In situ heating and deformation experiments in the SEM: A project introduction

Dan Tatham & Dave Prior

Earth & Ocean Science,
University of Liverpool, U.K.

Outline

- **EUROCORES**, **EuroMinScI** and the **Substructure Dynamics** group.
- The role of research at Liverpool in the Substructure Dynamics project.
- Current research.
- Proposed research.

EUROCORES

- **Euro**pean **Co**llaborative **Res**earch scheme
- Managed by the **European Science Foundation**
- Enables researchers in different European countries to develop **collaboration** and scientific synergie in areas where European scale and scope are required to reach critical mass necessary for cutting edge science.
- Nationally funded institutions networked through European initiative.
- Programmes in:
  - Physical & engineering sciences
  - Medical sciences
  - Life, Earth and environmental sciences
  - Humanities
  - Social sciences
- New themes selected annually
- www.esf.org

EuroMinScI Programme

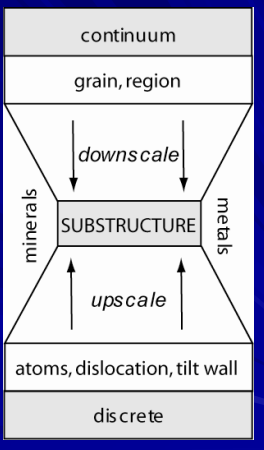
- **Euro**pean **Min**eral **Sci**ences **I**nitiative.
- Draws together experimental and computational techniques and expertise from forefront academic research institutions, in the Earth and mineral sciences, across Europe into integrated research projects.
- Aims to forge an intimate link between numerical and computational methods and experimental techniques:
  - Experimental data to support numerical models
  - Numerical simulations based around experimental results and observations
  - Numerical simulations to help explain experimental observations.
- Address the issue of the need for young scientists with an academic background in Earth sciences to be trained in more physics-based techniques.

Substructure Dynamics

- Overseen by Sandra Piazzolo and others.
- Six individual projects funded by national agencies, and
- Four associated projects funded independently,
- Dynamics of substructure formation and evolution in rocks and metals.

Substructure Dynamics

- Break barriers between, and integrate, *in situ* experimental techniques and multi-scale numerical modelling and simulations.
- *In situ* experiments are key in providing **time-series** data and observations for the validation and advancement of numerical simulations.

