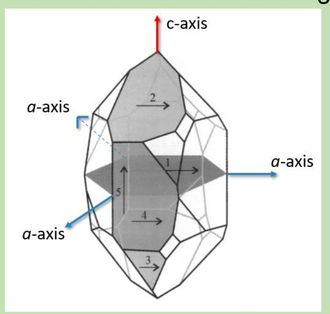
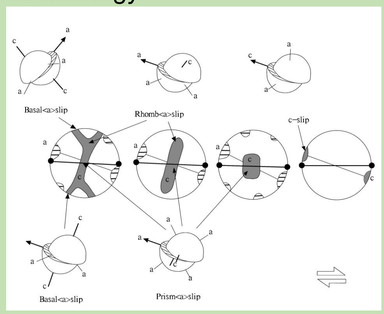
Crystallographic- and shape-preferred orientation of quartz phenocrysts in a sheared granitic porphyry and its implication for the activity of slip systems in deforming quartz under the upper crustal conditions

Wang Qi Department of Geosciences, Osaka City University, Osaka 558-8585, Japan

1. Introduction

- Quartz is the most dominant mineral in the uppercrust.
- Rheological property of quartz is representative of the continental upper crust.
- Quartz deforms plastically by dislocation creep under the upper crustal conditions.
- Understanding the dominant slip systems in the continental upper crust is crucial for evaluating crustal rheology.

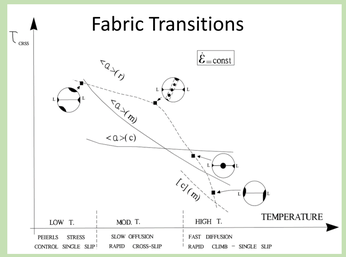


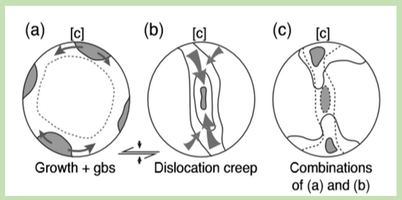


2. Key question

What is the dominant slip systems in the upper crust?

Based on the comparison between the quartz c-axis fabrics of naturally deformed rocks and numerical simulation results, basal<*a*> slip system is a most "easy" slip system under the upper crustal condition (~300–400 ℃).

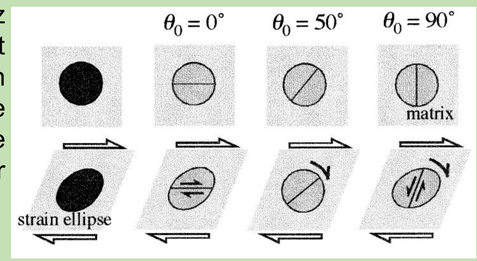




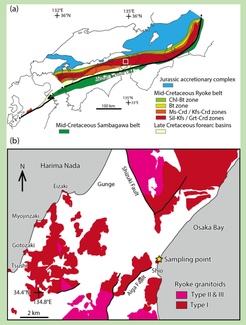
However, there are no "direct" observations in the naturally-deformed quartz so far. Recently, Kilian and Heilbronner (2017) argues that basal<*a*> slip system would not be active under the upper crustal condition.

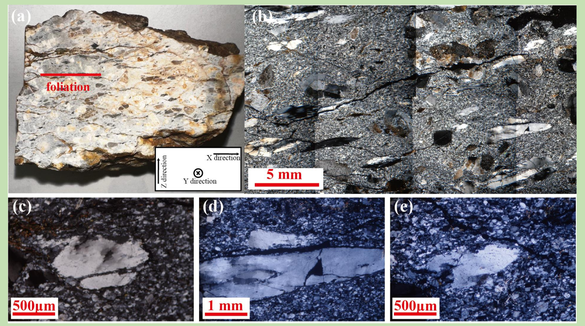
Advance of the study

Compared to fine grain quartz aggregates, quartz phenocryst tends to deform by a high concentration of easy-slip plane parallel to the shear zone boundary. Identifying their crystallographic orientation would reveal the active slip system (Ishii and Sawaguchi, 2002).



3. Background



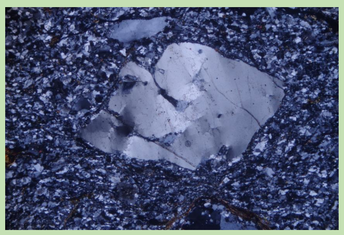


- The quartz phenocrysts are:
  - •elongated with different aspect ratios (i.e., strain)
  - •exhibit undulate extinction

4. Methodology

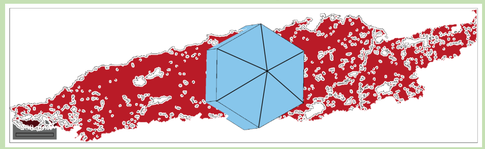
- Thin section is cut parallel to the lineation (X) and normal to the foliation (XY).

