Evidence for localized high temperature hydrothermal fluid flow within the sub-crater environment of the Rochechouart impact structure: observations from a polymict breccia dike S. L. Simpson[1], P. Lambert[2], M. R. Lee[1]. [1]University of Glasgow, University Ave, Glasgow, G12 8QQ, UK. [2]Sciences et Applications, 218 Boulevard Albert 1er, 33800 Bordeaux, France. S.Simpson.1@Research.gla.ac.uk.

Introduction: Hypervelocity impacts into volatile-bearing terrestrial targets can initiate hydrothermal circulation for a finite period of time; evidence for this is preserved in approximately one-third of impact structures on Earth [1, 2]. Hydrothermal environments can host extremophile life, and microbial communities have been found to colonize impact craters [3, 4]. The majority of impact structures on Earth have yet to be studied in great detail; many aspects of the post-impact environment such as the extent and duration hydrothermal circulation with respect to location within the structure as well as crater diameter, target composition and external influences, (paleogeography) are not fully understood.

We present evidence for high temperature hydrothermal fluid circulation within the sub-crater environment of the highly eroded, 23km diameter, Mesozoic Rochechouart impact structure located in west-central France [5]. This evidence is a new impact lithology that was found during a recent field campaign at a collection site located approximately 7.5km north-east of the structure's center. It is a highly porous, polymict lithic impact breccia dike containing carbonate mineralization found below the transient crater floor. Secondary hydrothermal mineral assemblages are diagnostic of a range of temperatures (>100°C to low temperature diagenetic).

The Rochechouart impact structure: The highly eroded Rochechouart impact structure has been dated to 201±2 Ma and is located on the western border of the Central-Massif and north-eastern edge of the Aquitaine basin [5, 6]. The target consists of plutonic and metamorphic granitic basement rocks of the Variscan orogeny. Despite being highly eroded, a full suite of impactites is preserved at Rochechouart [5]. The rocks represent a continuum of transitional lithologies, ranging from clast-poor, vesicular impact melt rock to autochthonous, shock-fractured basement [5, 7]. Rochechouart impactites are primarily granitic in composition, consistent with the geology of the target. *Post-impact hydrothermal alteration*: hydrothermal alteration is a feature of Rochechouart, and has been reported by previous authors [1, 5-8]; K-metasomatism is the most pervasive and has affected all impactites at various levels. Other pervasive secondary mineral assemblages are argillic and oxide, and locally, carbonate and sulphide.

Rochechouart lithic impact breccias: Lithic breccias are preserved in a variety of settings within Rochechouart. These breccias contain a mixture of angular to sub-angular basement fragments within a melt-free, fine to medium grained clastic matrix, and can be found as both polymict and monomict. The breccias form either continuous (allochthonous) or discontinuous (parautochthonous) units, and localized breccia dikes above and below the transient crater floor, respectfully [5].

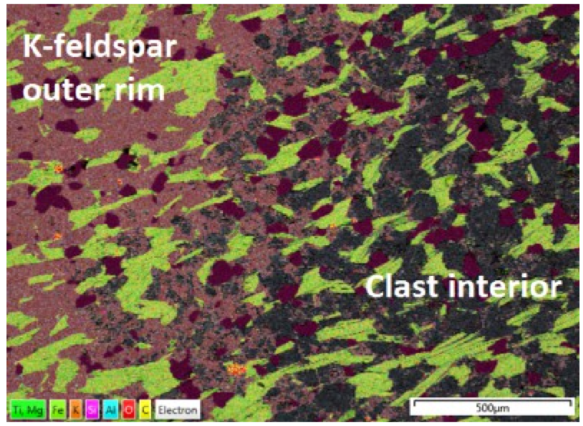

Figure 1: SEM (EDX) chemical map of reaction rim of polymict breccia dyke clast, showing K-feldspar-rich outer rim (left, pink area) and Al-rich, K and Si-depleted, altered interior (right, dark area).

