Plagioclase crystal size distributions, growth and nucleation rates in an anhydrous arc basaltic andesite

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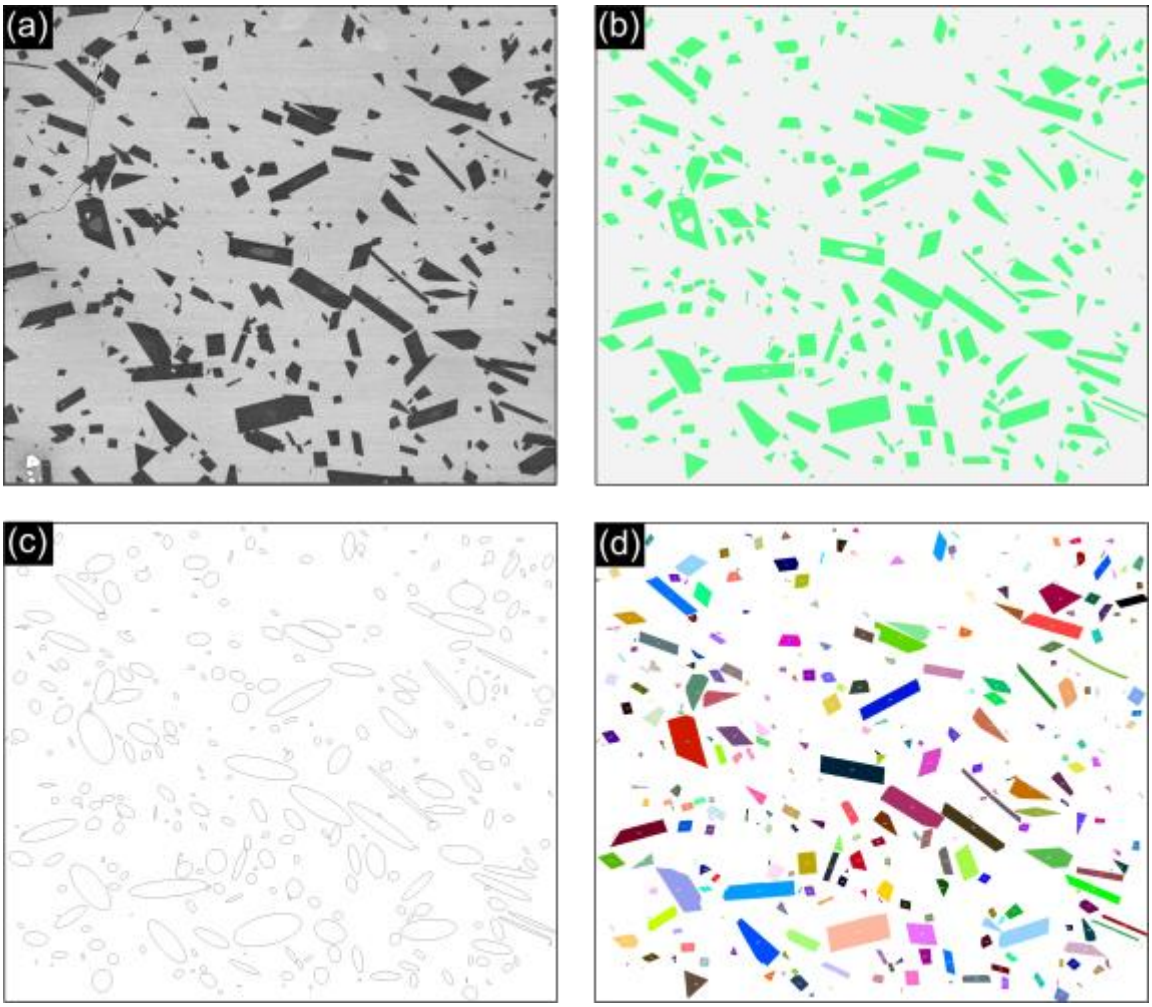
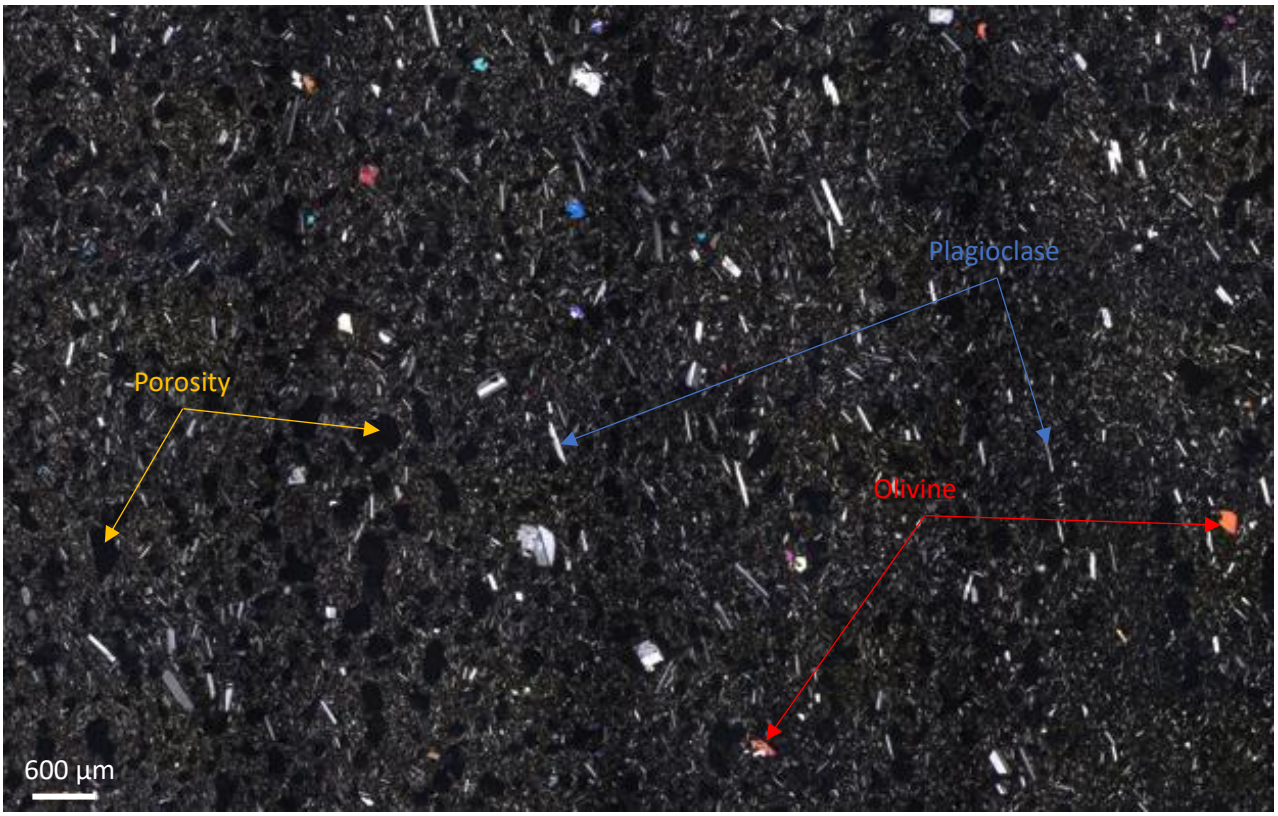
Example of segmentation



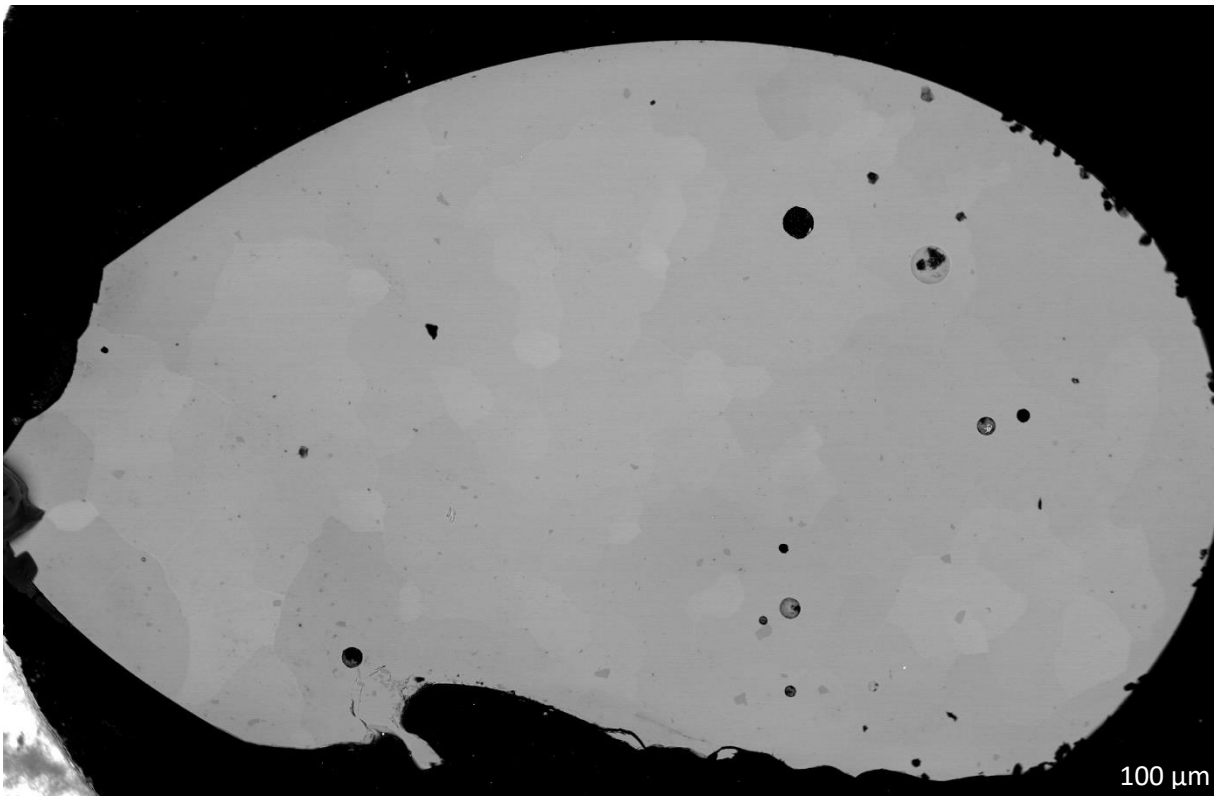
Sequence of images illustrating the various stages of segmentation: (a) SEM BSE image. (b) Separation of the various phases by segmentation (using Fiji or GIMP). Each color corresponds to a phase (here, green represents plagioclase). Crystals are separated manually. The best-fitted ellipses (c) are obtained for each plagioclase using Fiji software, along with the corresponding crystal (d).

OS 36 thin section



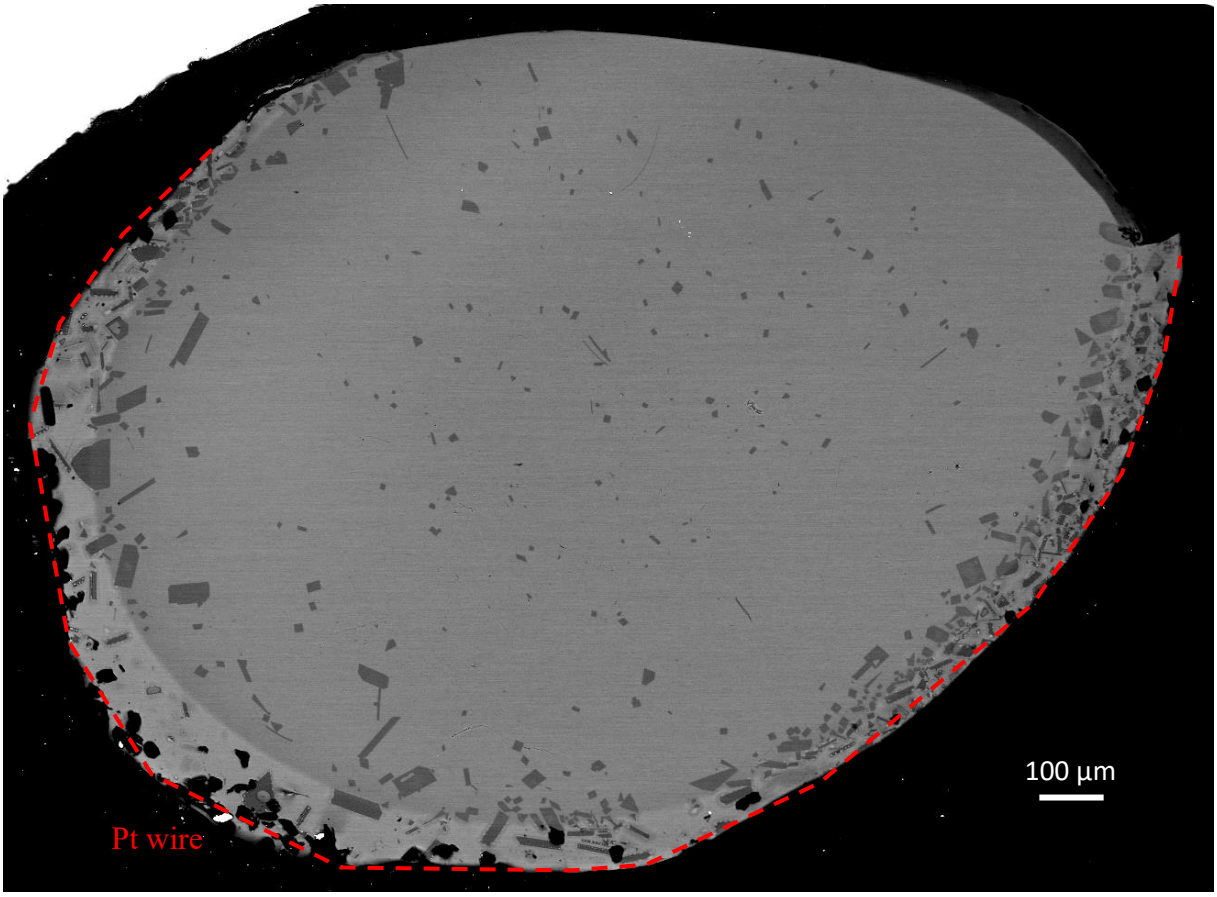
OS36 Thin section Scan

GERO 0: Isothermal crystallization at 1190 °C during 24 hours



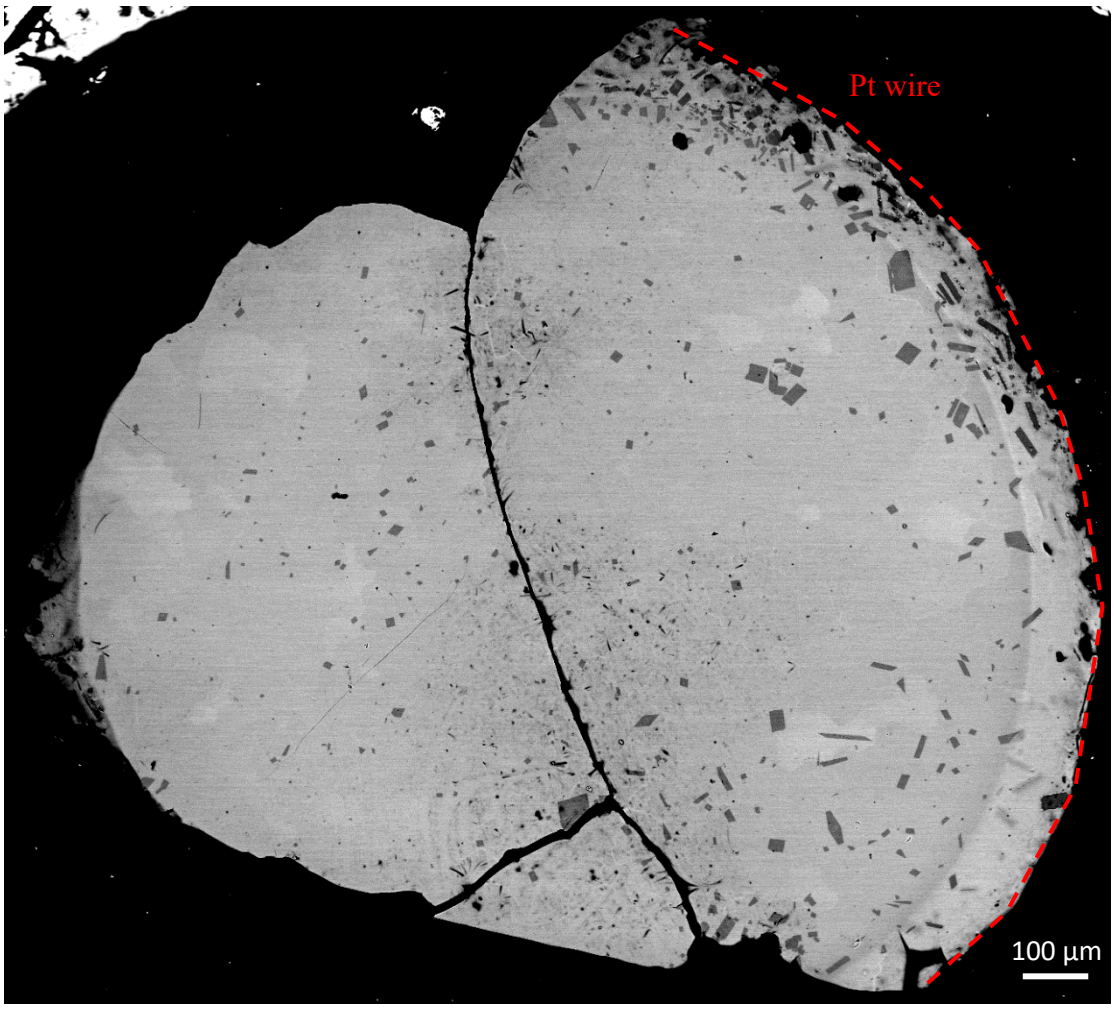
BSE image of the run GERO 0 (T_f = 1190 °C during 24 hours). *The dark grey crystals correspond to pre-existing plagioclase partially dissolved (resorbed aspect). The mosaic aspect of glass is due to an old coating.*

