UNIVERSITY OF MANITOBA

13-3

CANADA FOUNDATION FOR INNOVATION
Innovation Fund

Notice of Intent

1. Completed NOIs must be submitted by the Associate Dean (Research)/Research Liaison Officer of the "Lead" Unit to the Office of Research Services to: Birtukan.Gebretsadik@umanitoba.ca by May 15, 2018.

Proposed name of project: **Ceramic Characterization Laboratory (CCL)**	**Estimated Total Project Costs:** **$1.06 million**
Designated Project Leader/Faculty/Dept: Kent Fowler/Arts/Anthropology: x **List Principal Users/Faculty/Dept:** **1.** Mostafa Fayek/CHREER/Geological Sciences x **2.** Norman Halden/CHREER/Geological Sciences x **3.** Robert Hoppa/Arts/Anthropology x **4.** Haskel Greenfield/Arts/Anthropology x **5.** Kevin Brownlee/Archaeology/MB Museum x **6.** Scott Hamilton/Anthropology/Lakehead U. x	
'Lead' Unit ADR/RLO: **Name:** **Robert Hoppa**	

Briefly describe (max 2 pages, 12 pt. font size, 2 cm margins):

- The proposed research and how it is world-class, innovative and demonstrates clear benefits to Canada.
- The infrastructure and how it will enhance the University's existing research capacity.
- The excellence of the team, including expertise and existing collaborations necessary to conduct the proposed research.
- Plans to secure matching funds and the potential funding sources for the operation and maintenance of the infrastructure.

Provenience research in archaeology

Provenience research of artifacts in archaeology aims to identify the raw materials used in the manufacturing of technologies in order to infer the organization of production and the exchange of finished products in past societies. Ceramics are amongst the most difficult objects to source because they are composites of many materials. Low-fired pre-industrial ceramics normally contain rocks, minerals, and organic materials that were added to raw clays before being fired. Mineral and chemical analyses aim to identify the geological origin of clay and other materials to define the compositional profile of objects. Most previous research has taken a 'hierarchical approach' in determining source materials. Definite sources are not known. Instead, analysts define compositional groups by comparing sherds from a site. Groups outside the compositional space known from local geology are interpreted as either the range of geochemical variability in a region or as imports.

The problem

The main problem with conventional ceramic provenience research is that 'local' production areas are defined in geological terms, not in terms of the community of potters who utilized them. Materials science data has no inherit social meaning. To link materials science analyses of ceramics to the societies that produced them requires a comparative interpretive framework that minimally accounts for (1) geological variation, (2) the resource areas used by potters, (3) how clays are modified during manufacturing, and (4) the ability to detect change and variation practices over time. It is not enough to detect whether raw materials are 'local' or 'non-local' in geological terms or to identify what may have been removed from or added to raw clays. The problem also cannot be solved by having more samples. To improve the correspondence between ceramic compositional groups and locations of production, analysts have proposed three solutions: (1) improved research designs, (2) innovative statistical analyses; and (3) improved instrumentation.

There have been significant changes in research designs as a result of ethnographic work examining the technical and social reasons impacting resource procurement. Clay deposits used by present day potters or potential sources used in the past are often sampled to better define resources in both geological and social terms. Likewise, statistical analyses have improved our ability to define the geochemical variability of finished objects and identify how the behavior of potters impacted their composition. In stark contrast, there have been few advances in instrumentation used in ceramic provenience research over the past 30 years. The last major advance was the commercialization of Inductively coupled plasma-mass spectrometry (ICP-MS) in 1983. Innovations have since focused upon introducing the sample into the plasma in different ways (as a solution or by laser ablation of solid sample). Laser ablation is increasingly used, but solution analysis provides limits of detection 1000 times better for most elements. *Presently, the University of Manitoba has the capacity to study the mineral composition of ceramics (petrography) and chemistry through laser ablation.* Only one new method has been advanced in the past thirty years for the provenience determination of ceramics. Over 15 years ago, Kaare Rasmussen (Department of Chemistry, University of Southern Denmark, Odense, Denmark) developed and tested the effectiveness of using magnetic susceptibility (MS) and thermoluminescence (TL) to distinguish the geological origin of raw materials used to make archaeological ceramics. While successful, the MS-TL method has either been ignored or forgotten despite results being published in the leading archaeometry periodical, the *Journal of Archaeological Science*.

