Supplementary Material

This supplementary section includes reflected light images of each sample to visualize where exactly data were collected (LA-ICP-MS trace element transects and Fe isotope raster spots). When zoning was observed by these data, additional elemental maps were collected for Al and Ti by EPMA (beam current: 300 nA, accelerating voltage: 20 kV, spot size: 1 µm, counting time: 80 ms/step). No common threshold can be given for trace element concentrations indicating magmatic-hydrothermal or igneous origin, respectively, due to complex interplays that change over depth (higher trace element concentrations are detected with increasing depths). However, discrimination can be conducted by looking at individual samples. Samples that provide a zoning from igneous to hydrothermal parts (sudden changes in trace element concentration) give evidence of how much trace elements can be expected for different origins (igneous vs. magmatic-hydrothermal) at each depths and help to interpret those samples that do not provide distinct zoning. Further, textural appearance helps to estimate different origins. Inclusion-rich crystals/areas are rather indicators for an igneous origin, while pristine magnetite texture implies a magmatic-hydrothermal formation (Knipping et al. 2015a and b). A description is given for each sample to show how their origin (igneous vs. magmatic-hydrothermal) was determined.

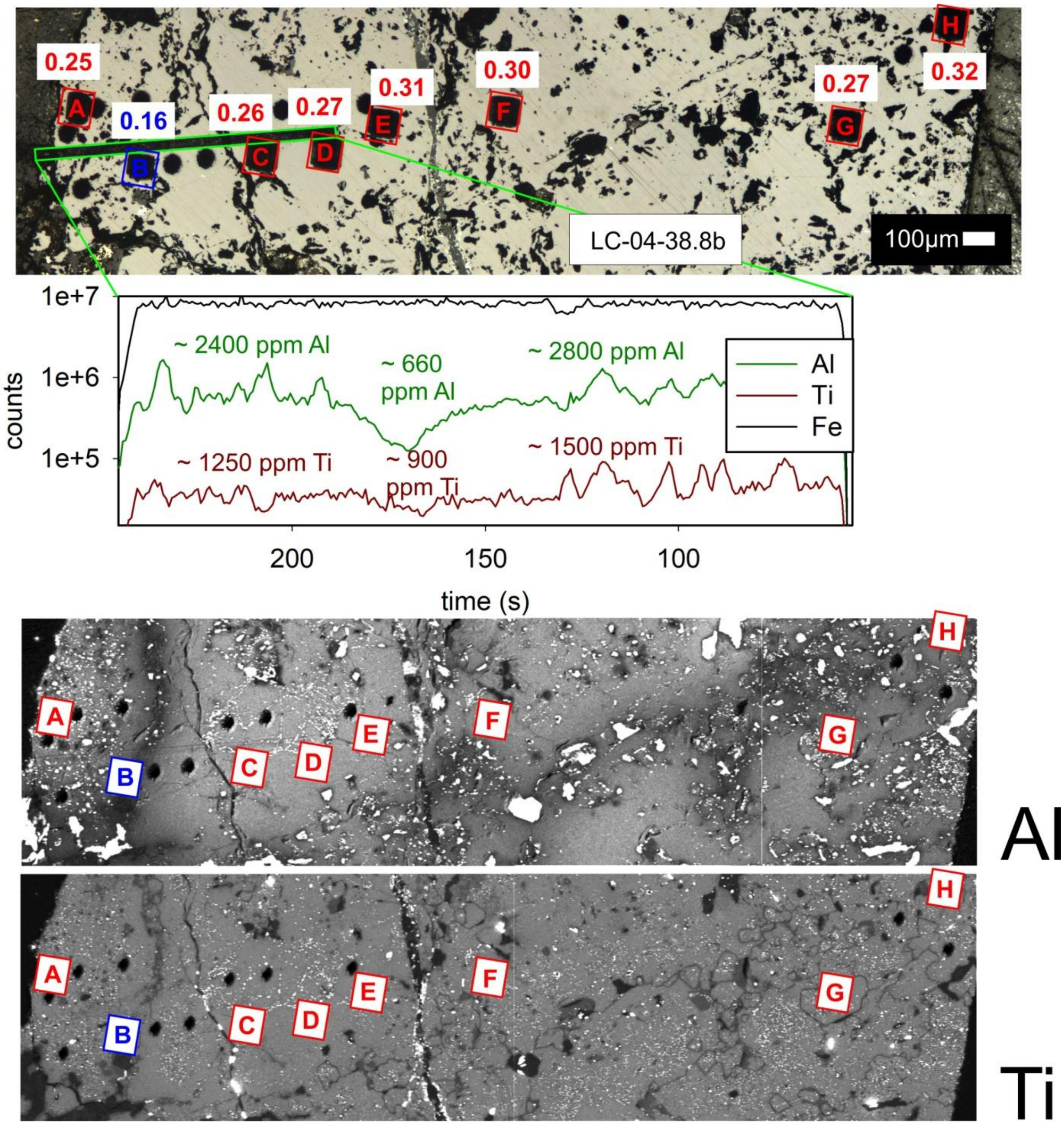

Fig. 1: Reflected light image of the shallowest sample of drill core LC-04 (LC-04-38.8b) including location of LA-ICP-MS trace element transect (highlighted in bright green) as well as location and values of in-situ δ^{56}Fe measurements (red or blue). Fe-isotope values were assigned to igneous (red) or hydrothermal origin (blue) based on measured trace element concentration (Ti and Al). A clear drop in Ti and Al concentration at location B indicates a hydrothermal vein between igneous parts with relatively high Al and Ti concentrations. This vein is also visible in the Al and Ti elemental maps measured with EPMA. Therefore, B was interpreted as hydrothermal, while A, C and D were interpreted as igneous magnetite. The remaining raster spots E, F, G and H were also assigned as igneous, since their isotopic values as well as their textural appearance correlate with the raster spots A, C and D.

