Chapter 26
3D Laser Scanner Techniques: A Novel Application for the Morphological Study of Meteorite Impact Rocks

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ABSTRACT

The use of 3D scanning systems for acquiring and analyzing the external shape features of arbitrary objects has different applications in different cultural, scientific, and technological fields. In this work, 3D laser scanning techniques are used, for the first time, to our knowledge, as a novel and non-destructive application for the morphological study of meteorite impact rocks. The subject of the study was a rock displaying impact textures and associated with the Karikkoselkä impact crater (Finland) (Lehtinen et al. 1996). This methodology permitted: (1) a computerized three-dimensional modelling to be carried out on the bulk impact-related rock; (2) other more specific characterizations to be performed, such as detailed topographic studies of its surface impact features; (3) some physical properties of the rock to be determined (volume); (4) the shatter cone impact texture to be completed with a realistic estimation of its convergence angle; and (5) a broad demonstration of the significance and effectiveness of 3D laser scanning techniques as a complementary tool for the study of this type of meteoritic impact-related rocks.

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INTRODUCTION: IMPACT ROCK (KARIKKOSELKA IMPACT CRATER)

Numerous studies on terrestrial rocks have shown they have different types of geological features which can be used as micro or macro-markers of large impact events (Koeberl & Martinez-Ruiz, 2003). Certain shock effects have been shown to be uniquely and unequivocally associated with meteorite impact craters. These include, among others, multiple sets of microscopic planar deformation features, mainly in quartz and feldspar grains, high-pressure mineral phases (e.g. stishovite, coesite) and shatter cones (impact textures which form when the shockwave from a meteorite impact event passes through and modifies the target rocks). The study and detailed characterization of these impact-related signatures in terrestrial environments encompasses the use of classical mineralogical and geochemical techniques and the development of theoretical, numerical and experimental models.

The impact rock used in the work (Figure 1) was sampled by one of the authors (JMF) in the Karikkoselka area of Finland and forms part of the lithotheque at the Spanish Centro de Astrobiologia. The well known northern European Fennoscandian Shield has at least 32 impact structures, of which 10 are located in Finland (see Earth Impact Database, Spray, 2009). This shield is extremely important for impact cratering research, since it is well exposed, easily accessible and has been mapped in detail (Plado & Pesonen, 2002). The Karikkoselka structure (62º13' N; Long. 25º15' E) was proposed as a meteorite impact crater by Lehtinen et al. (1996). The crater is the smallest of those so far identified in Finland, with a diameter of 1.5 km and a depth of 150 m. The geological setting corresponds to the Central Finnish Granite Complex dating from the Paleoproterozoic Age. The target rock is of porphyritic granite from a site where many shatter cones have been found. In general terms, shatter cones can be defined as unusual, striated, horse-tailed conical fractures, measuring from millimetres to meters in length aand produced in different types of rocks by the passage of a shock wave (Sagy et al. 2002), although the mechanism by which they are formed is not well understood (Dawson, 2009). The directional striated surfaces of shatter cones are positive/negative features. An extremely interesting (and useful) feature of shatter cones is that the tips point toward the origin of the shockwave. This means that they can be used to reconstruct the location, size and shape of prehistoric impact craters that have subsequently been modified by later processes. Shatter cones are usually formed at pressures between 2 and 6 GPa, although rocks have been found that had been subjected to pressures around 25 GPa (Milton 1977). Further information on impact textures can be found, for example, in Dietz 1947, Amstutz, 1965, Milton, 1977, Roach et al. 1993, Gibson & Spray, 1998, Baratoux & Melosh, 2003 Sagy et al. 2002, 2004, Lugli et al. 2005, Dawson, 2009, Ferrière L. & Osinski, 2010).

The impact rock from the Karikkoselka impact crater (Figure 1) is a red-coloured granitic specimen, measuring 131.10 mm x 82.30 mm x 92.80 mm, with a rough surface marked with incomplete but well-defined shatter cone textural features.

3D LASER SCANNER TECHNIQUES

We began our research projects, by questioning site and artefact documentation methodologies when participating in periodical archaeological campaigns. We first became acquainted with laser scanners in 2003 through the Leica company, which put one at our disposal for a data acquisition test. The modelling subject chosen was the statue of Cibeles in Madrid and the project was duly carried out after obtaining the necessary licences. The experience was briefly analysed in the journal of the Colegio Oficial de Ingenieros Técnicos y Topografía (Farjas & Sardiña, 2003). The images thus obtained were quite surprising