Methodology

MS and TL techniques are normally used for dating archaeological materials. Rasmussen's method instead uses these techniques to source ceramic samples. The MS-TL method compares the amount and mixing of iron-bearing materials in a sherd using MS to the density of electron traps in minerals using TL-sensitivity. Both parameters are thus purely material (physical) parameters of the ceramics. The MS/TL ratio distinguishes ceramics made using resources from different geologic locations. The method is designed to measure small sub-samples from vessels, ranging from 5mg to 3g. For each sherd, surface

contamination is removed, the samples are dried at 120ºC for 24 h, and samples are split and weighed for each analysis. With no further preparation, MS is measured using a magnetic susceptibility-meter. A sub-sample for TL measurements is prepared differently. These are lightly crushed in a darkroom, sieved, and the 100-300 micron-size fraction is kept for analysis. No chemical pre-treatment of the samples is necessary. Ten milligrams of sample are weighed, and measurements are performed using a TL system.

Our research using the MS-TL method will initially focus upon two issues. The *first* issue is understanding how potter's choices during manufacturing impact ceramic composition. In modifying raw clays, potters can profoundly affect our ability to relate the composition of ceramics to the raw materials used in their manufacture. To understand these effects, we will compare MS-TL results against mineral and chemical data obtained from the study of modern and experimental research on ceramics from Africa, South America, and central Canada. The *second* issue is defining the limits of geochemical variability in regions where raw clays are homogenous over vast areas. Rasmussen found that MS-TL effectively sources ceramics made from glacial till clays, which are extremely difficult to distinguish using conventional analyses. We will apply MS-TL to pre-contact ceramics from Manitoba and adjacent regions where glacial till clays are abundant. This work will influence ceramics provenience research on every continent where potters access glacial till clays. Initially applied to these two issues, the MS-TL method will provide new insights into nature of ceramic production over the past 20,000 years.

Equipment

We are requesting funds from CFI to develop a Ceramic Characterization Laboratory (CCL) at The University of Manitoba, similar to the lab that Rasmussen built in Denmark. *CCL expands existing capacity for the provenience of stone technologies and human and animal remains at the University of Manitoba.* This laboratory is unique. It will position the departments of Anthropology and Geological Sciences and The University of Manitoba as the only other source and resource for ceramic provenience research of this kind globally. To achieve our proposed research goals, the following equipment is essential: (1) Kappabridge magnetic susceptibility meter, pick-up, control unit ($205,329); (2) Lexsyg research imaging thermoluminescence (TL-OSL-RF) system with TL dating package ($369,270); (3) sample preparation equipment (balances, furnace, grinders, saws, Nikon Eclipse LV100Pol polarizing microscope for quantitative optical petrography ($49,000); renewed infrastructure including the redesign of N304/307 Duff Roblin for equipment, consumables, sample storage capacity, security and work spaces for researchers, and contiguous expansion for dedicated TL darkroom and MS room ($360,000); equipment dedicated computers, monitors, and software ($22,400).

Excellence of the team

We have assembled a team of principal investigators with expertise in Anthropogenic and Earth materials characterization including, ceramic manufacturing (Fowler, Brownlee, Hamilton), geochemistry (Fayek and Halden), and provenience studies (Fowler, Fayek, Greenfield, Hoppa). The primary users are established and emerging leaders in fields critical to the technological and economic growth of Canada. Team members have a track record of collaboration, and the proposed research will foster further partnerships as a single team to develop novel and transformative techniques for provenience research. The requested infrastructure is critical to developing technological and scientific breakthroughs and interdisciplinary research programs that transcend traditional academic boundaries.

Plans to secure matching funds/funding for operations and maintenance

The primary users of the CFI requested infrastructure have attracted considerable research support over the past 10 years. Their research grants will help support the research that will be enabled by the requested infrastructure. IOF will be used to support personnel for training and maintenance during the lifetime of the award. Administrative support within Anthropology will facilitate the management of income accounts to ensure funding past the IOF period is available for continued operation. Space will be provided within the CFI-established Bioanthropology Digital Image Analysis Laboratory in Anthropology. Operations and maintenance will be covered through user fees.