GERO 1-1: 1°C/h, 1165°C (sample 1)



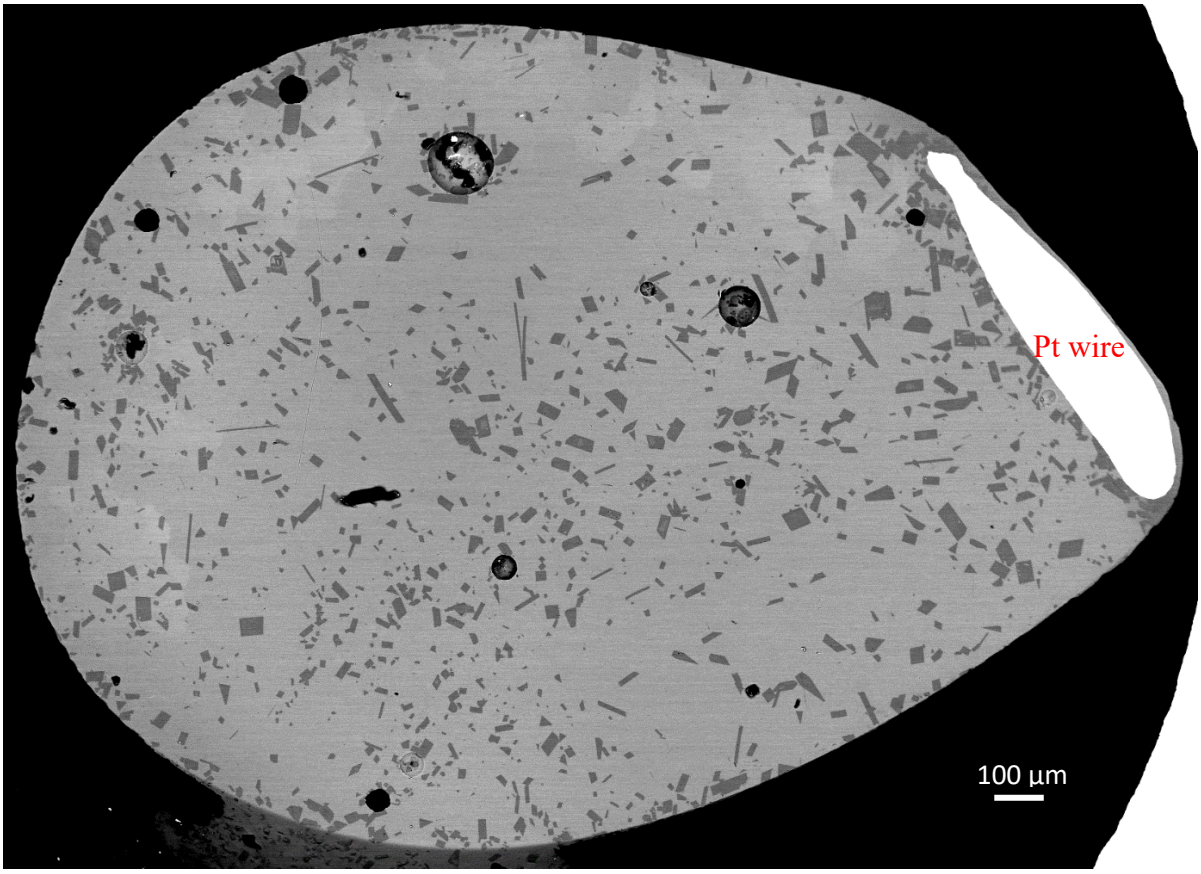
BSE image of the GERO 1-1 run (sample 1) (cooling: 1 °C/h, T_f: 1165 °C). *The center of the sample is dominated by small crystals (10 – 30 µm) with a tabular to elongated shape and a random distribution. At the edge of the sample (previous position of the platinum wire) the crystal density is high and some crystals are larger with a tabular shape (ranging from 40 to more than 100 µm, some with seeds).*

GERO 1-1: 1°C/h, 1165 °C (sample 2)



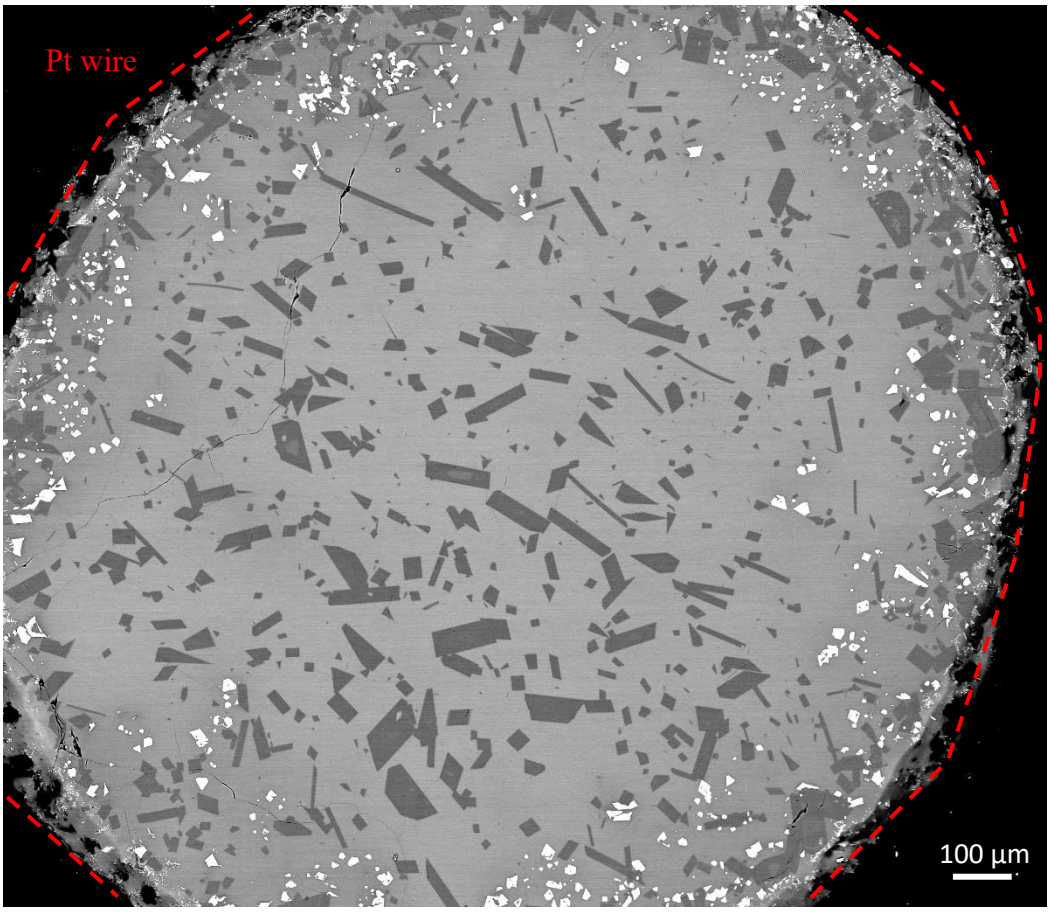
BSE image of the GERO 1-1 run (sample 2) (cooling: 1 °C/h, T_f: 1165 °C). *The observations are similar to GERO 1-1 (sample 1).*

GERO 1-2: 1°C/h, 1137 °C



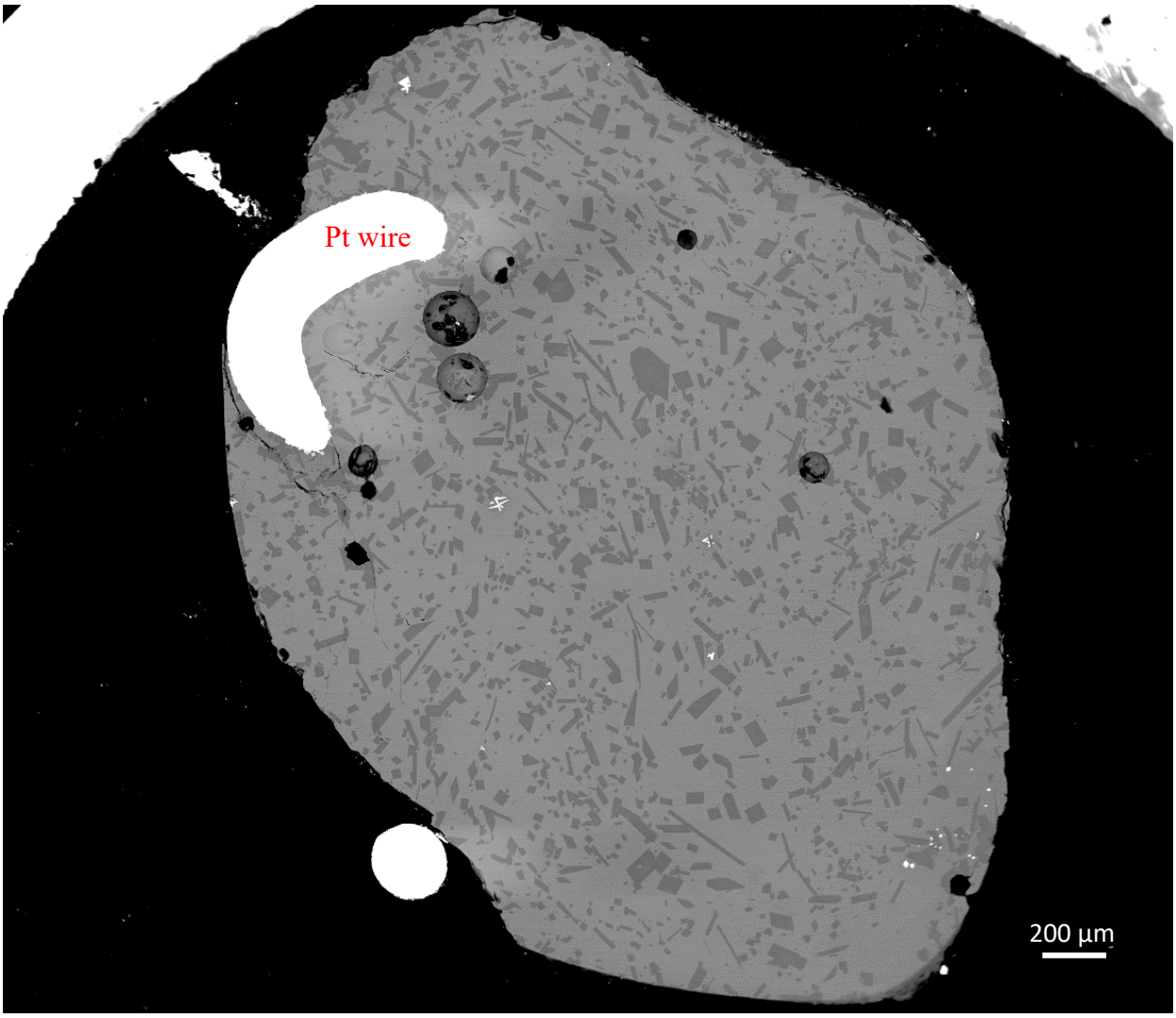
BSE image of the GERO 1-2 run (cooling: 1 °C/h, T_f: 1137 °C). *A non-homogeneous distribution of crystals is visible. Some areas are dominated by a high density of small crystals, while others exhibit the presence of larger crystals or a lack of crystallization. Agglomeration figures, as well as preferential nucleation around gas bubbles and the platinum wire, are visible.*

GERO 1-3: 1°C/h, 1120 °C



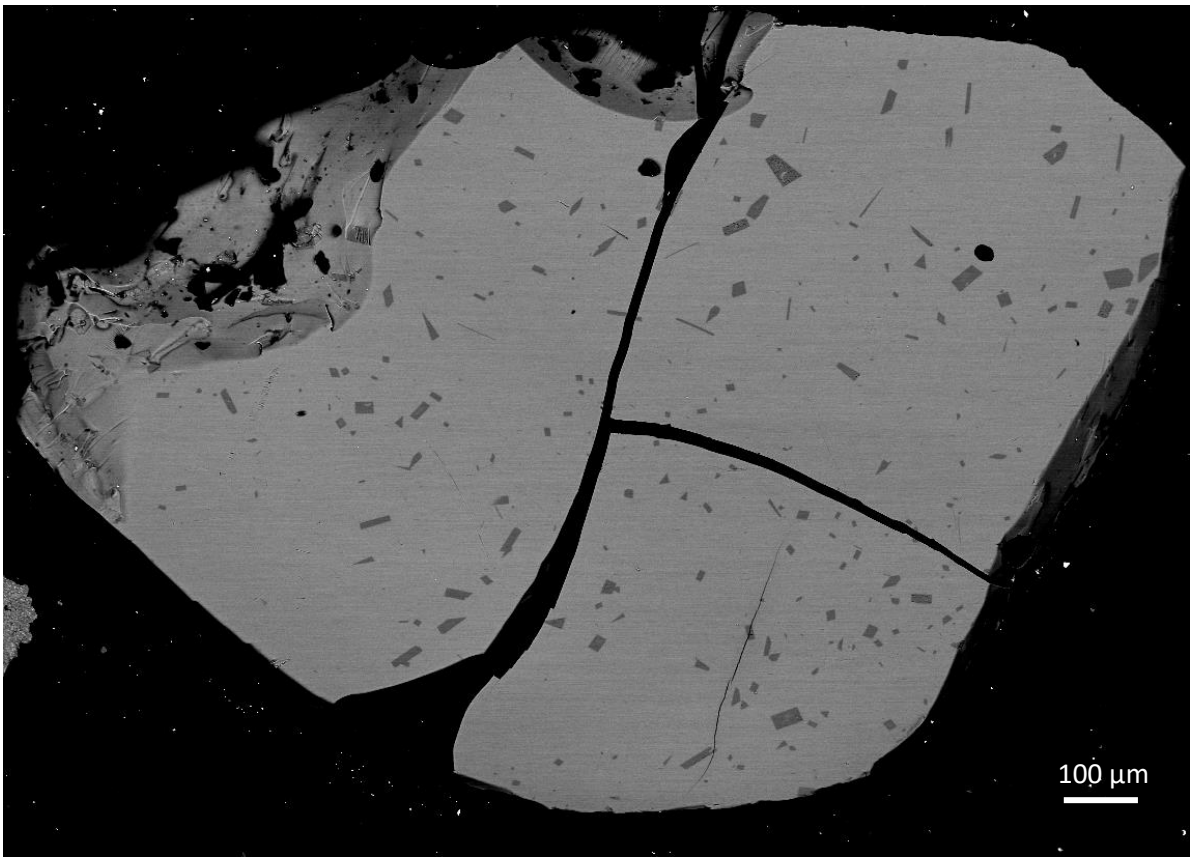
BSE image of the GERO 1-3 run (cooling: 1 °C/h, T_f: 1120 °C). *The edge of the sample (previous location of the platinum wire) is characterized by a preferential nucleation of plagioclase and oxide crystals (Titanomagnetite: white color). The sample exhibits crystals of varying size (from 5-10 µm to more than 100-150 µm) and shape (tabular, elongated), including in the center of the charge. Some of the largest crystals have seeds. Agglomeration figures are present.*