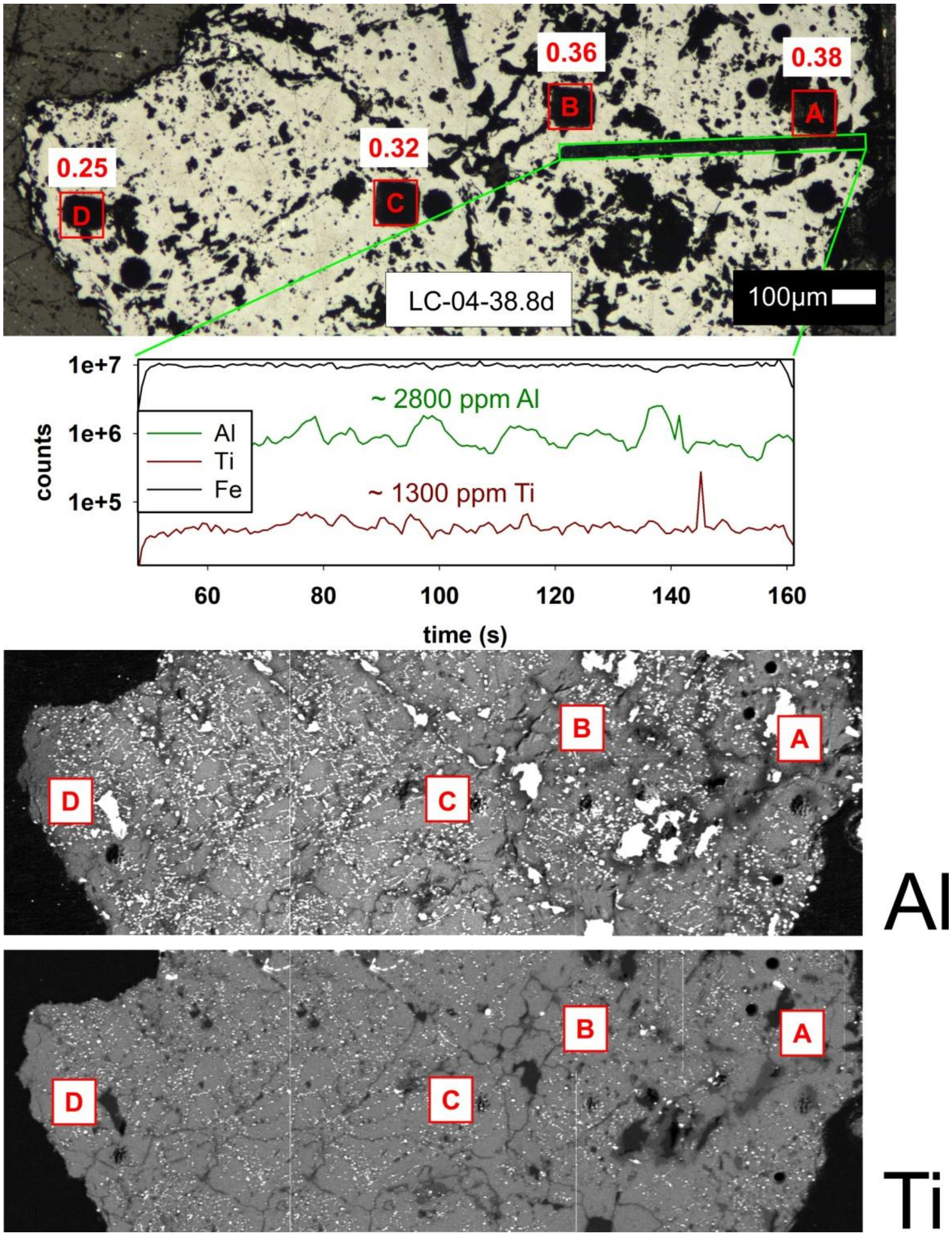

Fig. 2: Reflected light image of sample LC-04-38.8d including location of LA-ICP-MS trace element transect (highlighted in bright green) as well as location and values of in-situ δ^{56}Fe measurements (red). Fe-isotope values were assigned to solely igneous (red) origin based on trace element concentration (Ti and Al) comparable to igneous parts of samples from similar depth (LC-04-38.8b). The Al and Ti elemental maps measured with EPMA also indicate a similar texture for all measured spots (A, B, C and D).

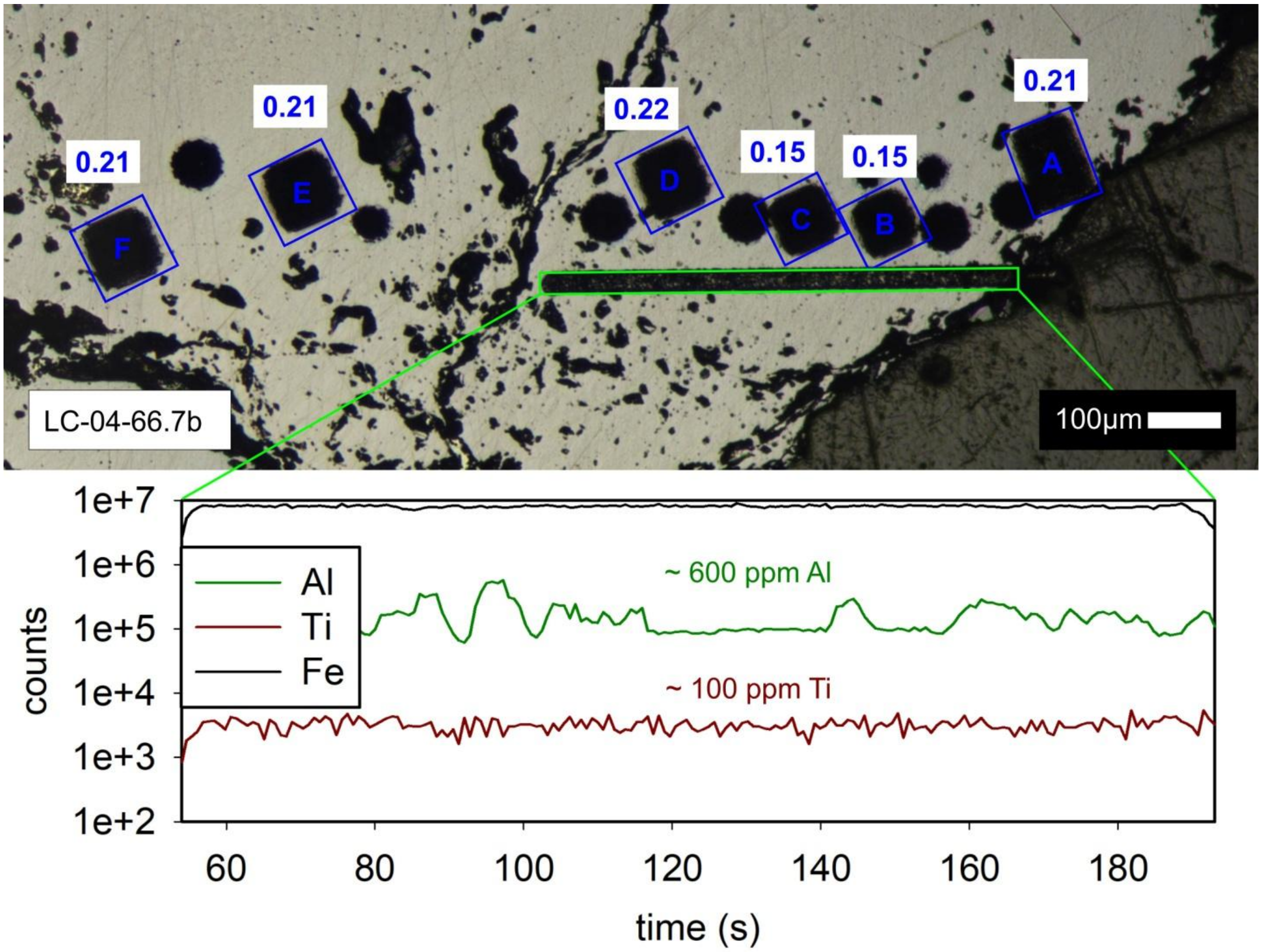

Fig. 3: Reflected light image of sample LC-04-66.7b including location of LA-ICP-MS trace element transect (highlighted in bright green) as well as location and values of in-situ δ^{56}Fe measurements (blue). Fe-isotope values of A, B, C and D were assigned to solely hydrothermal (blue) origin based on very low trace element concentration (Ti and Al) comparable to hydrothermal parts in sample LC-04-38.8b as well as a relatively smooth texture and LA-ICP-MS trace element signal. The remaining raster spots E and F were also assigned as hydrothermal, since their isotopic values as well as their textural appearance correlate with the raster spots A, B, C and D.

