**REVISITING THE CHAMPAGNAC IMPACTITES: INTERPRETING $\delta^{13}C$, $\delta^{18}O$ AND $\delta^{34}S$ ISOTOPE DATA OF SECONDARY CARBONATES AND SULPHIDES WITHIN THE CONTEXT OF A MARGINAL OR SHALLOW MARINE IMPACT.** S. L. Simpson[1], M. R. Lee[2] and P. Lindgren[3]. [1]NASA Johnson Space Center, Houston, TX, 77058 (sarah.l.simpson@nasa.gov), [2]The University of Glasgow, Glasgow, G12 8QQ, UK. [3]Geological Survey of Sweden, Kiliansgatan 10, 225 50 Lund, Sweden.

**Résumé:** Dans cette contribution, nous revisitons les données d'isotopes stables ($\delta^{13}C$, $\delta^{18}O$ et $\delta^{34}S$) des minéraux carbonatés et sulfurés secondaires de diverses impactites de la carrière de Champagnac, obtenues lors d'une précédente étude qui s'est terminée en 2015. La composition géochimique des principales lithologies d'impact de Rochechouart suggère une composition de cible granitique et cristalline. Cependant, la paléogéographie de la zone suggère un impact marin marginal ou marin peu profond probable ; les résultats préliminaires de la plus récente campagne de forage de 2017 soutiennent également cette interprétation. Il est probable que si de l'eau de mer circulait dans la structure pendant la phase de refroidissement, les minéraux d'altération secondaire portent cette signature isotopique. Nous discutons ici de l'interprétation de ces résultats d'isotopes stables de Champagnac dans le contexte d'un impact marin marginal ou marin peu profond.

**Introduction:** The 23km-diameter Rochechouart impact structure (~207 Ma; [1]) is located in west-central France, on the western margin of the Central-Massif and northeastern edge of the Aquitaine basin. Despite being highly eroded a suite of impactites representing various degrees of shock and mixing is preserved. Hydrothermal alteration is a well-recorded and pervasive feature of Rochechouart, most notably as a K-metasomatic overprint present throughout all lithologies.

Prior to the most recent 2017 drilling campaign, geologic samples were limited to what could be obtained at a small number of eroded, fairly inaccessible outcrops throughout the structure, and the main impact lithologies were divided primarily into 5 or 6 rock types named with respect to their location of occurrence [2]. These initial lithologies are all fairly heterogeneous and complex, and their interpretation indicates a crystalline target composition for Rochechouart consisting primarily of Variscan granitoid igneous and metamorphic basement. However, the regional paleogeography suggests a marginal or shallow marine impact was likely; preliminary lithologic interpretation of the 2017 drill core also supports this hypothesis [3,4].

If the impact occurred in a shallow marine environment, the various secondary minerals that formed as a result of hydrothermal circulation during the cooling phase could carry a marine isotopic signature. In this contribution we revisit stable isotope ($\delta^{13}C$, $\delta^{18}O$ and $\delta^{34}S$) results preserved in secondary carbonate and sulphide minerals in the various lithologies found throughout Champagnac quarry [5], and discuss their interpretation within the context of the marginal marine paleogeography.

**Methods:** Samples were acquired from Champagnac quarry and Montbron during two field campaigns from 2013-2014 [5,6]. *Target and autochthonous material*: Samples of basement amphibolite gneiss containing sulphides both within the fabric and cross-cut by secondary carbonate and sulphide veins (1), coarse crystalline calcite, pyrite and chalcopyrite coatings on fracture surfaces (2) and K-feldspar veins containing minor amounts of euhedral pyrite were collected for analysis (3).

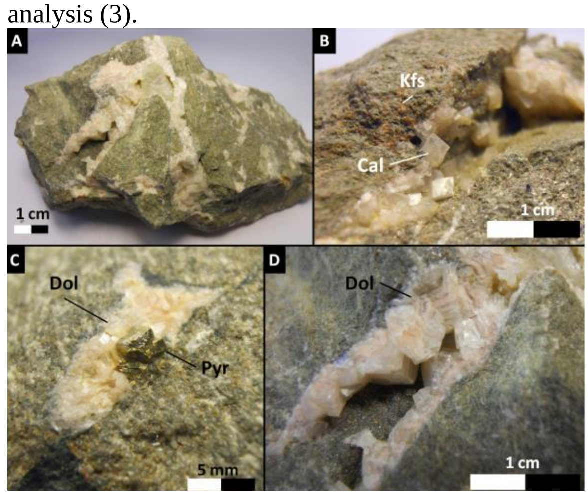


**Figure 1:** Hand sample of monomict lithic breccia from Champagnac with secondary calcite, dolomite and Fe-sulphides (Cal = calcite; Dol = dolomite; Kfs = K-feldspar; Pyr = pyrite).

