National Argon Map: an AuScope Initiative
$^{40}Ar/^{39}Ar$ Geochronology Laboratory Sample Submission Form

This form must be completed and returned to Marnie Forster (Marnie.Forster@anu.edu.au) before any work can be commenced in the Argon Laboratories.

Person submitting samples: Paul Duuring and Dave Kelsey
Affiliation: The Geological Survey of Western Australia
Project Title:
Sample Number(s) (including IGSN if one exists): 224274
Mineral separation required? Yes or No: Yes
Date submitted: 17th May 2021

GEOGRAPHIC AREA/ PROVINCE/ BASIN : Paterson Orogen	
1:250k SHEET NAME: Anketell	**NUMBER:** SF51-02
1:100k SHEET NAME: Weenoo	**NUMBER:** 3256
LOCATION METHOD: (GPS: WGS84 / AGD66 / AGD84 / GDA94) GPS GDA94	
ZONE: 51	
EASTING: 392449	**NORTHING:** 7718972
LATITUDE: -20.62537	**LONGITUDE:** 121.96774

STRATIGRAPHIC UNIT FORMAL NAME *:
STRATIGRAPHIC UNIT INFORMAL NAME:
LITHOLOGY: Amphibolite (after a mafic igneous intrusion)

DRILLHOLE ID (if applicable): PND001
PROSPECT (if applicable): Obelisk
DEPTH FROM (metres): 326.70 m
DEPTH TO (metres): 326.85 m

* Stratigraphic Unit names can be searched and checked within the Australian Stratigraphic Units Database via the following link: https://asud.ga.gov.au/

Dating Objective

What is the geological question $^{40}Ar/^{39}Ar$ analysis will address? Dating hydrothermal biotite alteration and Au–Cu mineralization in the host amphibolite at the Obelisk prospect.

What type of age(s) are expected? (e.g. magmatic crystallisation, metamorphism, fluid alteration/mineralisation, cooling, shearing etc): alteration/mineralization

Mineral target(s) for dating: hydrothermal biotite, located in the proximal zone to a sulfide-rich vein in amphibolite

Estimated $^{40}Ar/^{39}Ar$ age (e.g. Cenozoic, Mesozoic, Paleozoic, Proterozoic, Archean – provide estimated numerical age range if possible): a conservative estimate is between 850 and 650 Ma (constrained by the likely c. 830 Ma age of metagabbros in the Paterson Orogen and the ~650 Ma age of granitic intrusions in the area that cut and postdate alteration).

Sample Information

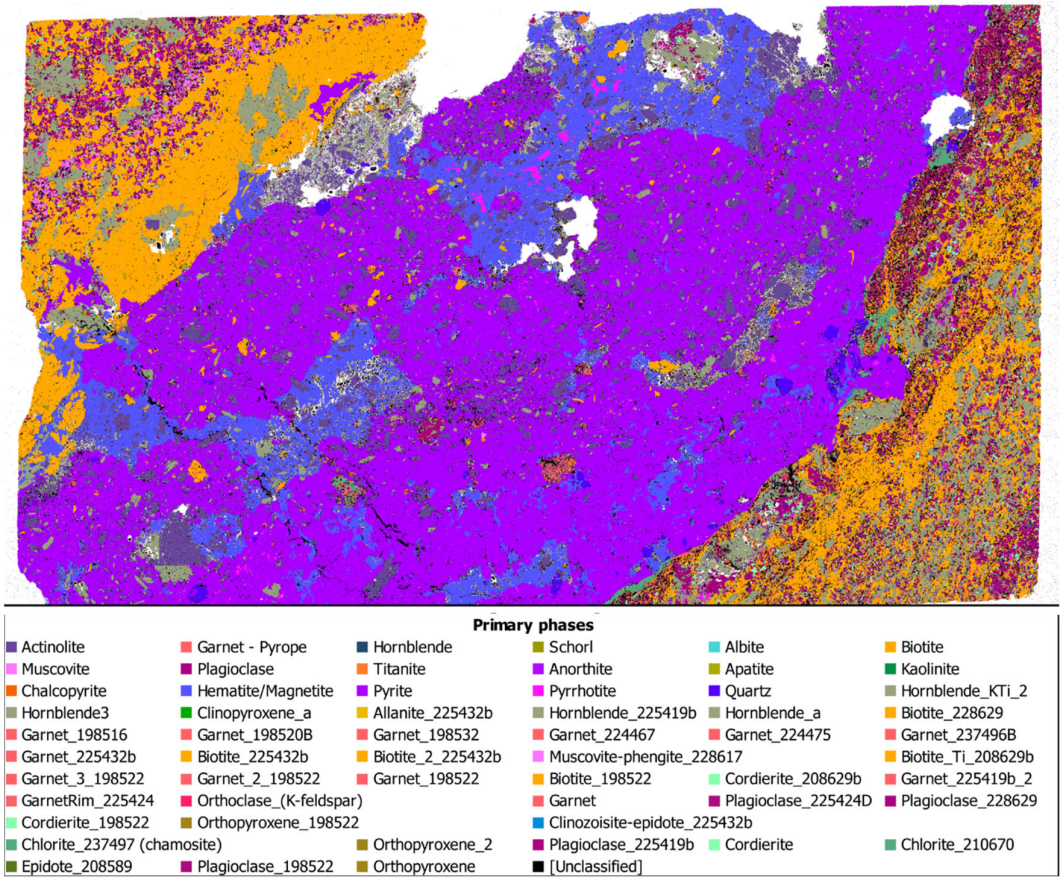
Location description (e.g. a sample of x was collected from y, z km from abc town): Sample 224274 was collected from drillhole PND001 at the Obelisk prospect in the Paterson Orogen. Drillhole PND001 is located 351 km E of Port Hedland in Western Australia.