GERO 1-4: 1°C/h, 1100 °C



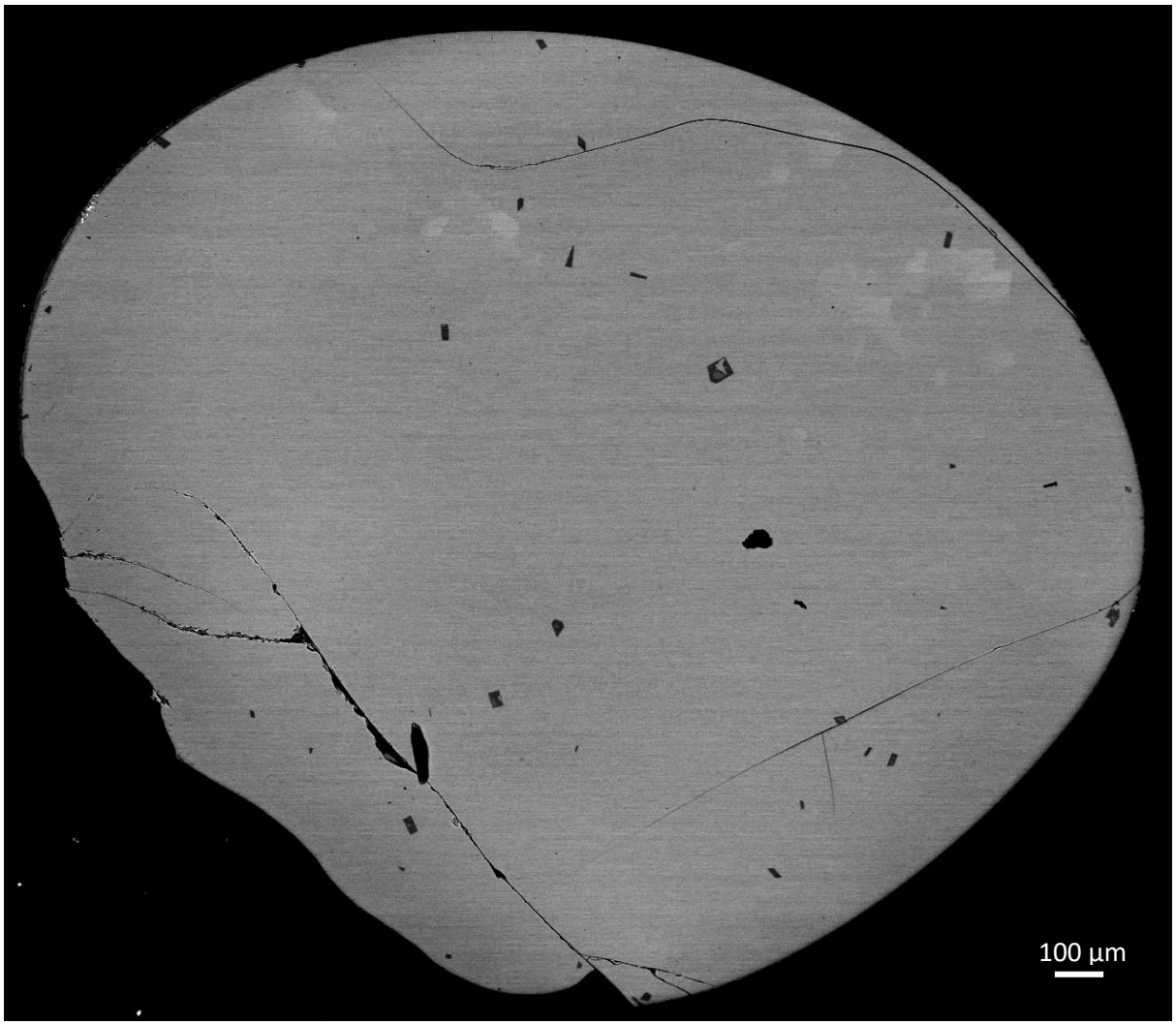
BSE image of the GERO 1-4 run (cooling: 1 °C/h, T_f: 1100 °C). *As for the other runs quenched at 1137 °C and 1120 °C, the sample exhibits agglomeration figures. The crystal size varies from 5-10 µm to more than 150-200 µm. The shape of the crystals varies from equant to tabular and elongated. Only few crystals of Titanomagnetite (white) are visible (probably due to the absence of the edge of the sample).*

GERO 2-1: 3°C/h, 1165 °C (sample 1)



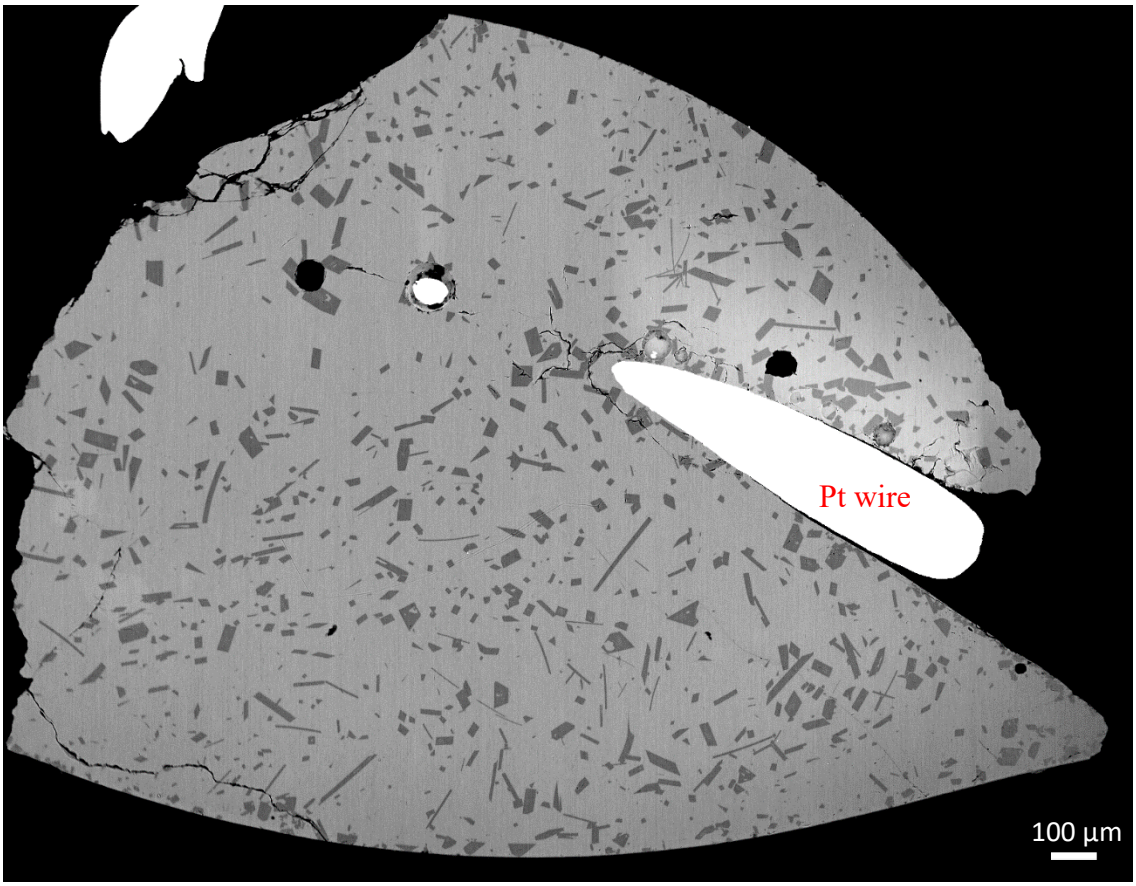
BSE image of the GERO 2-1 run (sample 1) (cooling: 3 °C/h, T_f: 1165 °C). *The crystals measure between 5-10 µm and 50 µm. Seeds are visible in some of the larger crystals. No preferential nucleation (due to a previous platinum wire) is present here.*

GERO 2-1: 3°C/h, 1165 °C (sample bis)



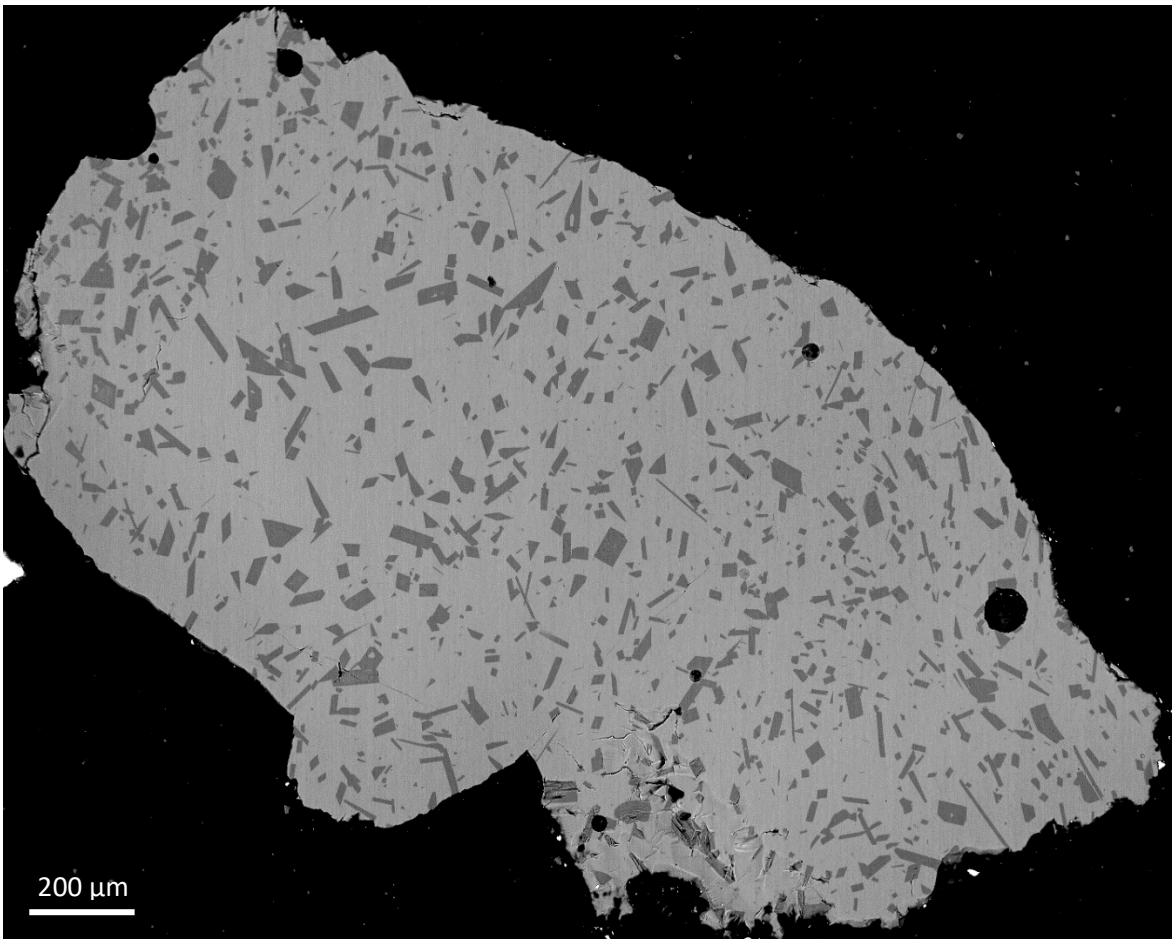
BSE image of the GERO 2-1 run (sample bis) (cooling: 3 °C/h, T_f: 1165 °C). Similar observations to the sample 1, but with a lower crystal density.

GERO 2-2: 3°C/h, 1140 °C



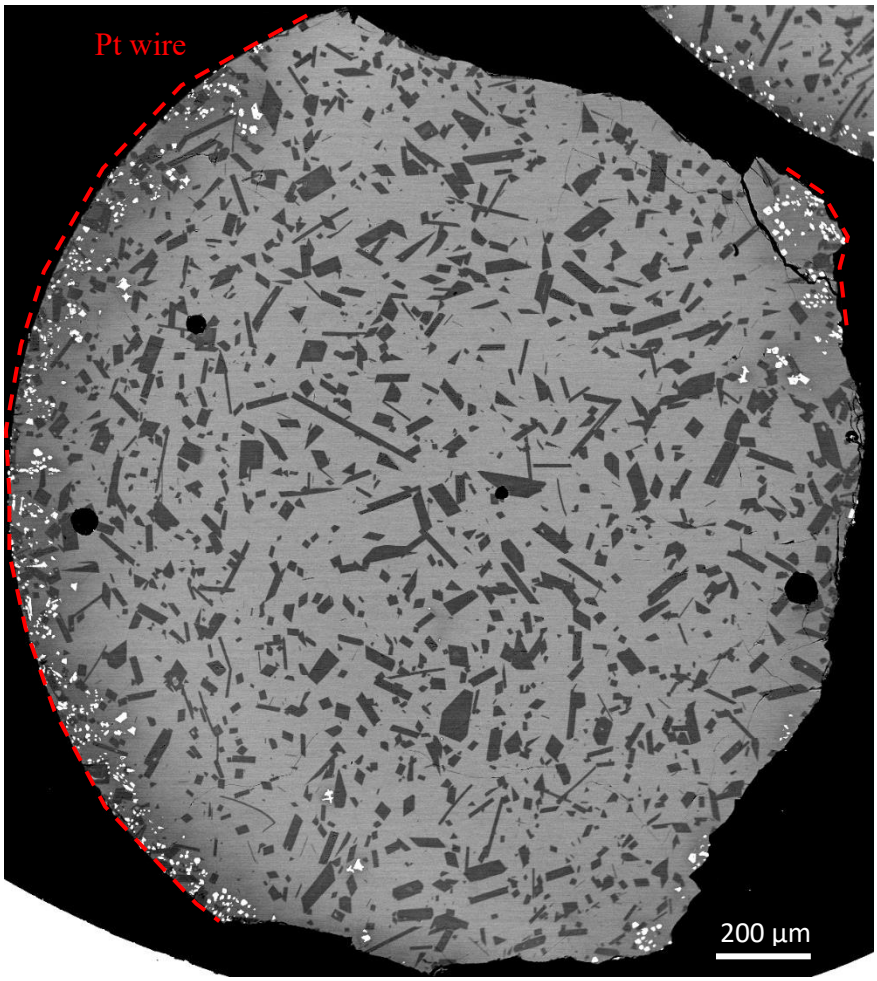
BSE image of the GERO 2-2 run (cooling: 3 °C/h, T_f: 1140 °C). *The observations are similar to the GERO 1-2 run (cooling: 1 °C/h, T_f: 1137 °C), but with a higher density of large, elongated crystals (between 100 and 200 µm). Crystal distribution is not homogeneous and agglomeration figures are visible.*

GERO 2-3: 3°C/h, 1120 °C



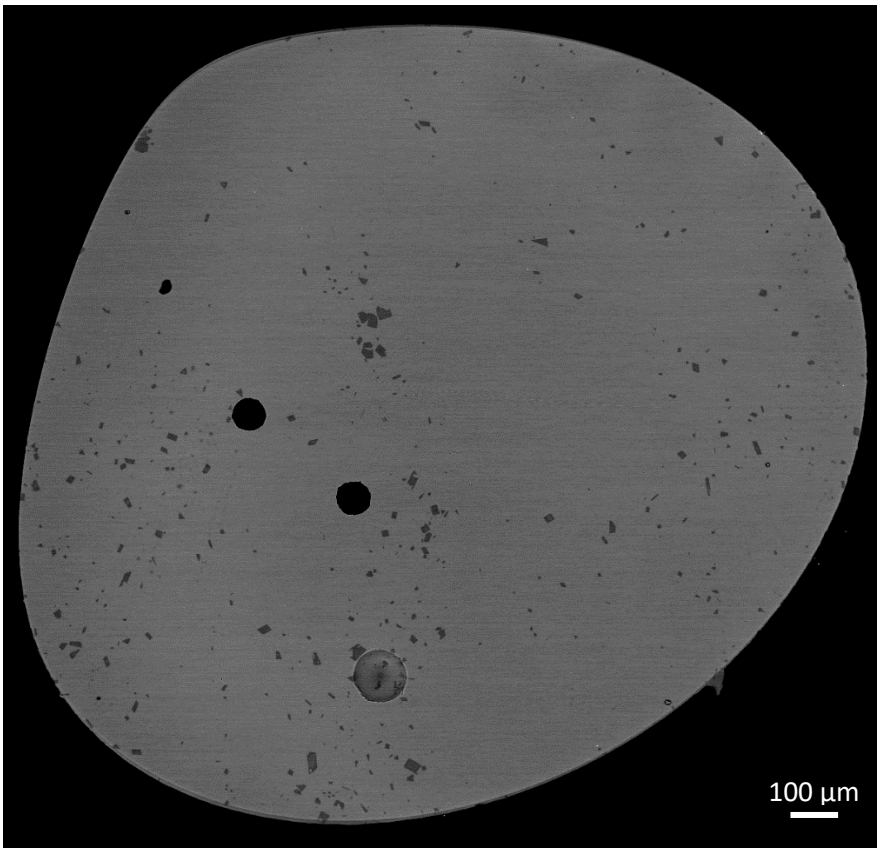
BSE image of the GERO 2-3 run (cooling: 3 °C/h, T_f: 1120 °C). *Crystal size varies from 5 to 125 µm. Agglomeration figures are present. The edge of the sample is not present, which explains the absence of oxide.*