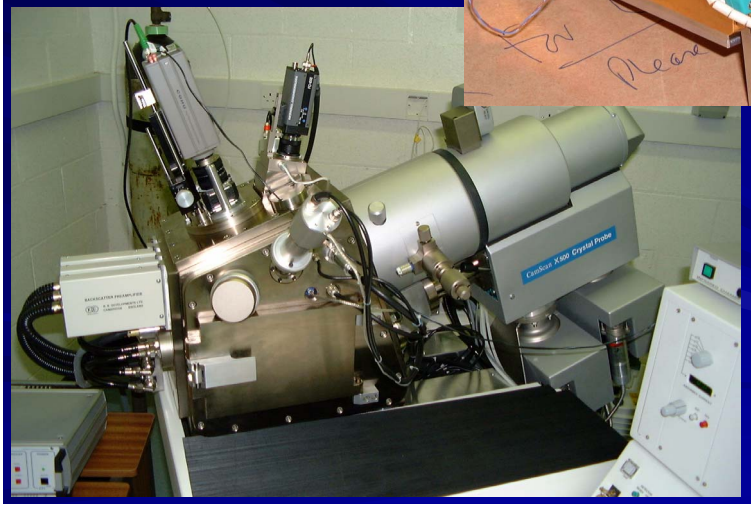


The Role of Liverpool

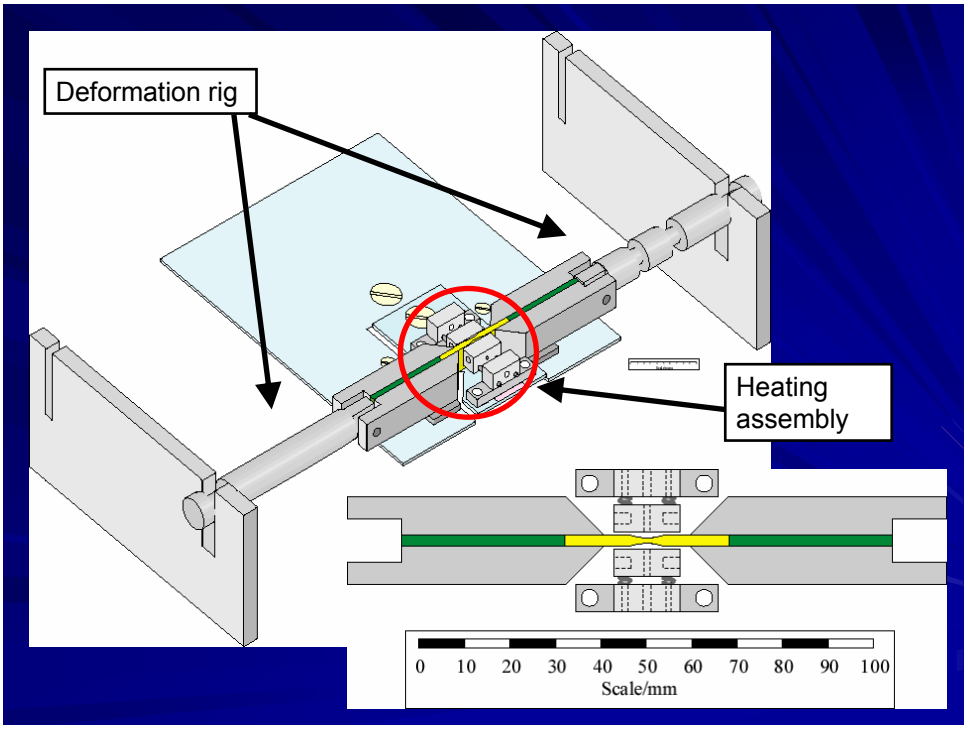
- Work with:
  - Dave Prior,
  - Dan Faulkner,
  - Elisabetta Mariana,
  - John Wheeler.
- We aim to document the kinematics of substructure development and the way these substructures interact with intergranular boundaries, during high temperature deformation experiments of MgO and forsterite.
- Specifically, to develop experimental protocols to conduct high temperature deformation experiments, using MgO and forsterite mineral samples, *in situ* in a scanning electron microscope.

Static heating stage

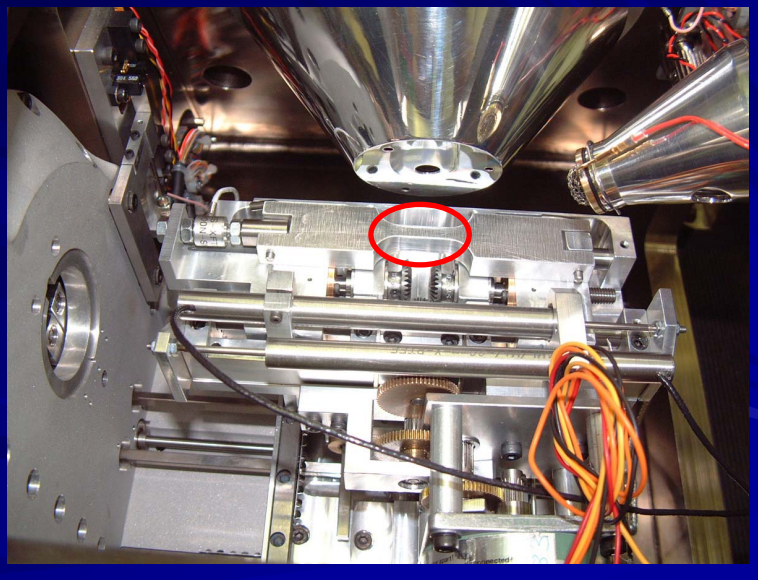
Seward et al., 2000 *Scanning*, 24, 232-240.