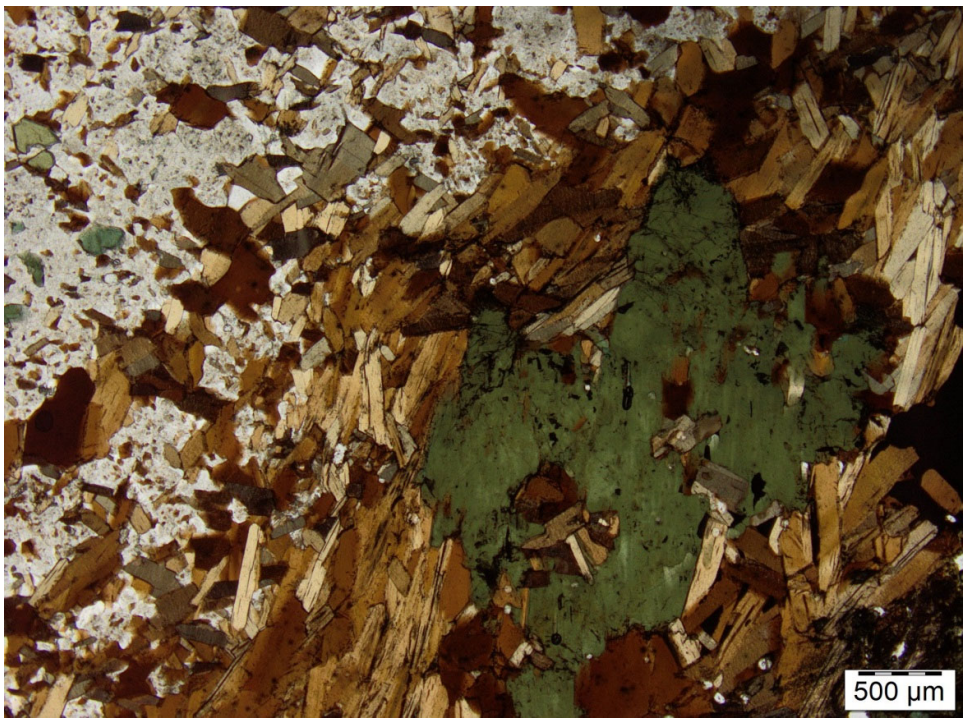
Lithological characteristics (rock description): Unweathered mafic amphibolite, cut by a 1 cm wide pyrite–pyrrhotite–chalcopyrite–carbonate vein. The sulfide vein is surrounded by a 0.5 cm wide proximal alteration halo comprising coarse-grained, hydrothermal biotite (see the associated TIMA mineral map below).

Relative age constraints (pertinent geological relationships with surrounding rock units and any previous geochronology):
Amphibolite age is likely c. 830 Ma on the basis of other dated mafic intrusions that were emplaced into Yeneena Basin sediments. However, there are also c. 753 Ma mafic intrusions known in the region, such as emplaced into the Officer Basin (Keene Basalt). Granitic magmatism into the Yeneena Basin is c. 635–650 Ma. The age of mineralisation and hydrothermal activity is likely to be about this age as metamorphic PT data suggest granitic magmatism was the heat source for metamorphism and fluid activity shallow in the crust.