GERO 2-4: 3°C/h, 1100 °C



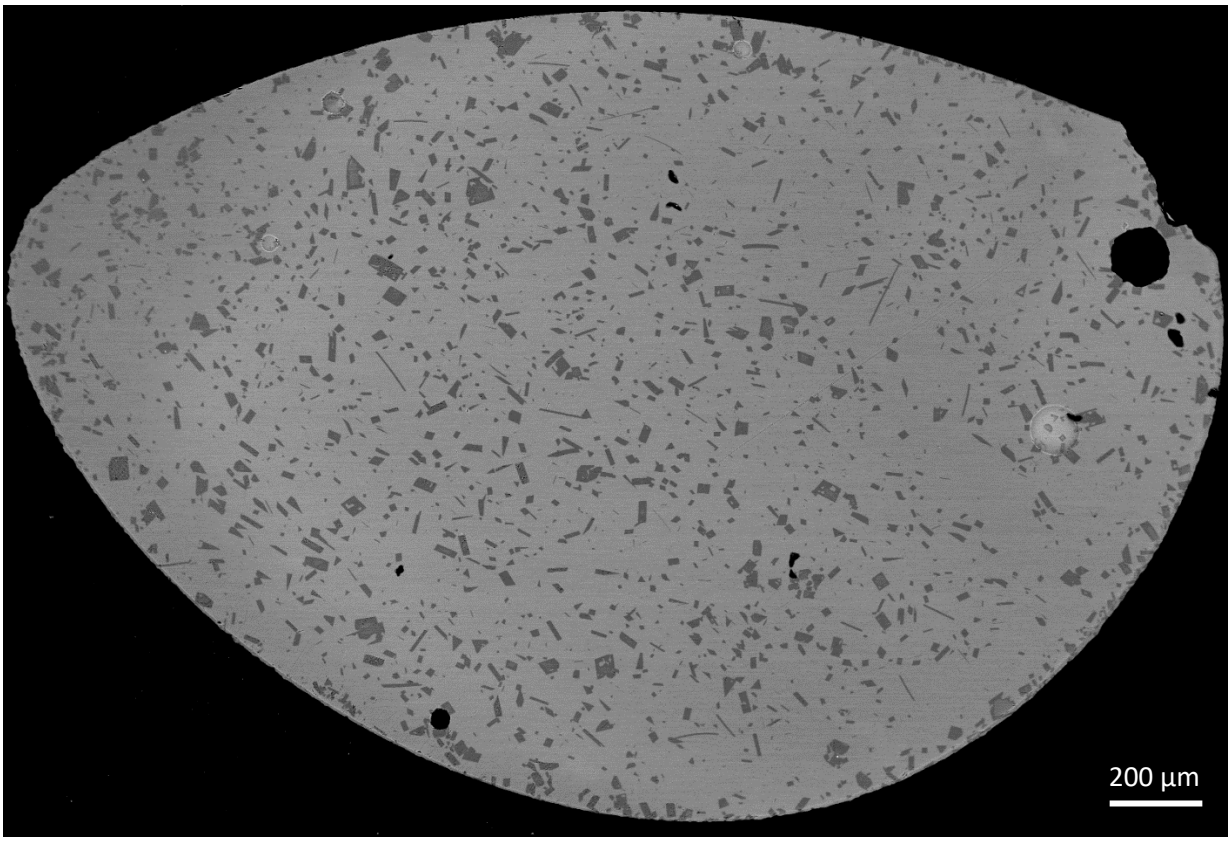
BSE image of the GERO 2-4 run (cooling: 3 °C/h, T_f: 1100 °C). *Crystal distribution become more homogeneous, and the density of larger (> 100-150 µm) elongated crystals increases. Numerous agglomeration figures are visible. A zone with titanomagnetite crystals, measuring 10-30 µm, is present at the previous position of the platinum wire.*

GERO 3-1: 9°C/h, 1165 °C



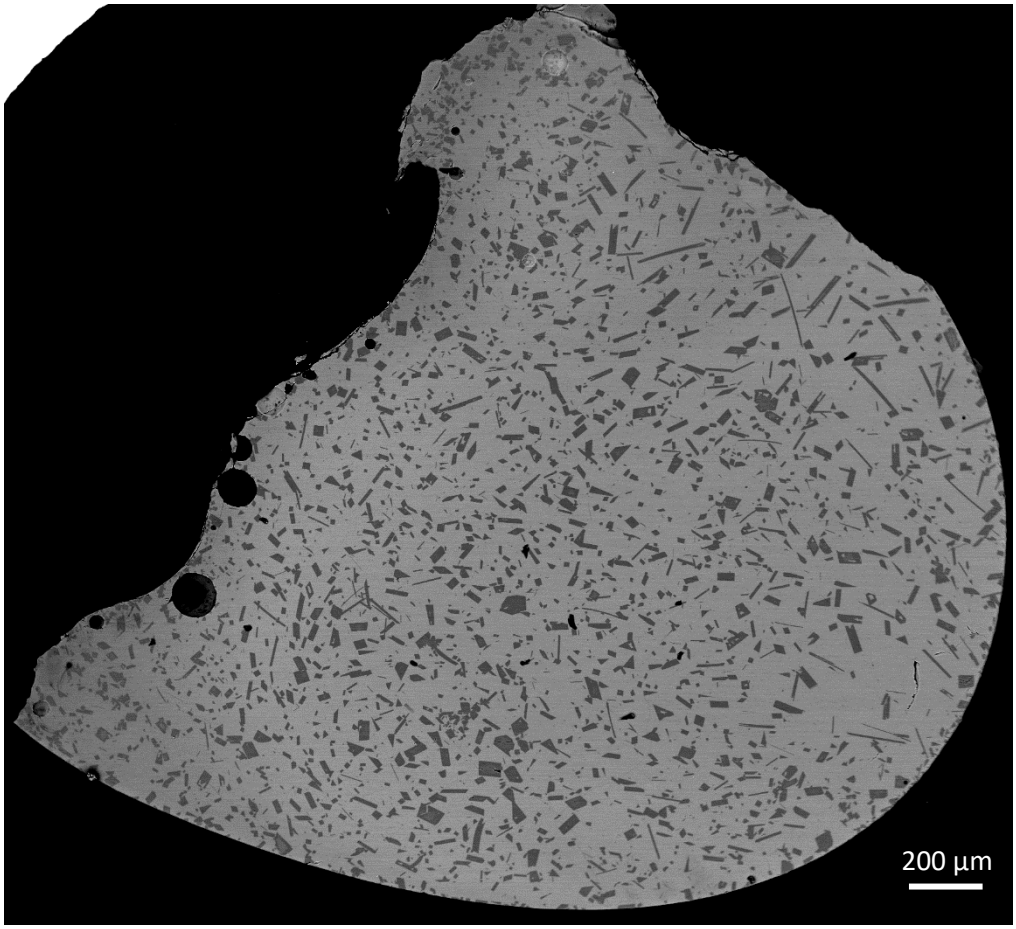
BSE image of the GERO 3-1 run (cooling: 9 °C/h, T_f: 1165 °C). *Crystals are generally between 5 and 30 µm. A few larger crystals (30 to 40 µm) locally contain seeds. The crystal density is higher than in samples cooled at 1 and 3 °C/h, at the same final temperature.*

GERO 3-2: 9°C/h, 1140 °C (sample 1)



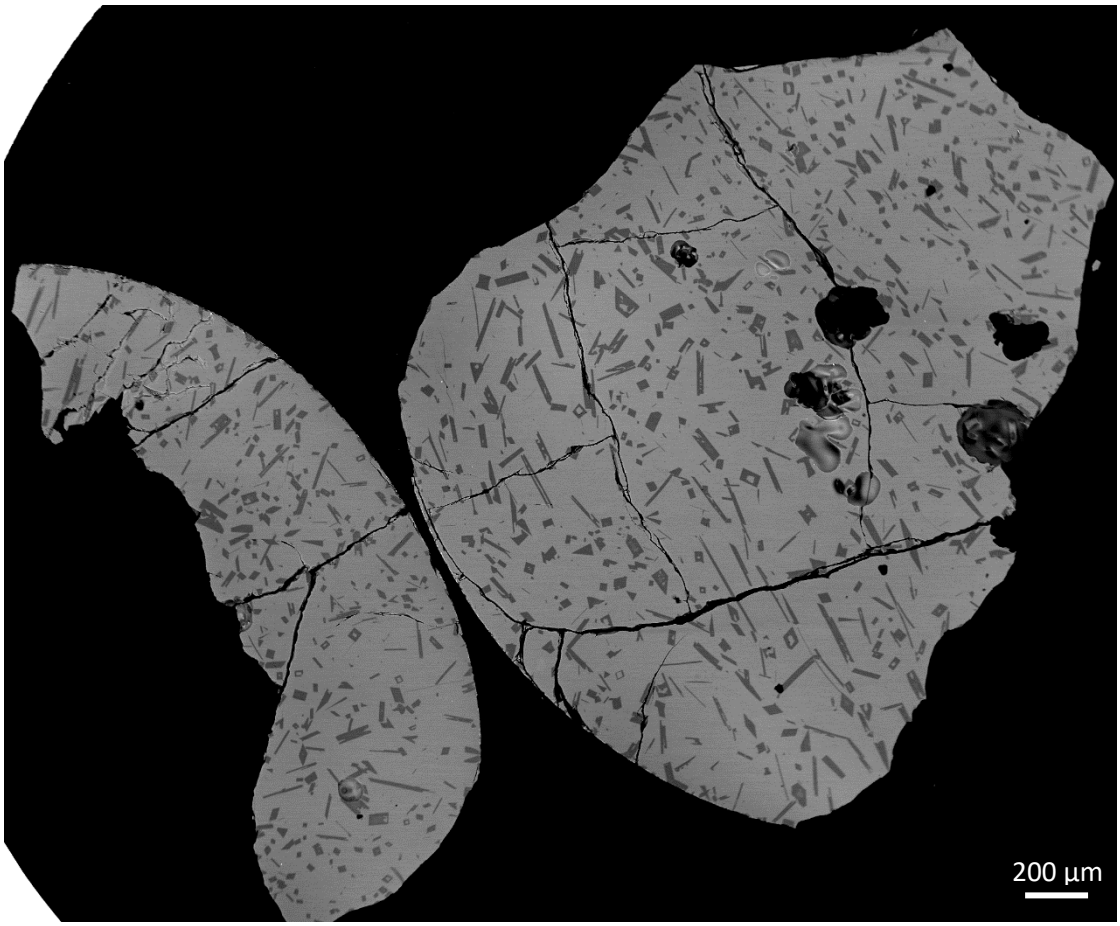
BSE image of the GERO 3-2 run (sample 1) (cooling: 9 °C/h, T_f: 1140 °C). *The crystal density is higher than in experiments cooled at 1 and 3 °C/h, at the same final temperature. Crystals start to exhibit hopper/skeletal texture. As for the other experiments quenched between 1165 °C and 1100 °C, the distribution of crystals is not homogeneous.*

GERO 3-2: 9°C/h, 1140 °C (sample 2)



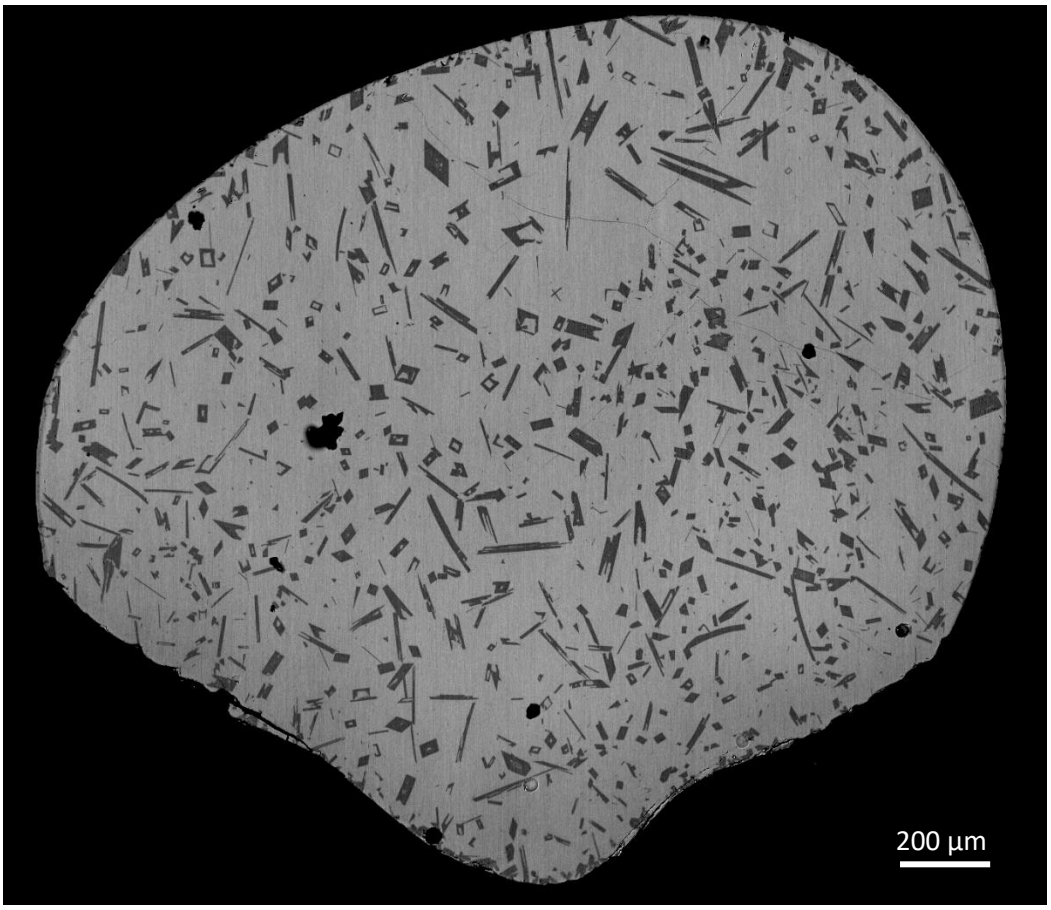
BSE image of the GERO 3-2 run (sample 2) (cooling: 9 °C/h, T_f: 1140 °C). *Large, elongated and swallowtail crystals (> 100-200 µm) are clearly visible but the other textural characteristics are similar to sample 1.*

GERO 3-3: 9°C/h, 1120 °C (sample 1)



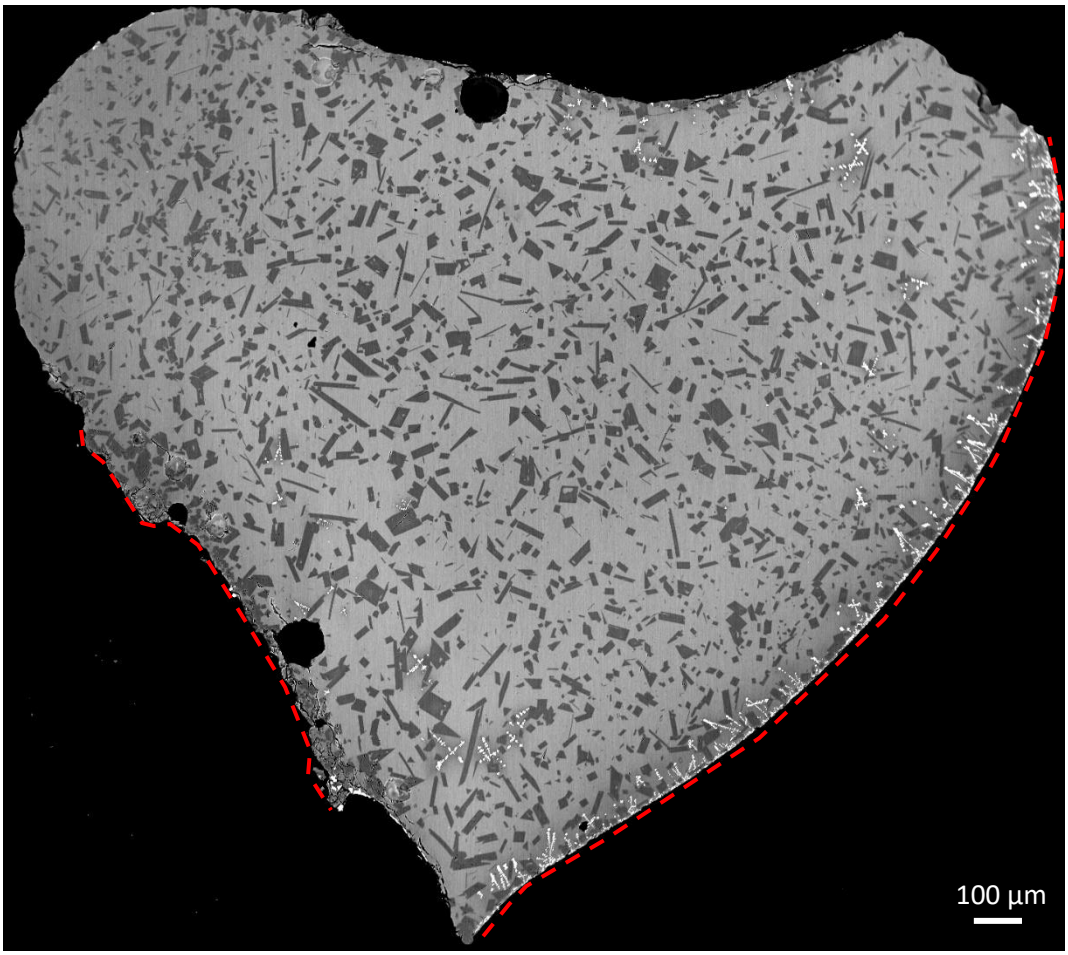
BSE image of the GERO 3-3 run (sample 1) (cooling: 9 °C/h, T_f: 1120 °C). *Most crystals are elongated and have swallowtail/skeletal texture*