- Tantalum wire coils
- <1150°C



Deformation stage in SEM

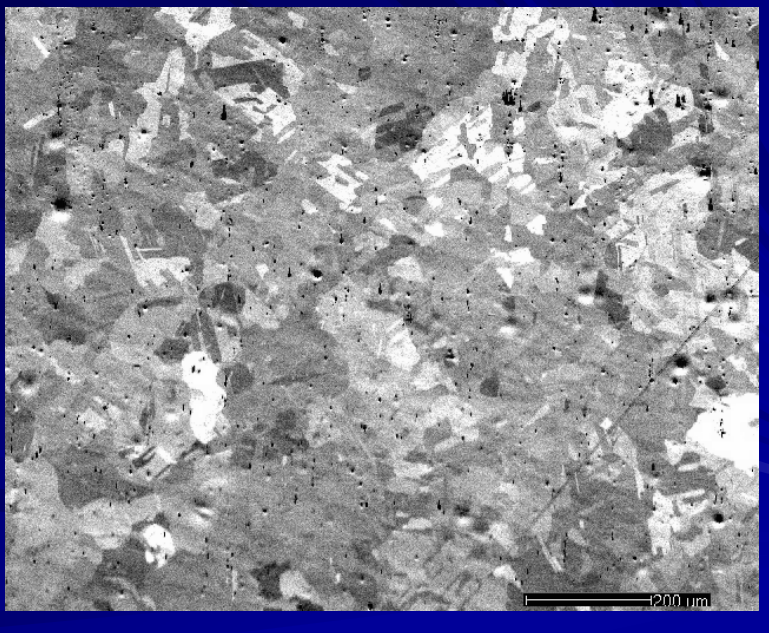


To date research towards satisfying project goals

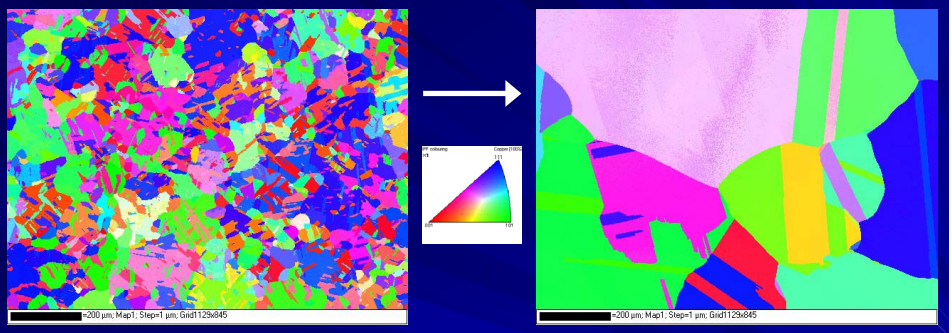
- Static heating experiments on Ni & Cu, primarily to assess the temperatures and length-scales of recrystallisation and grain growth in order to develop experimental setups for deformation experiments.
- Developing sample preparation techniques in metals suitable for EBSD,
  - e.g. electropolishing Cu.

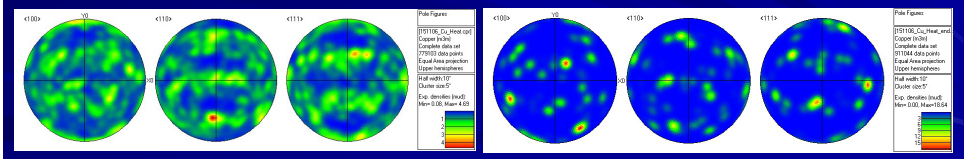
Grain growth in annealed copper at ~850°C

30x speed



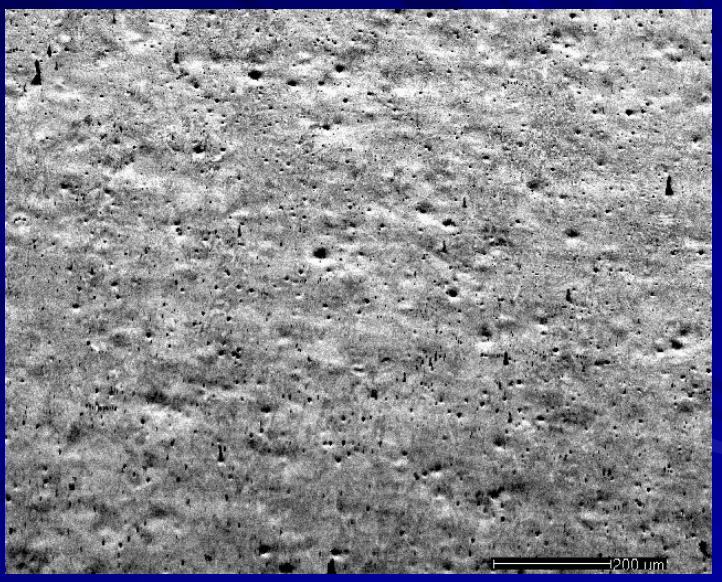
Grain growth in annealed copper at ~850°C