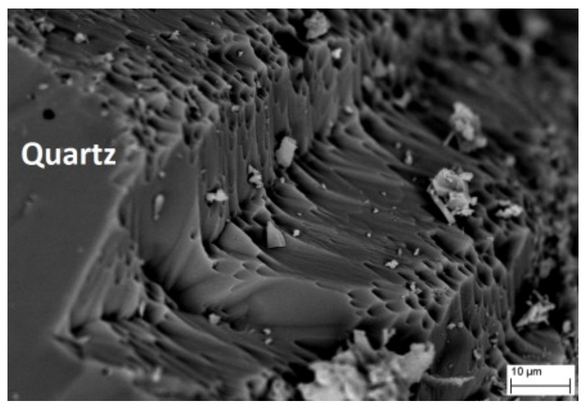

Figure 2: SEM image of alteration texture of quartz grain within matrix of polymict impact breccia dike,

Polymict lithic breccia dike: setting: A polymict lithic breccia dyke was found at a study site located 7.5 km north east of the structure's center directly beneath the transient crater floor, at Champagnac quarry; it is intruded into autochthonous basement rock and has a width ranging from 1 to 5m. The site where this dyke was found showcases the complexities involved in impact cratering at the basement-crater cavity interface; within only tens of meters laterally, we find outcrops of polymict lithic breccia dyke, monomict lithic breccia, autochthonous basement and pseudotachylite. Approximately 10 meters above this, is the continuous unit of polymict lithic breccia from where this dyke is believed to have originated. *Lithologic description:* A mixture of angular clasts of country rock are found within a fine-grained clastic matrix containing coarse to fine-crystalline secondary carbonates and bright red, coarse crystalline K-feldspar. Clast descriptions are as follows: (i) dark-grey, angular, 2 to 3cm clasts of amphibolite gneiss displaying high temperature reaction rims of dark red K-feldspar (figure 1 and 3), (ii) light-grey, 2 to 4cm sub-angular clasts of granitic plutonic and metamorphic basement, also displaying high temperature dark grey-red reaction rims, with phyllosilicate-rich interiors and (iii) 5mm to 1cm sub-angular quartz grains.

Figure 3: Photo of clean-cut face of polymict lithic breccia dyke.

The matrix is locally porous, and consists of a mixture of fine-grained, light grey to pale green clastic material with 2 to 3mm grains of bright red K-feldspar and dark-grey basement amphibolite, and coarse to fine-crystalline dolomite cement. SEM chemical analysis of the matrix shows Fe and Mn-rich dolomite cement with localized overgrowths of smectite clay. Both matrix and clasts show varying levels of chloritization and K-metasomatism, and localized growth of Fe-sulphides. Quartz grains within matrix also display a unique alteration texture not seen in any other Rochechouart impactites (figure 2).

Discussion: The example we have presented displays characteristic retrograde alteration patterns commonly observed in impact-generated hydrothermal systems [1, 8]. The secondary mineralization are suggestive of a complex cooling history over an extended period of time; reaction rims on clasts and pervasive chloritization suggest high temperatures (100 to 300°C), and the cloudy centers and clean rims of dolomite cement suggests moderate diagenetic temperatures (≤60°C) of crystallization. It is also important to note the high porosity of these rocks: melt-bearing lithologies of Rochechouart can have very low porosity, while lithic breccias are the opposite, making them ideal conduits for fluid flow. It is likely that this porosity difference is why we do not see such extensive mineralization, apart from K-metasomatism, within melt-bearing crater fill units. *Heat source:* Secondary alteration within this dyke presents indirect evidence for high temperatures during the post-impact cooling period. This is a localized occurrence; surrounding impactites within the study site do not reflect the same temperatures. As this material is allochthonous, sourcing from above the crater floor, it is likely the dominant heat source for this alteration originates from overlying melt-bearing units, which have since been eroded. *External influences:* The paleogeography of Rochechouart is complex; although impactite petrology clearly shows a primarily crystalline, granitic target, the impact took place near a coastal marine shoreline. Further, $\delta^{13}C$ stable isotope analysis of dolomite and calcite cement found within monomict lithic breccia, also collected from this site, shows contribution from both organic and inorganic reservoirs, supporting the hypothesis that seawater may have influenced post-impact mineralization. It has been suggested that basement fractures may have extended to the nearby Mesozoic sea, which would have channelled seawater to the structure [9]. This hypothesis will be tested further by analyzing stable isotope content from secondary carbonates within the polymict lithic breccia dyke.

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