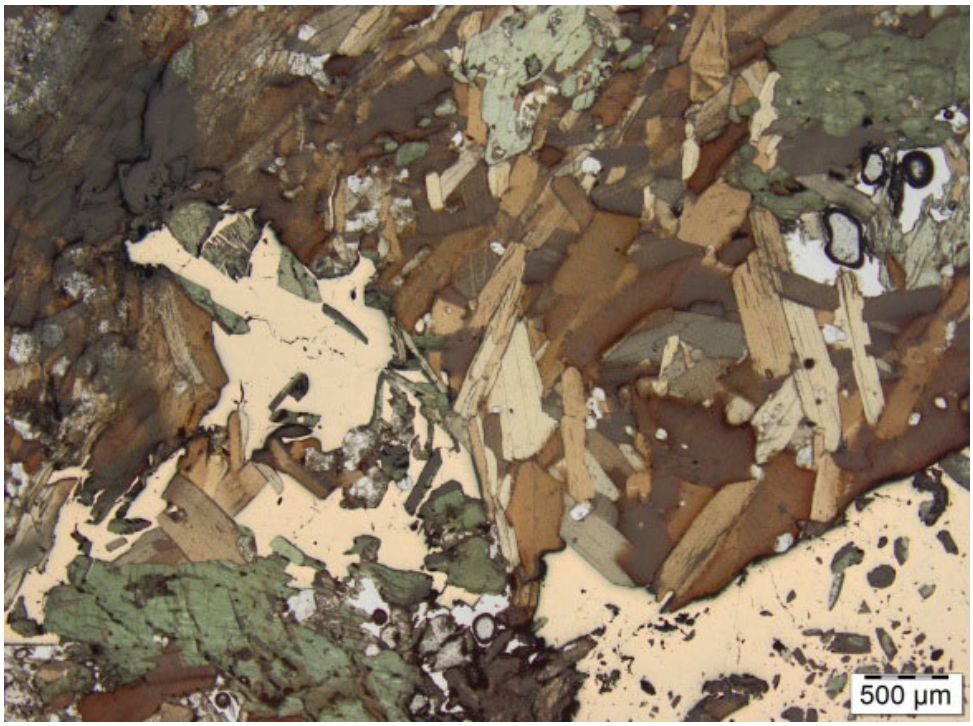
Thin section description (if available): The rock contains a weak foliation defined by alternating plagioclase- and biotite–hornblende-rich layers. A pyrite–siderite-rich vein is oriented sub-parallel to parallel to the foliation. The abundance of biotite is higher towards and at some margins with the sulfide vein, particularly in the top left of the TIMA map below. Chlorite and muscovite are other products interpreted as hydrothermal, and chlorite occurs proximal to the sulphide vein. On one side of the sulphide vein the silicate minerals (biotite, hornblende, plagioclase) are strongly sheared (mylonitic). The pyrite-rich vein contains inclusions of biotite, (actinolitic) hornblende, quartz, Fe-oxide (magnetite or hematite) and siderite; and siderite contains inclusions of pyrrhotite, (actinolitic) hornblende, Fe-oxide, pyrite and biotite. Many of the hornblende grains within the sulphide vein are moderately to strongly oriented, suggesting that either (a) the sulphide vein invaded an already foliated rock or (b) the sulphide emplaced as the rock was being deformed or (c) the sulphide + silicates were deformed post-sulfide mineralisation. The presence of the mylonite alongside the sulphide vein suggests (c) is likely. In the mylonite hornblende is typically the dominant porphyroclast, but further away from the sulphide vein biotite is the more dominant porphyroclast. Apatite occurs predominantly in the biotite-rich portions of the rock suggesting the two are of the same paragenesis. Apatite is rare within the sulfide-bearing vein.
In the top left corner of the TIMA image (below) biotite is coarser-grained but significantly more weakly foliated. It mantles and is intergrown with hornblende and plagioclase. In the bottom right corner of the TIMA image (below) biotite is significantly more strongly deformed/foliated, and in the far right corner biotite is only weakly oriented (analogous to top left corner). Therefore, this sample provides at least 3 different 'types' and microstructural settings of biotite that may each reveal different ages.