Optical microscope

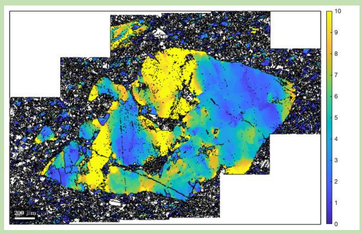


Crystallographic-preferred orientation

Evaluated by MTEX

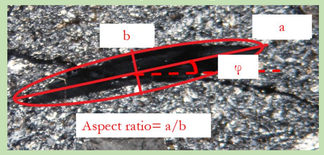


SEM-EBSD



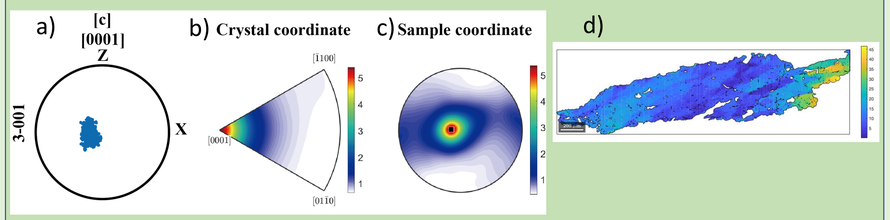
Shape preferred orientation

Evaluated by ImageJ software



Identification of the active slip system(s) based on:

a) Quartz [c] axes distribution on pole figures.
b) Misorientation axis distribution in crystal coordinate.
c) Misorientation axis distribution in sample coordinate.
d) Identification of subgrain boundary.



5. Results

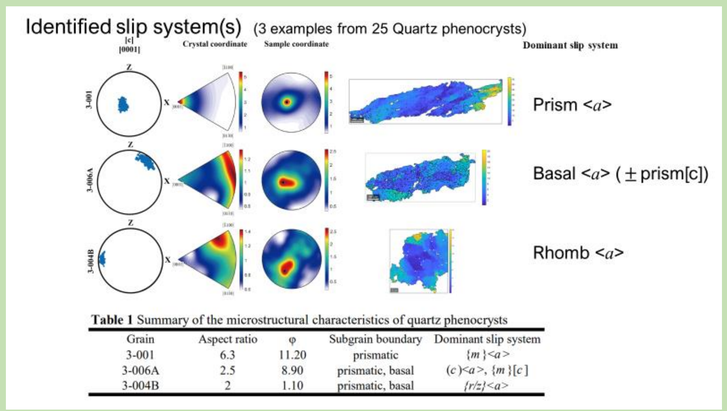
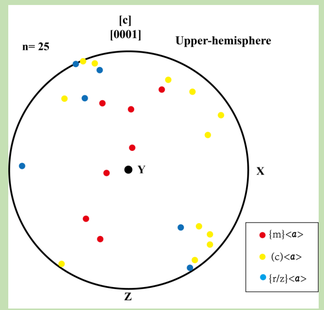


Table 1 Summary of the microstructural characteristics of quartz phenocrysts

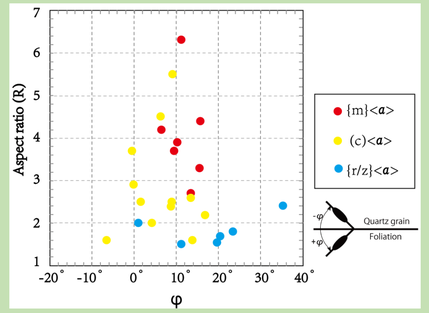
Grain	Aspect ratio	φ	Subgrain boundary	Dominant slip system
3-001	6.3	11.20	prismatic	{*m*}<*a*>
3-006A	2.5	8.90	prismatic, basal	(*c*)<*a*>, {*m*}[*c*]
3-004B	2	1.10	prismatic, basal	{*r/z*}<*a*>

Comparison of dominant slip system with:

Crystallographic preferred orientation



Shape preferred orientation



6. Discussion and conclusion

- Aspect ratio and slip system relation indicates activity of prism <*a*> and basal <*a*> (± prism [c]) slip systems are higher than rhomb <*a*> slip system.
- The crystallographic preferred orientation indicates quartz deformed by the basal <*a*> slip system forms the peripheral [c] axes.
- This is the first report with evidence of active basal <*a*> slip system in the upper crustal conditions.