I/UCRC Executive Summary - Project Synopsis	**Date**: March 26, 2019

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

Project Description: Cast Al-Cu alloys are an industrially relevant system due to low cost, high strength due to precipitation strengthening, and ease of manufacture. This project aims to study the mechanical properties and phase transformations in various cast Al-Cu alloys, including thermally stable alloys developed at Oak Ridge National Laboratory (ORNL). In particular, deformation mechanisms will be identified and quantified over a large range of temperatures and microstructures at the grain scale, precipitate transformation will be observed by advanced characterization techniques, and relevant experimental data will be combined with modeling results to obtain new knowledge about the mechanical behavior of these alloys.

Experimental plan: Neutron diffraction at ORNL's Spallation Neutron Source (VULCAN beamline) will be used to observe the grain-level deformation mechanisms *in situ*. Transmission X-ray microscopy (TXM) at Argonne National Lab's Advanced Photon Source (APS) will be used to observe the precipitates and their evolution during aging. Transmission electron microscopy (TEM) will be implemented to observe fine-scale precipitate morphology pre- and post-mechanical tests. Constitutive modeling will be implemented to quantify deformation mechanism changes. Creep testing at ORNL will also be done.

Related work elsewhere: A. Shyam's group (ORNL) is studying the mechanical behavior and phase transformations in the same alloys *ex situ*. N. Chawla's group (Arizona State University) is studying phase transformations of Al-Cu alloys *in situ*. C. Hutchinson's group (Monash University) are modeling deformation behavior of Al-Cu alloys from first principles and experimental data.

How this project is different: This project connects phase transformations to temperature-dependent mechanical properties and enables the testing of new, thermally stable Al-Cu alloys. It will also bridge modeling efforts and *in situ* experimental methods.

Milestones for the current proposed year:
- Perform additional post-mortem TEM to observe sheared precipitates;
- Analyze results from interrupted aging TXM experiments conducted previously;
- Perform in-situ aging TXM experiments once installation of in-situ capability at APS is completed;
- Apply model developed for strain hardening transitions for 206 to RR350 elevated temperature data.

Deliverables for the current proposed year:
- Write journal article on the strain hardening behavior of alloy 206;
- Give talks at the Gordon Research Conference on Physical Metallurgy 2019 and TMS 2020;
- Give CANFSA presentations and write CANFSA reports;

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. This 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 CANFSA's aerospace members.

Progress to Date: *In situ* neutron diffraction during tension and creep of various alloys, aging conditions, and temperatures; TEM of various alloys and aging conditions; creep testing at 300° and 350°C in various alloys; modeling of strain hardening phenomena; interrupted aging TXM of various alloys.

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.**