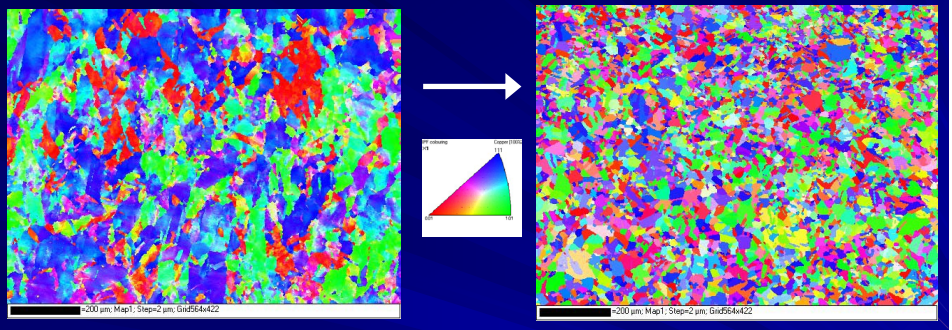


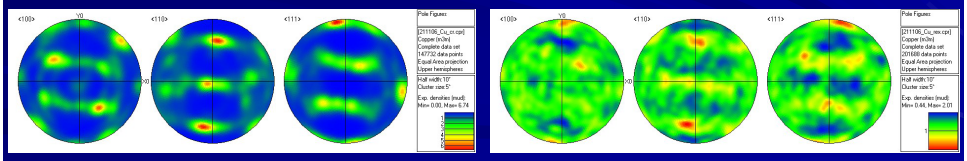
Recrystallisation in cold-rolled copper at ~350°C

6x speed

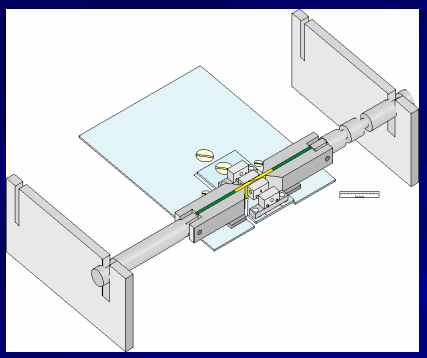


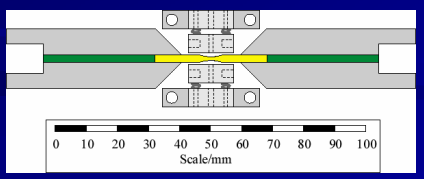
Recrystallisation in cold-rolled copper at ~350°C





Proposed research for the near future

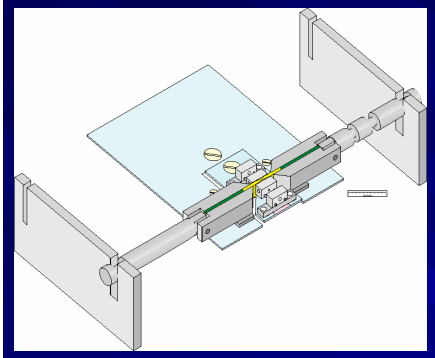


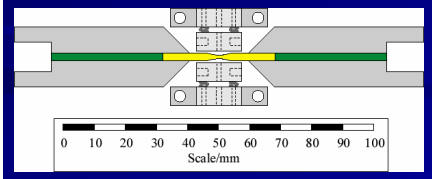


- Initially work on one-piece jig and sample milled from a single piece of copper bar.
  - Simple setup and predictable results during early stages of calibration of load cells, heating furnace and stage control.

1. *Ex situ* tests.
2. Cold deformation experiments.
3. Develop and integrate the high temperature furnace/cooling system into the deformation stage.
4. Heating and deformation experiments at moderate temperature for Cu.

Proposed research for the future





- Develop suitable materials and design for permanent sample holding jig.
- Begin development in producing synthetic MgO and forsterite single crystals, multi-layers and polycrystalline aggregates (Chris Spiers, Utrecht).
- Very high temperature heating and deformation experiments on MgO / forsterite (<1400^{o}C).
  - Necessary modification to detectors and heater/cooler system.

To sum up

- Exciting new EBSD research at Liverpool part of collaborative project into substructure development and evolution in rock materials and metals – *EuroMinSci* and *Substructure Dynamics Programme*.
- **Static heating experiments** on annealed and cold-rolled **Cu** are promising for use as a material for **preliminary investigations** and development of early experimental protocols.
- Initial work with the heating and deformation stage planned for the next few weeks to months should provide interesting results for presentation at forthcoming meetings

Thanks…

Questions ?

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