GERO 3-3: 9 °C/h, 1120°C (sample bis)



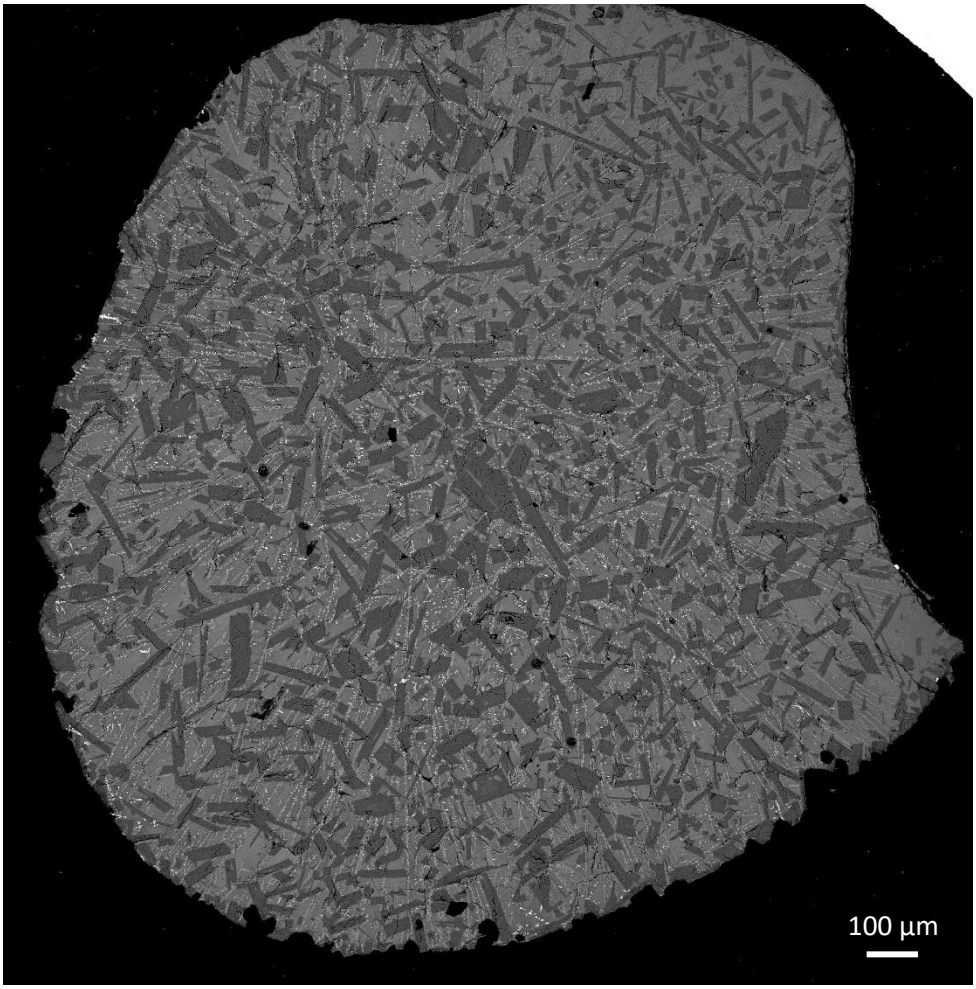
BSE image of the GERO 3-3 run (sample bis) (cooling: 9 °C/h, T_f: 1120 °C). *Similar to sample 1.*

GERO 3-4: 9°C/h, 1100 °C



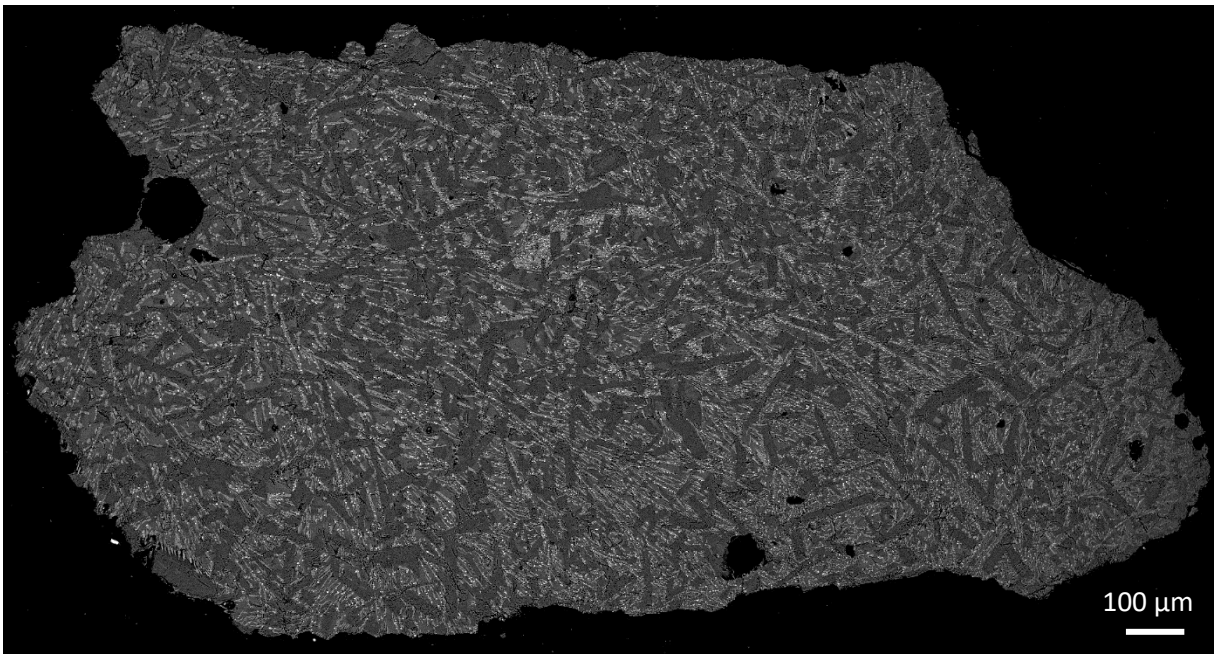
BSE image of the GERO 3-4 run (cooling: 9 °C/h, T_f: 1100 °C). *Crystal distribution is more homogeneous. Plagioclase crystals become more euhedral (elongated/tabular). Swallowtail/skeletal texture tends to disappear. A zone of oxide is present at the edge of the sample.*

GERO 3-5: 9°C/h, 1050 °C



BSE image of the GERO 3-5 run (cooling: 9 °C/h, T_f: 1050 °C). *Large tabular and elongated plagioclase crystals are present. No skeletal texture is visible. However, dendritic Cpx crystallized from plagioclase. Some oxide (often skeletal) are also present. The density of smaller crystals than 5-10 µm is lower than in experiments quenched between 1140 and 1100 °C.*

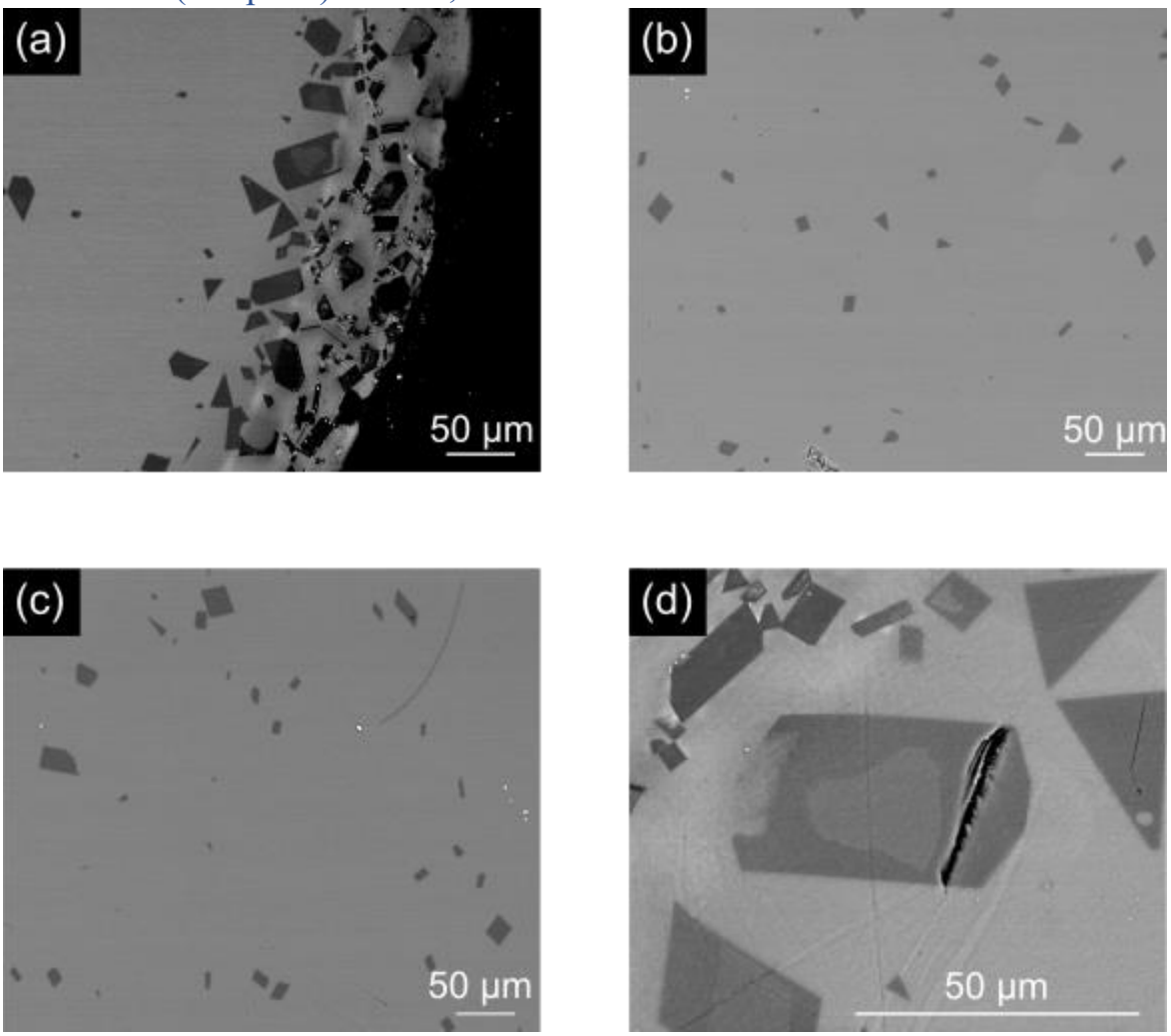
GERO 3-6: 9°C/h, 1000 °C



BSE image of the GERO 3-6 run (cooling: 9 °C/h, T_f: 1000 °C). *Similar texture to the experiment quenched at 1050 °C, with an increase of the proportions of plagioclase and Cpx.*

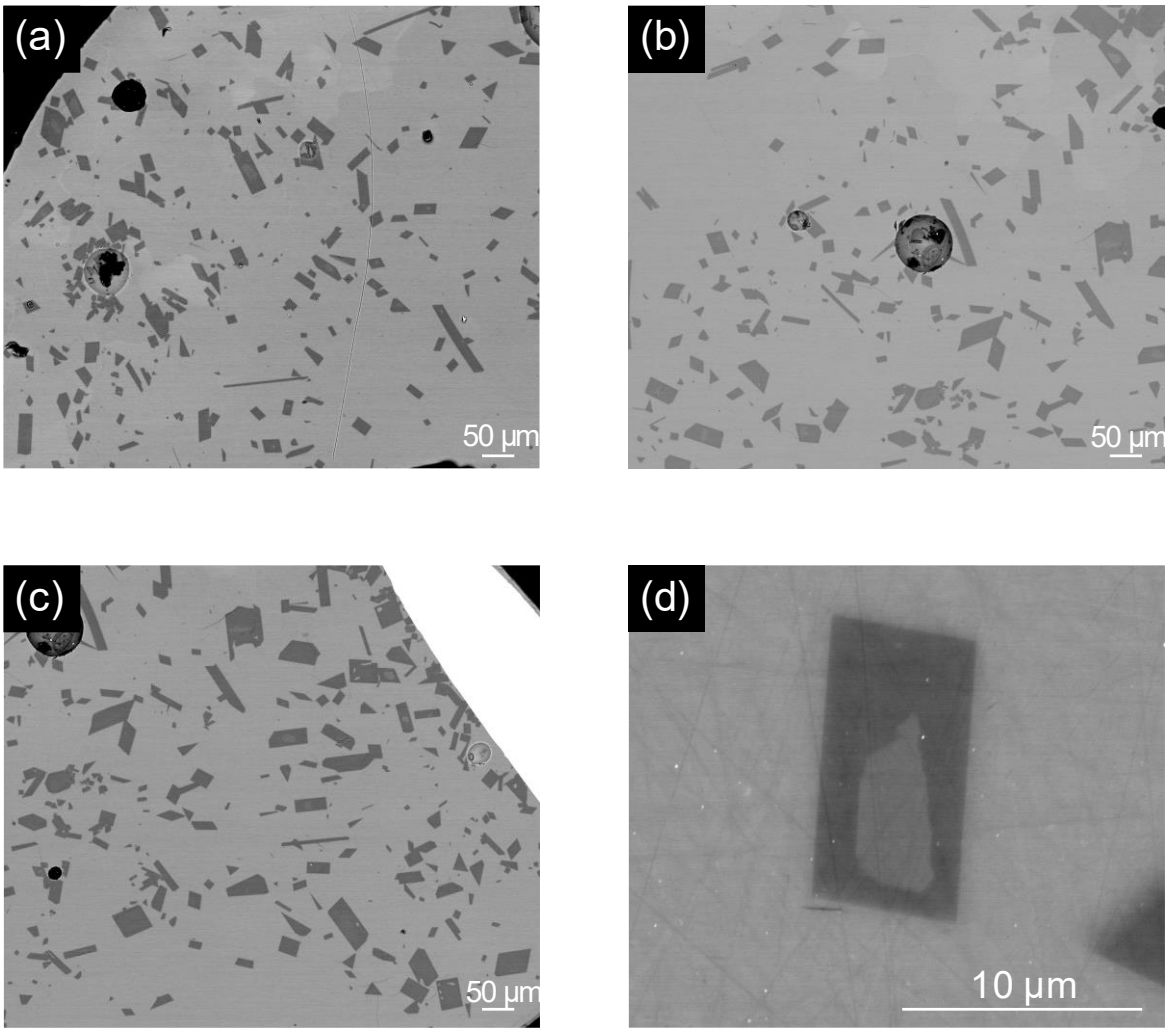
Magnification

GERO 1-1 (sample 1): 1 °C/h, 1165 °C



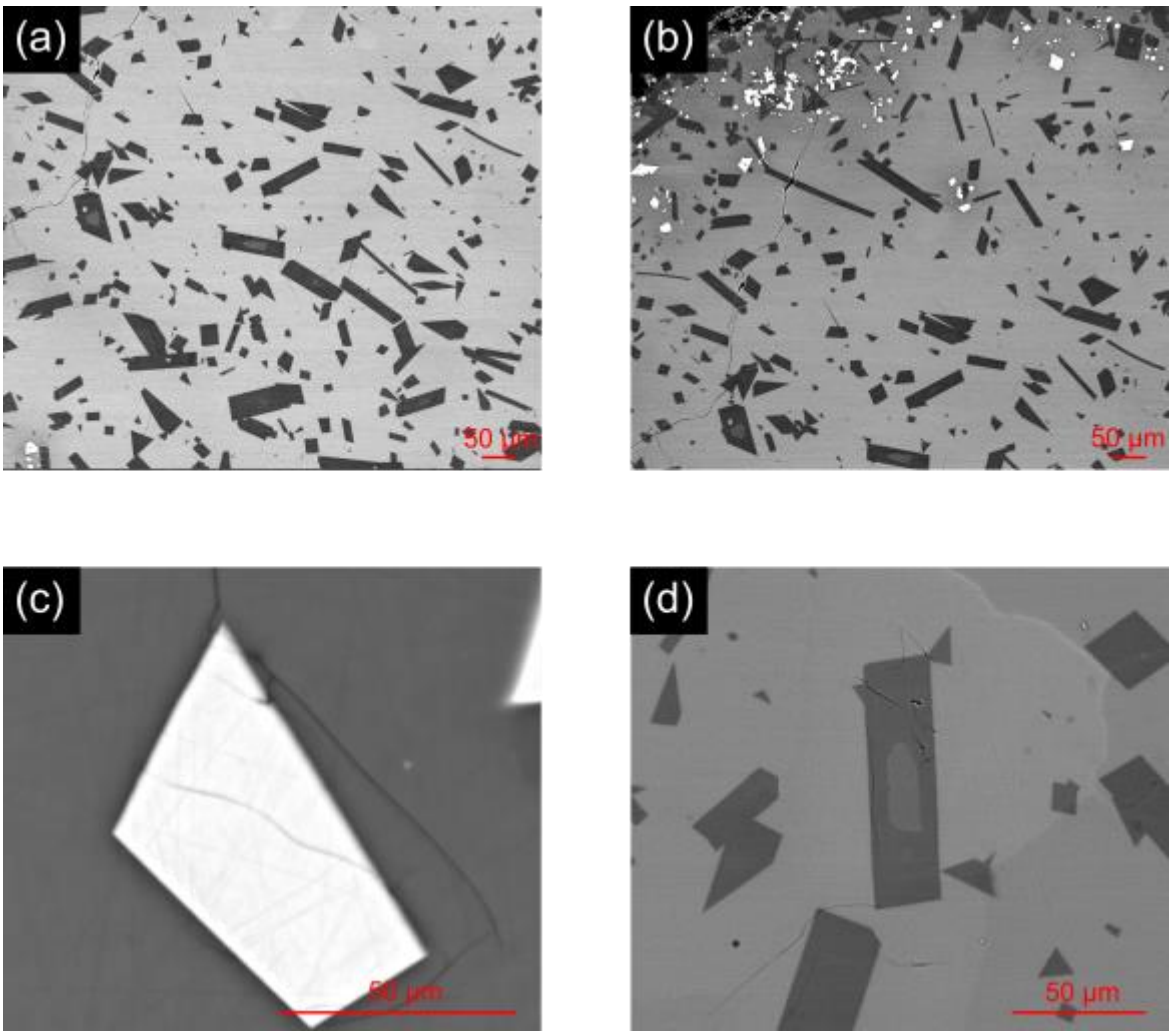
BSE image at various magnifications illustrating the plagioclase texture at 1 °C/h, 1165 °C. (a) Plagioclase-rich zone close to the platinum wire. (b and c) Small equant and tabular plagioclases. (d) An example of a seed (pre-existing plagioclase crystal) with plagioclase overgrowth.

GERO 1-2: 1 °C/h, 1137 °C



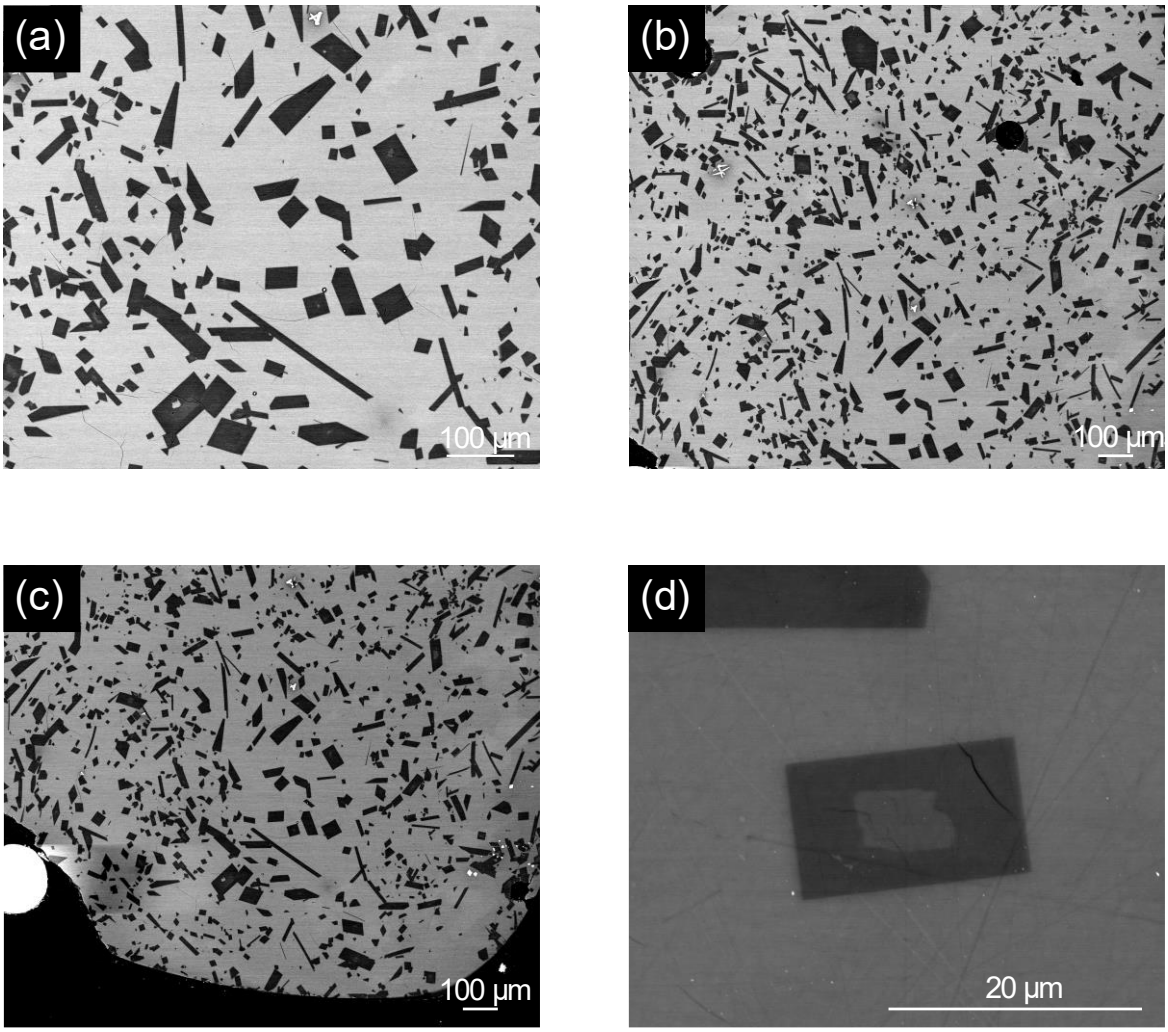
BSE image at various magnifications illustrating the plagioclase texture at 1 °C/h, 1137 °C. (a-c) Tabular/Elongated plagioclase heterogeneously distributed within the sample. (d) An example of seed (pre-existing plagioclase crystal) with plagioclase overgrowth.

GERO 1-3: 1 °C/h, 1120 °C



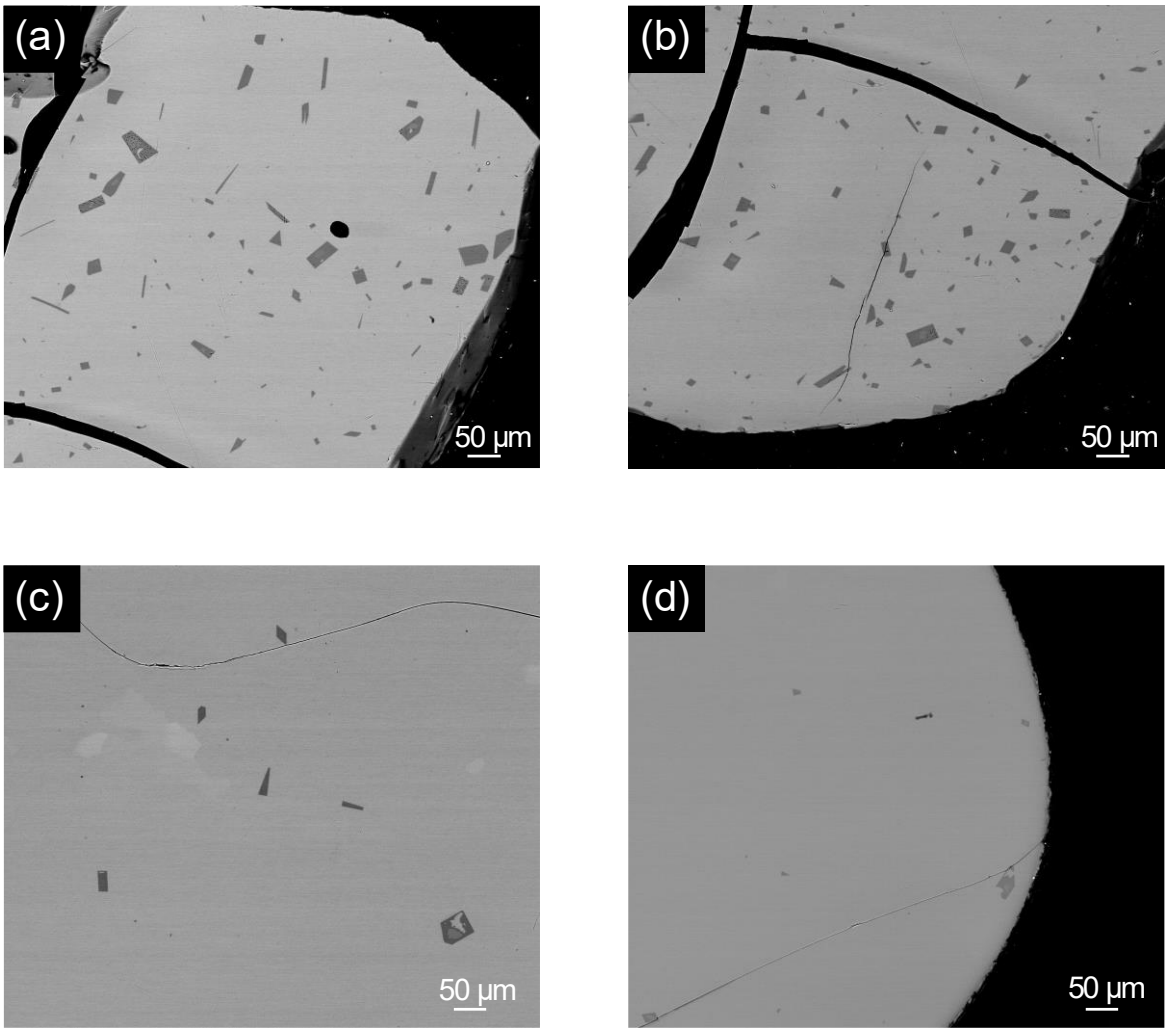
BSE image at different magnifications illustrating the plagioclase texture at 1 °C/h, 1120 °C. (a-b) Tabular/elongated plagioclase. (c) Euhedral titanomagnetite close to the platinum wire. (d) An example of seed (pre-existing plagioclase crystal) with plagioclase overgrowth.

GERO 1-4: 1 °C/h, 1100 °C



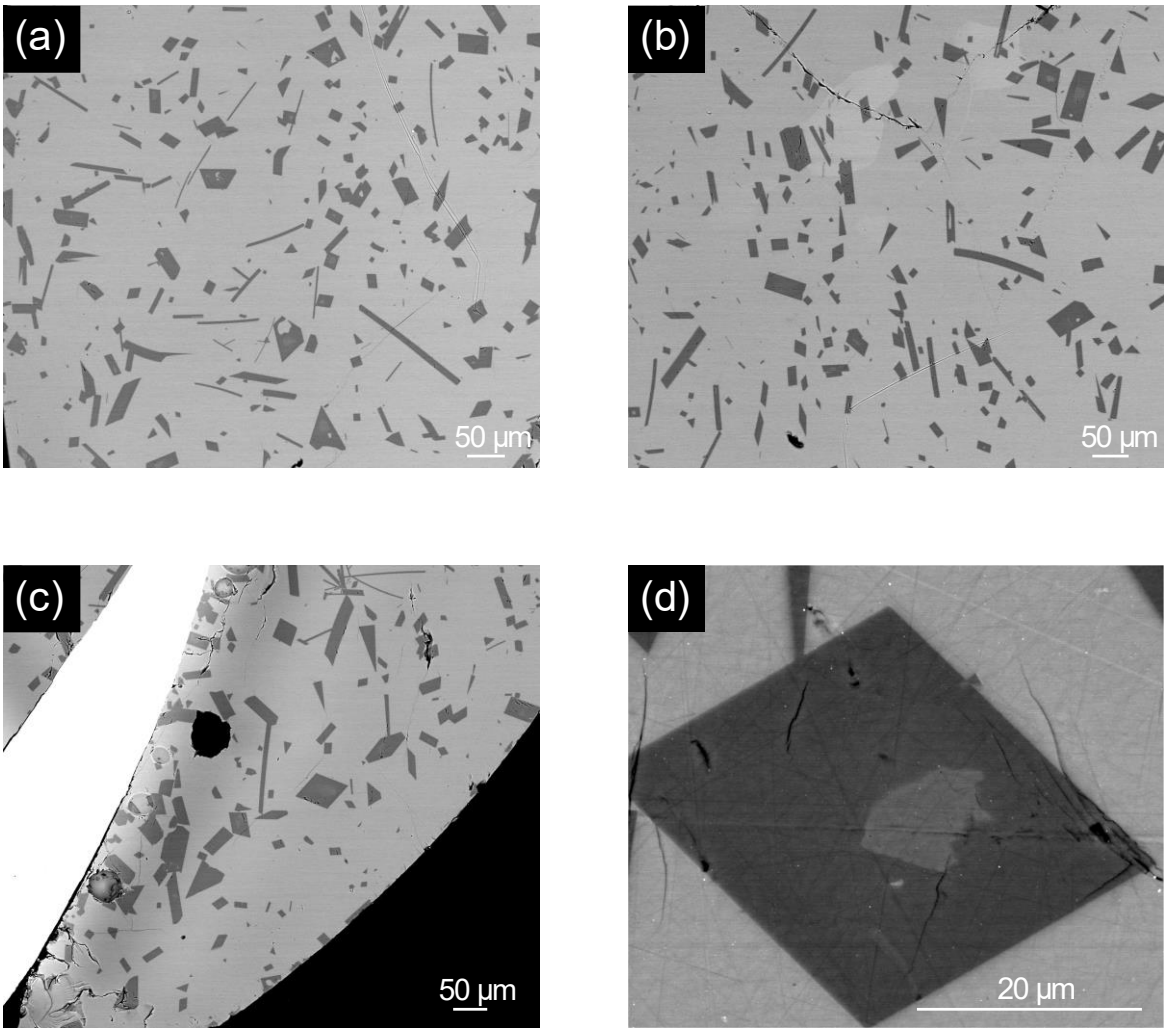
BSE image at different magnifications illustrating the plagioclase texture at 1 °C/h, 1100 °C. (a-c) Tabular/elongated plagioclases distributed in the sample. (d) An example of seed (pre-existing plagioclase crystal) with plagioclase overgrowth.

GERO 2-1: 3 °C/h, 1165 °C



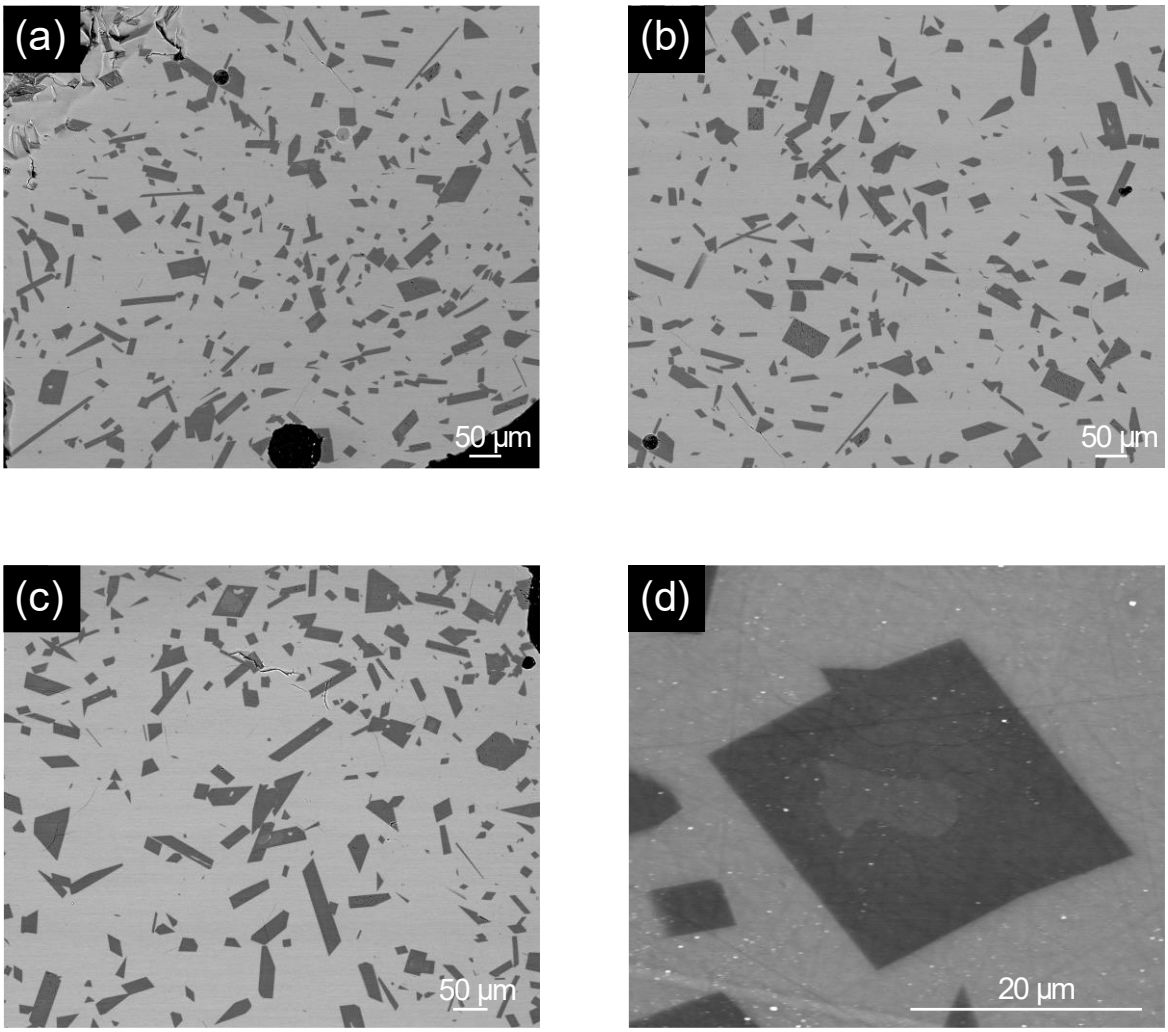
BSE image at different magnifications illustrating the plagioclase texture at 3 °C/h, 1165 °C. (a-b) Elongated/tabular plagioclase crystals distributed in the sample 1. (c and d) Small elongated and tabular plagioclases in the sample bis. *Note that there is a large difference in crystal density between the two samples.*

GERO 2-2: 3 °C/h, 1140 °C



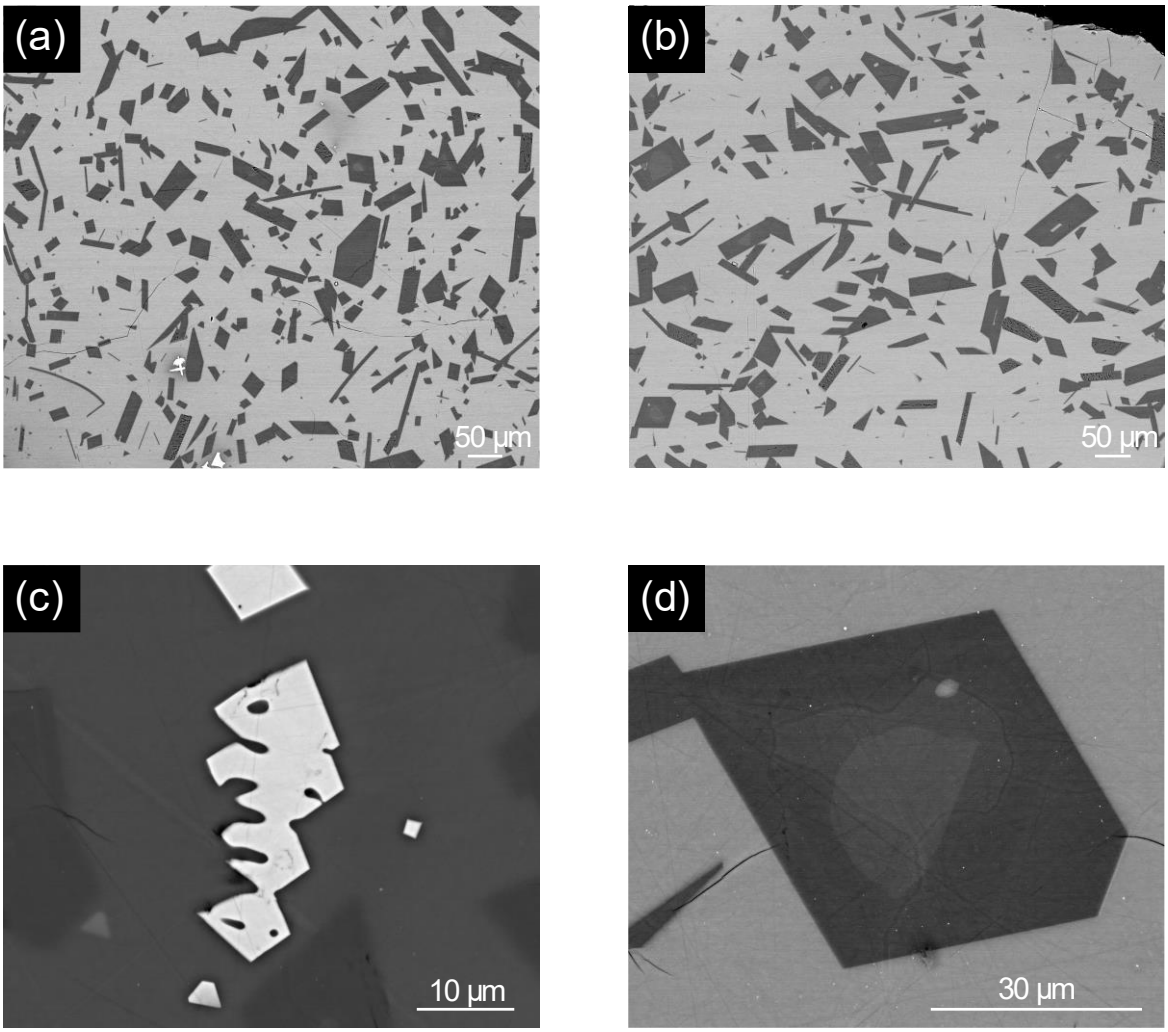
BSE image at different magnifications illustrating the plagioclase texture at 3 °C/h, 1140 °C. (a-c) Tabular/elongated plagioclases distributed in the sample. (a) Some crystals contain melt inclusions. (c) The platinum wire is surrounded by a higher crystal density. (d) An example of seed (pre-existing plagioclase crystal) with plagioclase overgrowth.

GERO 2-3: 3 °C/h, 1120 °C



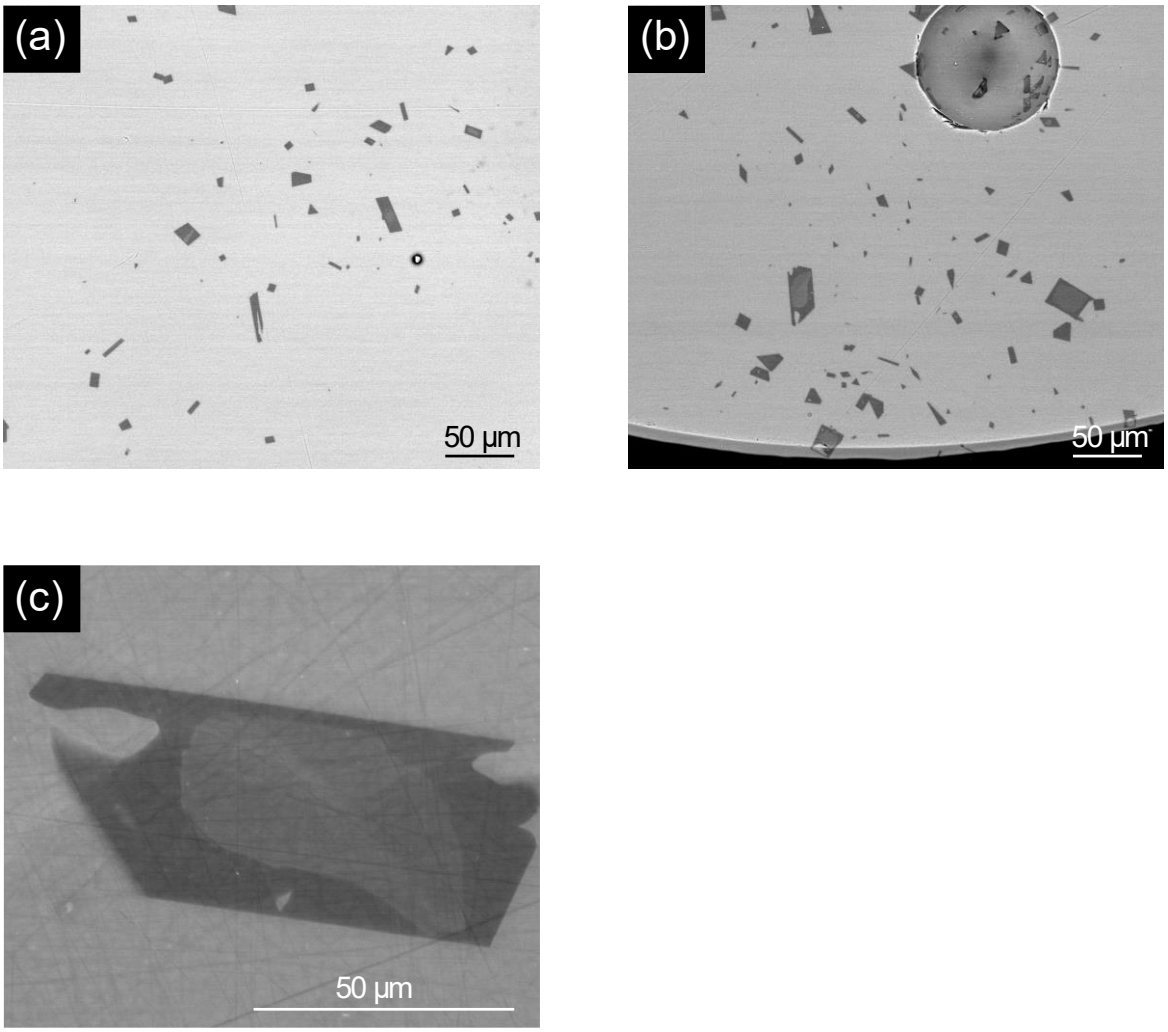
BSE image at different magnifications illustrating the plagioclase texture at 3 °C/h, 1120 °C. (a-c) Tabular/elongated plagioclases distributed in the sample. (a) Some crystals contain melt inclusions). (d) An example of seed (pre-existing plagioclase crystal) with plagioclase overgrowth.

GERO 2-4: 3 °C/h, 1100 °C



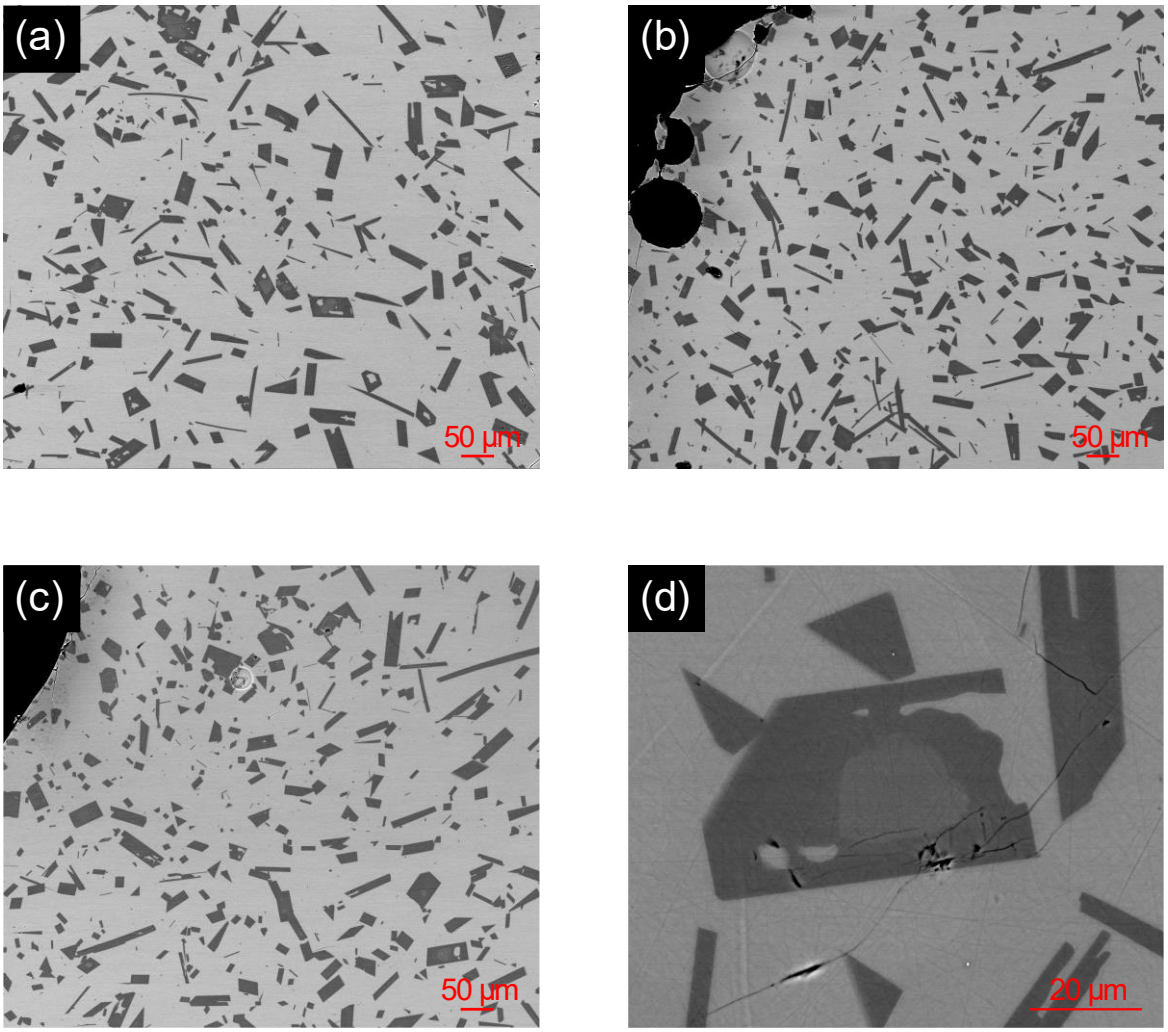
BSE image at different magnifications illustrating the plagioclase texture at 3 °C/h, 1100 °C. (a-b) Tabular/elongated plagioclases distributed in the sample. (c) An example of newly formed dendritic titanomagnetite. (d) An example of seed (pre-existing plagioclase crystal) with plagioclase overgrowth.

GERO 3-1: 9 °C/h, 1165 °C



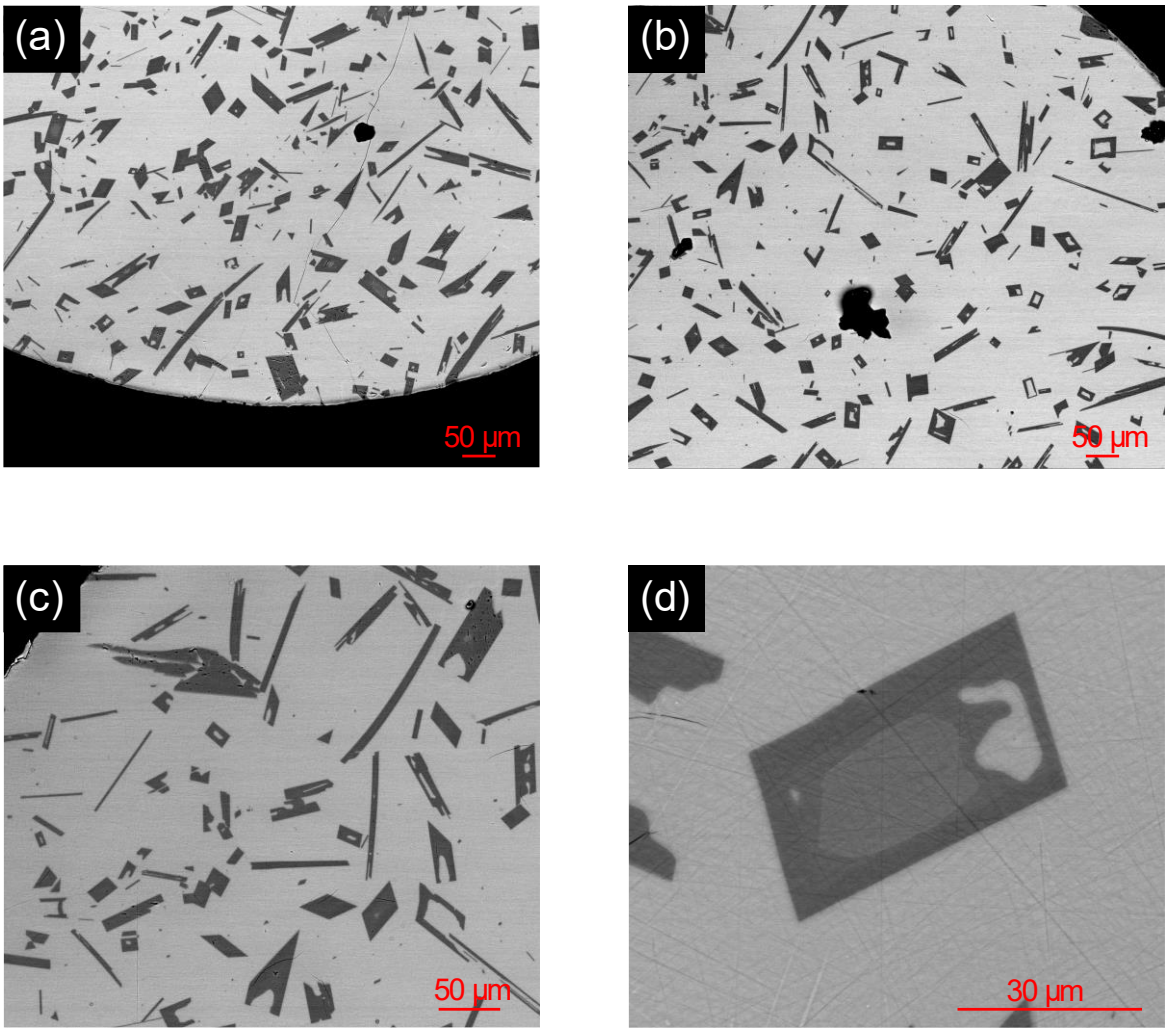
BSE image at different magnifications illustrating the plagioclase texture at 9 °C/h, 1165 °C. (a-b) Small equant and elongated plagioclases. The plagioclases with seeds have a larger size and a more tabular shape. Additionally, a small proportion of plagioclase crystals exhibit a skeletal texture. (c) An example of seed (pre-existing plagioclase crystal) with plagioclase overgrowth.

GERO 3-2: 9 °C/h, 1140 °C



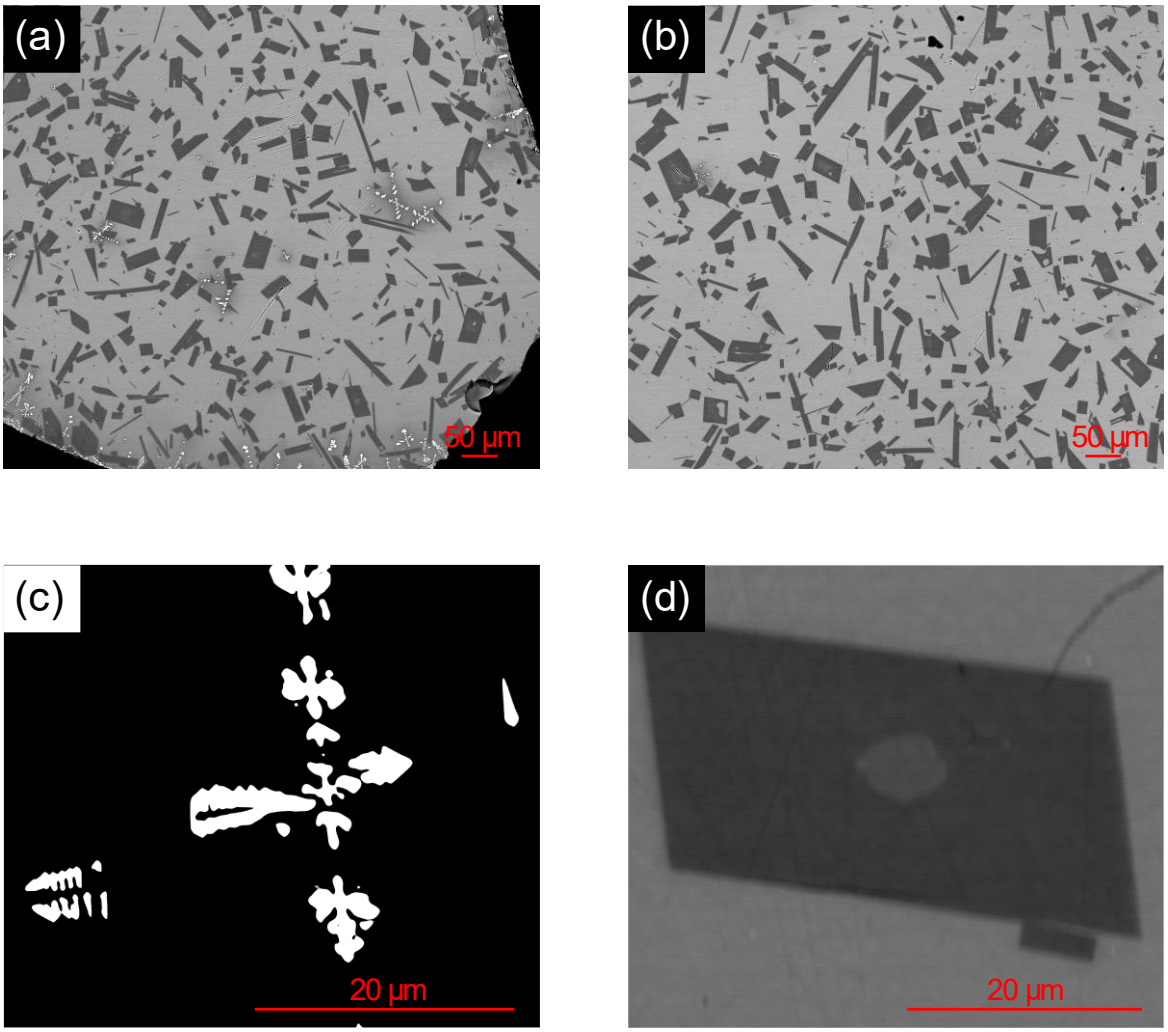
BSE image at different magnifications illustrating the plagioclase texture at 9 °C/h, 1140 °C. (a-c) Tabular/elongated plagioclases distributed in the sample. (d) An example of seed (pre-existing plagioclase crystal) in a new plagioclase. The plagioclases exhibit a more abundant elongated shape compared to the experiments at 1 °C/h and 3 °C/h.

GERO 3-2: 9 °C/h, 1120 °C



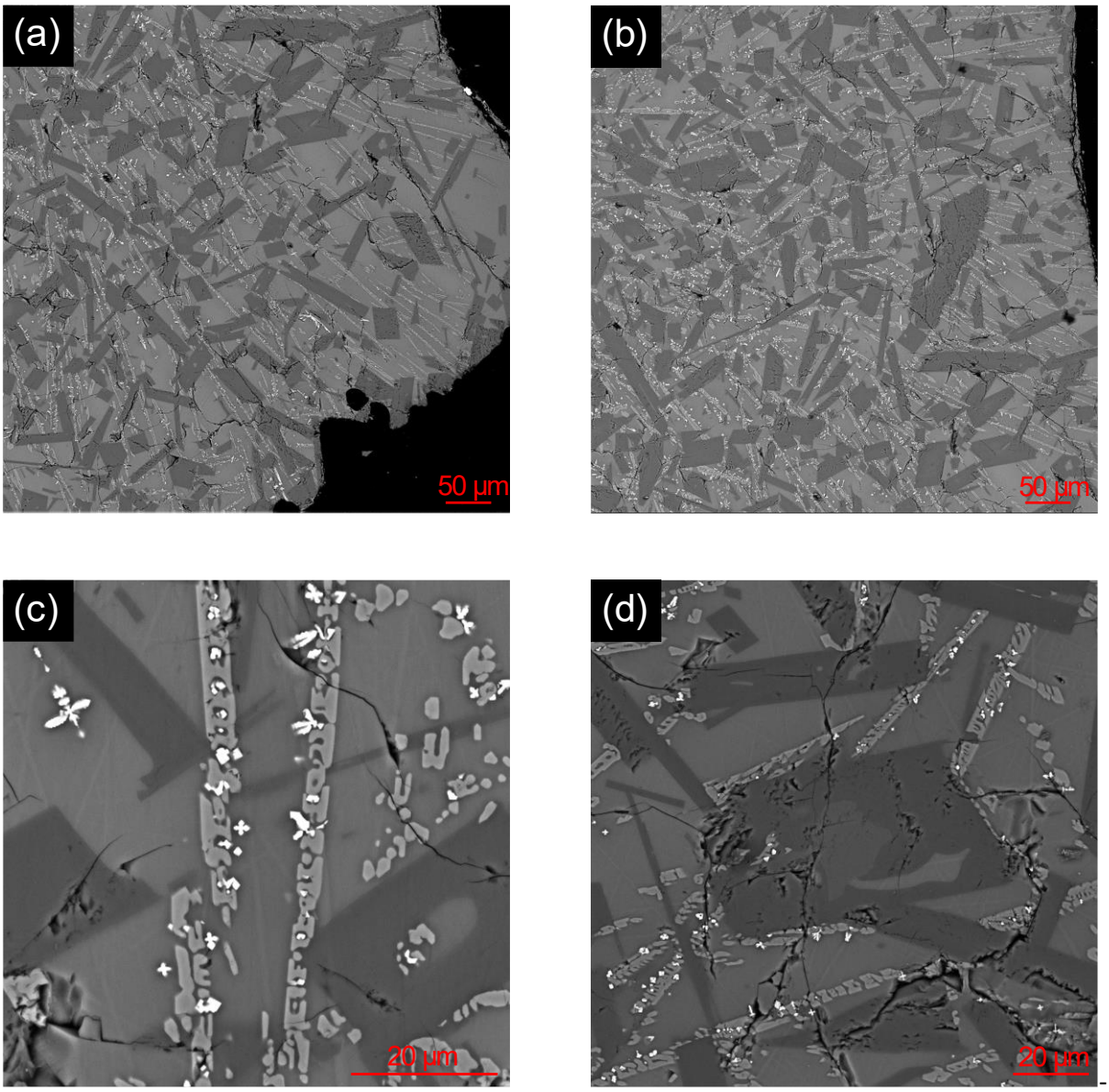
BSE image at different magnifications illustrating the plagioclase texture at 9 °C/h, 1120 °C. (a-c) Elongated and skeletal plagioclases distributed in the sample. (d) An example of seed (pre-existing plagioclase crystal) and melt inclusion in a new plagioclase. *We can notice a decrease in the abundance of small plagioclase crystals (<5-10 µm).*

GERO 3-2: 9 °C/h, 1100 °C



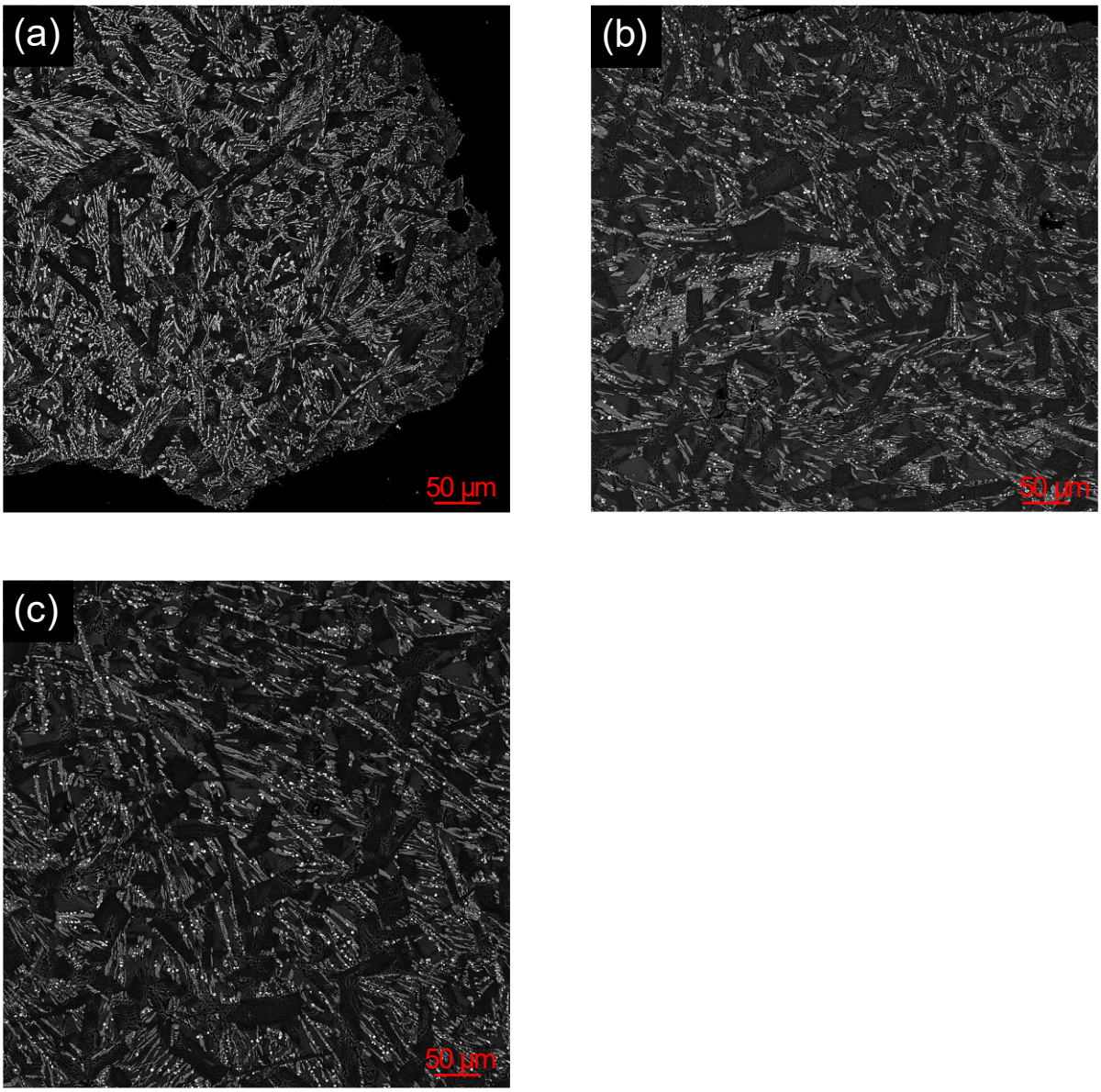
BSE image at different magnifications illustrating the plagioclase texture at 9 °C/h, 1100 °C. (a-b) Elongated and tabular plagioclases distributed in the sample. (c) An example of newly formed dendritic titanomagnetite (binarized image). (d) An example of seed (pre-existing plagioclase crystal) in a new plagioclase. *The skeletal texture has nearly disappeared, and the density of small plagioclase crystals (< 5-10 µm) has increased*.

GERO 3-2: 9 °C/h, 1050 °C



BSE image at different magnifications illustrating the plagioclase texture at 9 °C/h, 1050 °C. (a-b) Elongated and tabular plagioclases distributed in the sample. (c) An example of newly formed dendritic Cpx radiating from plagioclases. (d) An example of seed (pre-existing plagioclase crystal) with plagioclase overgrowth. The crystal is surrounded by Cpx dentrites.

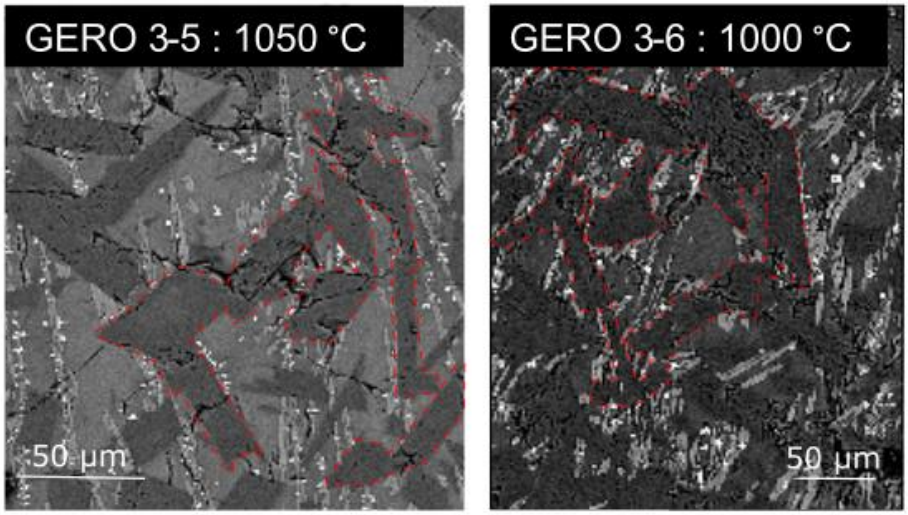
GERO 3-2: 9 °C/h, 1000 °C



BSE image at different magnifications illustrating the plagioclase texture at 9 °C/h, 1000 °C. (a-c) Elongated and tabular plagioclases distributed in the sample. We can observe a strong increase in dendritic Cpx proportion.

Crystal network

Crystal network



No crystal network