A data driven multiscale approach for understanding the Solar Systems oldest materials

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Introduction: Ca-Al-rich inclusions, or CAIs for short, are the oldest solar system materials that formed at incredibly high temperatures near the young Sun [1]. CAIs formed at the birth of the solar system 4.567 billion years ago. They are thought to have formed initially as pure high temperature equilibrium condensates [1]. However, they have also, in many cases, undergone back reactions with gases, thermal metamorphism and remelting processes in the nebular and alteration on their parent asteroid generating a diversity of textures [1]. Intriguingly, despite forming close to the young sun, they are now found embedded within all primitive chondrite meteorite types and even comets [1] that formed much further out in our solar system relative to CAIs. In particular, the largest examples of CAIs and the highest abundance are found in CV chondrites that formed beyond Jupiter. How did these objects come together? This project seeks to explore variations within the CAI population between chondrite meteorites to answer the question: What diversity of processes were at work in the CAI forming region? And how did CAIs end up in their current distribution within chondrites from their starting location near the Sun?

Project Description: In order to understand the distribution and variety of CAI's across all chondritic meteorites, machine learning analytics will be employed on a range of microscopy data sets, both archival and freshly acquired. Starting from optical micrographs a machine learning enabled correlative approach will guide data driven selection criteria for high resolution techniques, including Electron Backscatter Diffraction (EBSD) which measures the crystal structure of minerals. By combining these quantitative methods on the characterisation of CAI mineralogical microstructures a new advanced analytics derived classification system for CAIs will be developed. This big data approach of CAIs characterisation will enable us to establish the dominant processes affecting CAI formation and alteration and the distribution of CAI groups within chondrite meteorite types. The distribution of CAIs will in turn help us understand how these objects were delivered and concentrated in different asteroids that formed at various distances from the young sun.

Training: The student will work with a dynamic team of planetary scientists at the University of Glasgow where they will gain a suite of skills in machine learning, big data, mineralogy, petrology, planetary science and astrobiology in addition to science communication. The student will work within a vibrant planetary science research community in the UK and internationally and will have the opportunity to travel widely in order to undertake research and present results at conferences.

Application procedure: This project is one of seven advertised projects that are eligible to receive 3.5 years of funding available through an award from the Science and Technology Facilities Council to the University of Glasgow (Note only a single scholarship is available). Please apply via the website of the College of Science and Engineering*. The application deadline is 31 January 2023, and the project will start in October 2023. Contact Luke.Daly@Glasgow.ac.uk with any questions. *

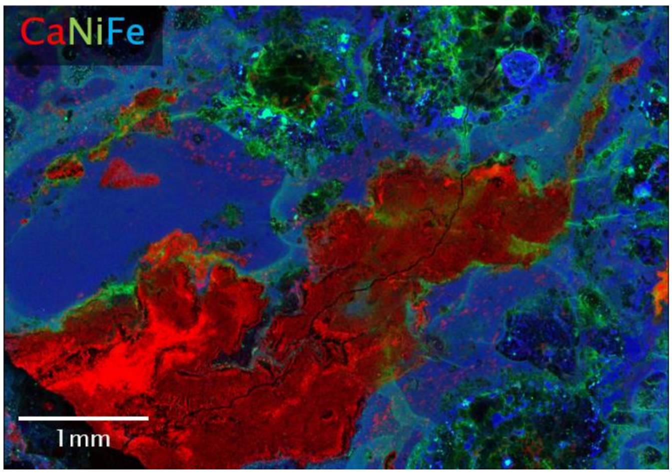

Figure 1: A synchrotron X-ray fluorescence false colour image of a CAI (red colour) within the carbonaceous chondrite Vigarano.

References: [1] MacPherson, G. J. (2003). *Treat. on Geochem.*, 1, 711