I/UCRC Executive Summary - Project Synopsis		Date: April 2020
Center/Site: CANFSA/Colorado School of Mines		
Tracking No.: 29-L: Identification of Deformation Mechanisms of Thermally Stable Cast Al-Cu Alloys via Neutron Diffraction	**Phone :** (906) 370-9057	**E-mail :** bmilliga@mines.edu
Center/Site Director: CANFSA/M. Kaufman/P. Collins/A. Clarke		**Type: (Continuing)**
Project Leader: Brian Milligan		**Proposed Budget**: $240,000, Leveraged

Project Description: The classic Al-Cu alloy system has long been popular due to its low cost and the ability to create low density, high strength alloys. However, room still exists to fundamentally understand the microstructures and mechanical properties produced by aging. This project aims to improve the scientific understanding of deformation behavior in Al-Cu alloys as a function of precipitate structure and temperature from the individual precipitate scale to the bulk, and then apply that knowledge to inform heat treatment and alloy design.

Experimental plan: Neutron diffraction at ORNL's Spallation Neutron Source (VULCAN beamline) is being used to observe the grain-level deformation mechanisms *in situ*. Transmission electron microscopy (TEM) will be implemented to observe fine-scale precipitate morphology pre- and post-mechanical testing. Constitutive modeling will be performed to quantify deformation mechanism changes. Collaboration will be performed with co-authors to implement molecular dynamics and crystal plasticity modeling.

Related work elsewhere: A. Shyam's group (ORNL) is studying the mechanical behavior and phase transformations in the same alloys. N. Chawla's group (Arizona State University) is studying phase transformations and deformation of Al-Cu alloys *in situ*. C. Hutchinson's group (Monash University) is modeling deformation of Al-Cu alloys from first principles and experimental data. S. Mishra's group (IIT Kanpur) is studying precipitate/matrix load transfer mechanisms during yielding and strain hardening.

How this project is different: Other projects related to deformation in Al-Cu alloys focus either on an individual precipitate scale or on a bulk, polycrystalline scale. This project aims to bridge the gap between the bulk and precipitate-scale in-situ.

Milestones for the current proposed year:
- Continued analysis of the grain-scale and precipitate-scale deformation mechanisms in Al-Cu alloy RR350 as a function of temperature by in-situ using neutron diffraction;
- Begin analysis of creep mechanisms in-situ for various alloys using neutron diffraction;
- Continued development of mesoscale load transfer model.

Deliverables for the current proposed year:
- Submit journal article in preparation on the effect of precipitate size and morphology on strain hardening behavior;
- Write journal article on temperature-dependent deformation mechanisms in alloy RR350;
- Thesis proposal;
- Write CANFSA reports and give CANFSA presentations.

How the project may be transformative and/or benefit society: Understanding of temperature- and microstructure-dependent deformation mechanisms and phase transformations can be used to improve the mechanical properties of these alloys, which may allow for improved performance of relevant applications, including improved efficiency in cylinder heads for light duty engines.

Research areas of expertise needed for project success: Mechanical properties of metals, including dislocation behavior and strain hardening, kinetics of phase transformations in metastable phases, and advanced characterization techniques such as neutron, electron, and X-ray diffraction and imaging.

Potential Member Company Benefits: This work may be applied directly to automotive applications, with several alloys being studied intended for cylinder head applications. High strength, thermally stable, low-cost Al alloys are also of interest to Novelis and CANFSA's aerospace members.

Progress to Date: *In situ* neutron diffraction during tension and creep of various alloys, aging conditions, and temperatures has been performed. Data from the neutron diffraction tests have been analyzed to translate from patterns to deformation mechanisms for the room-temperature data. Quantitative modeling of processes that influence precipitate-scale anisotropy during strain hardening has been performed.

Estimated Start Date: Fall 2017	**Estimated Knowledge Transfer Date**: Spring 2021

The Executive Summary is used by corporate stakeholders in evaluating the value of their leveraged investment in the center and its projects. It also enables stakeholders to discuss and decide on the projects that provide value to their respective organizations. **Ideally, the tool is completed and shared in advance of IAB meetings to help enable rational decision making.**