Photograph(s) e.g. field site, hand-specimen, photomicrograph:

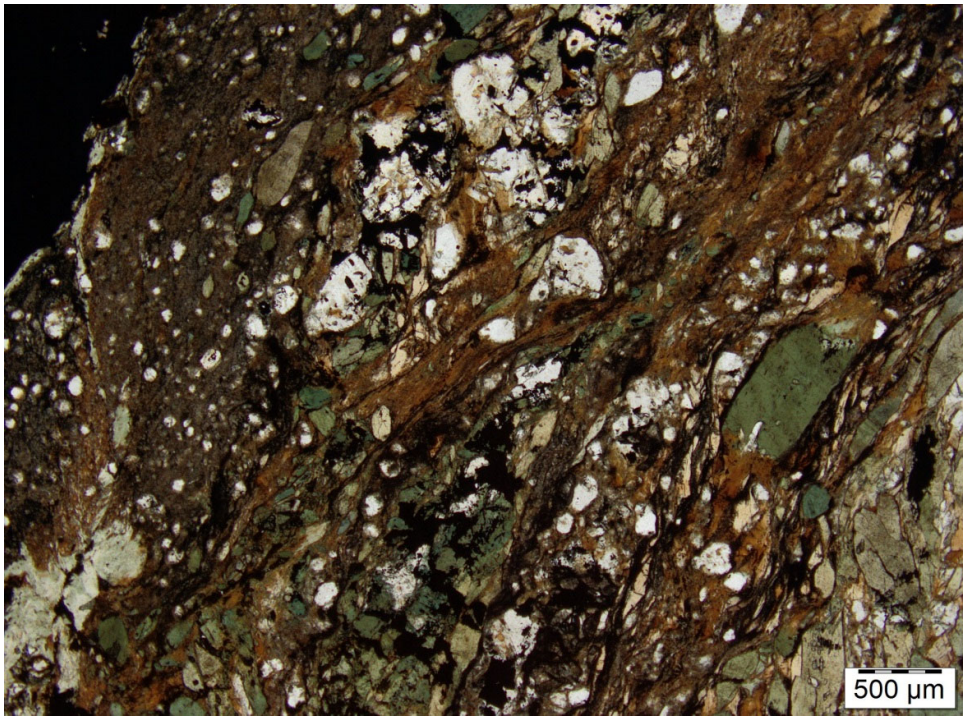




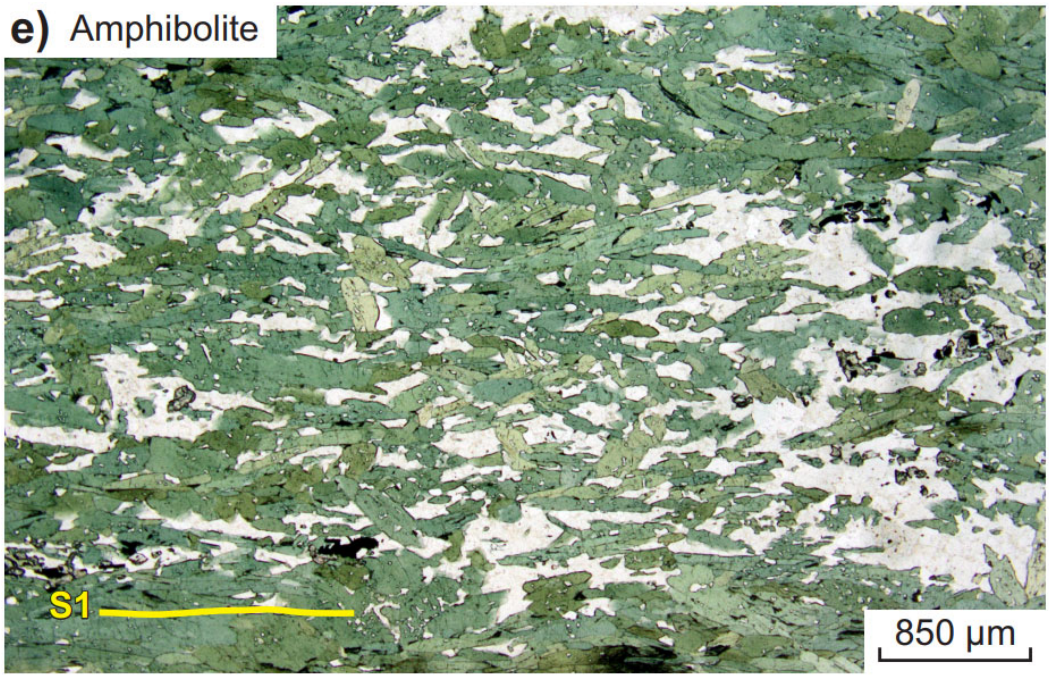
Hydrothermal biotite partly replacing igneous hornblende in the wallrock to the sulfide vein



Hydrothermal biotite intergrown with pyrite and apatite (replacing igneous hornblende)



A deformed margin of the sulfide vein, showing the development of S–C shear fabrics and deformation around isolated hornblende crystals



An example of a least-altered amphibolite (sample 224258 from PND001 at 226.7 m).

Relevant bibliographic references: