Appendix 2-6: Thin section micrographs.

This appendix presents micrographs of thin sections from the Hawai’i sample set (see Appendix 2-3 for sample and site descriptions). Typical features of mugearites and benmoreites are shown in pages 1-4; only incipient weathering was found in most outcrop. Representative stages of alteration and common alteration features are shown for select weathering profiles in pages 5-9. Characteristics of altered tephra from the summit of Maunakea are presented on pages 10-13. See appendix 2-5 for further petrographic details.

The images on the left are plane-polarized, and the same view is shown on the right with crossed polarizers, except where noted.

Mugearites / Benmoreites

Kohala, Hawi mugearite MK15-2a
Trachytic texture, typical minimally or unaltered mugearite. Plag, olv, opaques.

Kohala, Hawi mugearite MK15-3a
Trachytic texture, typical minimally or unaltered mugearite. Plag, olv, opaques. Olivine phenocrysts contain spicular inclusions.
Kohala, Hawi mugearite MK15-3a

Olivine phenocrysts contain spicular inclusions, possibly apatite.

Kohala, Hawi mugearite MK15-3c

Incipient weathering, fine-grained rinds forming in cracks and vesicles (yellow arrows), some oxidation, plag is transmissive in xp. Plag contains spicular inclusions (white arrows indicate examples)

Kohala, Hawi mugearite MK15-3c

Lower mag of previous showing additional spicular inclusions, interpreted to be apatite. (Arrows)
Maunakea, mugearite MK15-4a  Trachytic texture, unaltered mugearite. Plag, olv, opaques. Large ~100-300 µm euhedral opaque oxides are found in some flows.

Maunakea, mugearite MK15-4a  Trachytic texture, fresh unaltered mugearite. Plag, olv, opaques. Large ~100-300 µm euhedral opaque oxides.

Maunakea, mugearite MK15-61a  Trachytic texture, fresh unaltered mugearite. Plag, opaques, olivine
Maunakea, benmoreite MK15-35a

Trachytic texture. Dominantly plag, opaques, some small olivine. Minimally altered.

Maunakea, benmoreite MK15-35b

Ferric oxidation indicates incipient weathering.

Maunakea, benmoreite MK15-35b

Same as above, higher magnification and plane polarized with 20 µm scale bar. Red oxidation around oxide grains “smears” and imparts fairly widespread red color to rock.
Pedogenic weathering features in weathering profiles

Kohala, Pololu basalt MK15-34a

Typical plag, opaques, olv texture of least altered basalt sample. Plag is transmissive.

Kohala, Pololu basalt MK15-34a

Olivine phenocryst. Red rims indicate iddingsite formation and incipient weathering.

Kohala, Pololu basalt MK15-34a

Red oxidation from incipient weathering apparent in fractures (arrows).
Least altered sample in roadcut profile, Plag, olv, opaques, some oxidation of olivine, oxidized rims on larger xls. Plag is transmissive.

Olivine phenocrysts with iddingsite formation on rims. Plag is transmissive.

Plane polarized examples of iddingsite formation, formation controlled by crystallinity, likely preferentially along xl planes (arrows)
Maunakea olivine phyric basalt MK15-37d

Moderately extensive alteration. Magnetite is replacing the olv as a pseudomorph, retaining some original birefringence. Plag is mostly isotropic. Ferric oxidation is apparent through most of the rock.

Magnetite pseudomorph on bottom right. White arrow indicates possible secondary isotropic phase. Yellow arrow indicates example of isotropic plag grain.

Magnetite pseudomorph after olivine. μXRD shows only spinel, no olv peaks, no evidence of poorly xline phases. Single domain extinction is consistent with the primary olv xl.
Maunakea high alkali basalt MK15-38a

Least altered sample. Plag, olv, opaques. Plag is transmissive and olivine has minimal iddingsite.

Maunakea high alkali basalt MK15-38b

Moderate alteration. Isotropic plag (Red arrows) and apparent filling of cracks with secondary oxidized isotropic phases (white arrow)?

Maunakea high alkali basalt MK15-38b

Same as above, higher mag. Isotropic plag with degraded crystal faces, apparent filling of cracks with secondary oxidized isotropic phases (white arrows)?
Maunakea high alkali basalt MK15-38d

Extensive alteration, vesicle filled with gibbsite per µXRD

Tephra/ash below summit

Maunakea, tephra, ash layer MK15-4b

Angular lithic and palagonitized fragments. Lithic fragments have plag in opaque matrix.
Tephra samples, Maunakea summit, Collections of D. Ming and D. Morris (all image are plane polarized unless noted). Select features are described. See Appendix 2-5 for further descriptions.

HWMK777: Breccia is common in the tephra, with lithic fragments (left side) apparently cemented by a fine-grained mixture of sulfates, ferric oxides, and amorphous material (right side).

HWMK951: The rock fabric is a mix of very fine grained pale white, pale yellow sulfates, and small reddish, nearly opaque grains dispersed in the fine-grained white and yellow sulfates. Plag lathes preserved as lighter laths, suspended in the sulfate. Some mixed lithic fragments with plag and opaque matrix is cemented in the sulfates. This mixture is heterogeneous on the sub-mm scale.

HWMK777: Typical lithic fragment with plag laths and very fine-grained to opaque matrix. Red oxidative alteration is common. Crossed polarizers.

HWMK951: Pale yellow/white altered fabric. Plag laths (black arrows) appear suspended in matrix and are not birefringent. Primary vesicles (V) appear to be preserved.
HWMK951: Plag laths (arrows) suspended in fine-grained pale yellow/white matrix with ferric oxidation.

HWMK951: Small lithic fragment with plag laths (black arrow) and ferric oxidation (white arrows).

HWMK951: Plag laths (arrows) suspended in fine-grained pale yellow/white matrix

HWMK951: Higher magnification of typical plag in fine-grained matrix.

HWMK952: Pale yellow/white and ferric oxidation, primary texture of hawaiite is preserved by plag laths.

HWMK953: Relatively unaltered lithic fragment in tephra, plag and fine-grained opaque matrix.
HWMK959: Plag laths in fine-grained matrix, opaques with some ferric oxidation. The inside of the vesicles are coated with a clear layer of unidentified, likely secondary material.

HWMK959: Example of heterogeneous mixture of fine-grained pale yellow/white phase with ferric oxidation, ~5-10 µm red grains, and plag laths.

HWMK959: Plag laths in fine-grained matrix, opaques with some ferric oxidation. The inside of the vesicles are coated with a clear layer of unidentified, likely secondary material.

HWMK959: Example of heterogeneous mixture of fine-grained pale yellow/white phase with ferric oxidation, ~5-10 µm red grains, and plag laths.
HWMK976: Example of lithic fragment with extensive ferric oxidation, some fine-grained pale yellow secondary material (arrow).

HWMK976: Very fine-grained mixture of pale yellow, red, and opaquesecondary material. No remnant primary texture is apparent.

HWMK976: Example of lithic fragment with extensive ferric oxidation, some fine-grained pale yellow secondary material (arrow).

HWMK976: Very fine-grained mixture of pale yellow, red, and opaquesecondary material. No remnant primary texture is apparent.