2)-making the cores available to the international community via a dedicated on-site facility and the creation of a coordinating organization [4]. Thanks to the support of the local authorities, the French State, and a number of scientists who endorsed these two complementary projects, the CIRIR was created in 2016 and the drilling program was undertaken in 2017-2018. A total of 8 sites were drilled in the "Reserve Naturelle Nationale de l'Astroblème de Rochechouart-Chassenon" delivering over 540 m of core [2]. The rocks exposed in the field and the core material directly contribute to the project as do the CIRIR facilities installed at Rochechouart. One unit of the facility is designed for accommodating and managing the cores and the surface samples collected by scientists and by the public (citizen science project). It builds up a unique "dynamic" impact sample library made available to the community ("impact on shelf") [5], directly serving the project. Beyond storage, the unit includes a laboratory for sample preparation and for optical studies. The second unit provides housing and office facilities for up to 10 persons. A linked unit located 12 km from Rochechouart can accommodate up to 50 people in 16 chalets. These facilities are maintained thanks to public funding and are available at no charge as part of a "world public service" for promoting the Rochechouart geosite and impact science in general. Mutual benefits are then expected for both the site and all its users (researchers, space agencies, industry, and others) taking advantage of the site and facilities for their research, testing, learning and training needs. Already ~70 individuals and organizations from over a dozen countries are involved. They form the CIRIR consortium (full list in [2]) which is the active core of the CIRIR association. The CIRIR program currently counts ~60 research projects covering essentially all impact-related topics, ranging from large crater formation, modification and cooling history, to impact tsunamis (that most probably also occurred on Mars) and impact-triggered hydrothermal cells. Similar mechanisms have been proposed for large impact sites on planetary surface (including on the early-Earth and Mars), for bringing and for maintaining free water to the surface, and thus for setting the conditions for emergence of life [6].

4. Summary and Conclusions

Owing to its accessibility and exposure, the Rochechouart impact crater structure is a unique site for field learning and for experiencing all scientific and practical issues related to **large** impacts on Earth and on other planetary surfaces (Moon and Mars in particular). Its level of erosion allows to study both the crater fill of a large complex crater and the target beneath, thus combining two key assets for our project. On site facilities are already operational for hosting trainees and trainers that will benefit from the support provided by the CIRIR team composed of a large part of the world specialists on impact. Yet Rochechouart does not cover the whole sequence of impact related features. The forthcoming steps are thus to enlarge the project in association with other geosites and to set up practical programs in conjunction with the specific end-users. These issues will be addressed at the conference.

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