*Parautochthonous and allochthonous material*: Monomict and polymict lithic breccias were collected at the top of Champagnac quarry. Clasts of both breccia types display K-feldspar thermal reaction rims and soft clay-rich interiors, as well as a secondary dolomite, calcite and Fe-sulphide-rich matrix cement (Fig. 1). *Jurassic-Triassic boundary limestones and the Aquitaine basin shoreline*: What is left preserved of the Jurassic-Triassic shoreline unconformably overlies crystalline basement approximately 17km WSW of the structure's center, ~5km outside the currently accepted crater diameter. The age of these limestones is poorly constrained and mapped by the French Geological Survey as “Triassic-Jurassic limestones”, spanning a 20 million year period, from 210 to 190Ma (Rhaetian to

Hettangian) [7], contemporaneous with the age of Rochechouart. It is also worth mentioning that evidence presented by other authors supports a larger diameter (40 to 50km) for the structure than what is currently accepted (23km) [2,8]. Samples of these limestones were collected from an outcrop in Montbron; this unit contains few or no fossils and is comprised of calcite, dolomite and quartz.

Isotopic analysis ($\delta^{13}C$, $\delta^{18}O$ and $\delta^{34}S$) of secondary carbonates and sulphides throughout the Champagnac impactites and Montbron limestones was performed at the Scottish Universities Environmental Research Center (SUERC). Seqeuntial acid extraction methods were used to isolate the calcite and dolomite for separate analyses. Conventional and *in-situ* laser combustion methods were used for the Fe-sulphides [5].

**Results and discussion:** $\delta^{13}C$ isotope results varied from -13.1 to -4.5 ‰, while $\delta^{18}O$ remains fairly consistent, from +23.8 to +28.7 ‰, with the exception of one dolomite value of +13.5 ‰ (Fig. 3). $\delta^{34}S$ of the Fe-sulphides was more variable, from -35.8 ‰ to +0.4 ‰.

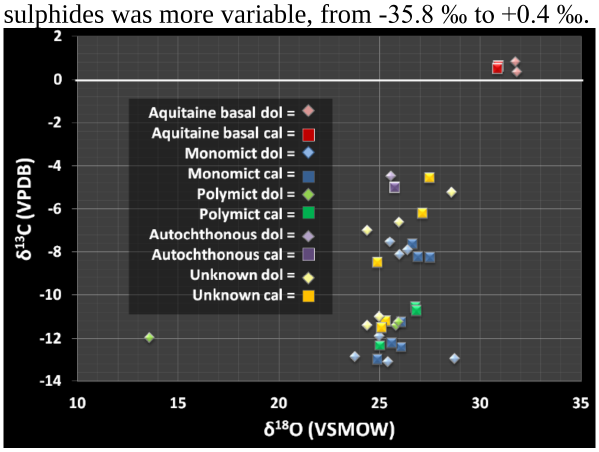


**Figure 2:** $\delta^{13}C$ and $\delta^{18}O$ of all carbonate minerals. $\delta^{13}C$ of impactites varies from -4.5 to -13.1‰, while $\delta^{18}O$ remains more consistent, from +23.8 to +28.7 ‰, with the exception of one dolomite reading of +13.5 ‰ [5].

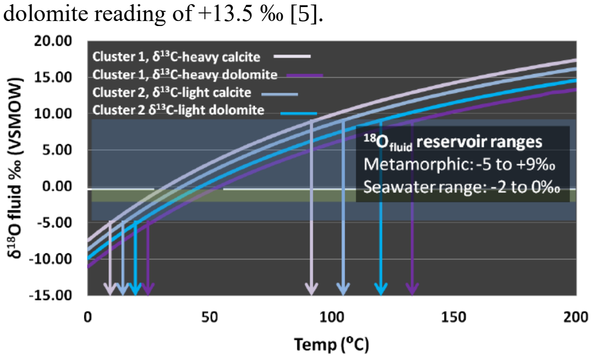


**Figure 3:** Temperature and fluid models for secondary carbonates from the monomict lithic breccias. Because the isotopic composition of the starting fluid in Rochechouart is unknown, temperatures were modeled over a range of possible fluid values using the O'Neil et al. (1969) equation for calcite and Vasconcelos et al. (2005) for dolomite [5].

Because the $\delta^{18}O$ of the fluid circulating within Rochechouart during the cooling period is unknown, temperatures can only be constrained and modeled by placing limits on known potential sources. The reservoirs considered for this study are seawater and metamorphic (crustal) fluids; Late Triassic seawater $\delta^{18}O$ was likely between -2 and 0‰ and metamorphic fluids were estimated from +9 to -5‰ (for Hercynian fluids) [9,10]. We could also consider the reduced $\delta^{34}S$ signatures, which necessitate an open supply of sulphate, as a possible indicator of a seawater-dominant source. Realistically, these waters were likely sourced from a mixture of reservoirs. If we model a seawater endmember, calculated temperatures from the carbonates are within the range of late stage impact-hydrothermal or diagenetic (~20 to 45°C). The exception to this is one higher temperature dolomite from a breccia dike in Champagnac, which could record an earlier generation (higher temperature; ~125-150°C) carbonate. If a more crustal/metamorphic fluid is considered, the range of these temperature models varies substantially (~10 to +250°C), highlighting the need for tighter constraints on possible fluid reservoirs during the crater's cooling phase, as these current estimates do not lend themselves to meaningful interpretation or discussion. Previously we did not consider a purely (ancient) meteoric fluid source which can be more difficult to constrain based on the regional paleogeography and paleoclimate, a topic that is open for discussion.

**References:**


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