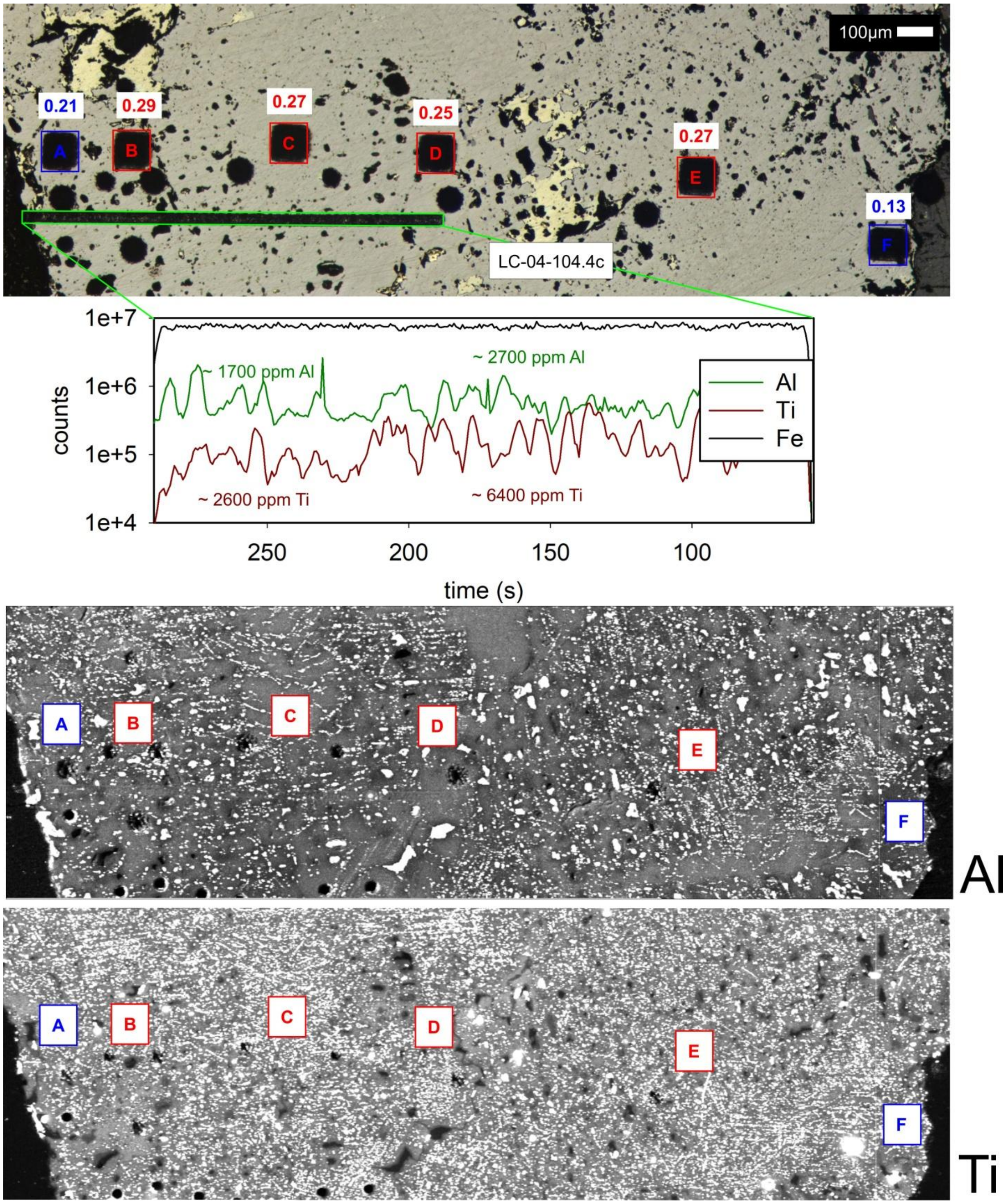

Fig. 4: Reflected light image of sample LC-04-104.4c including location of LA-ICP-MS trace element transect (highlighted in bright green) as well as location and values of in-situ δ^{56}Fe measurements (red or blue). Fe-isotope values were assigned to igneous (red) or hydrothermal origin (blue) based on measured trace element concentration (Ti and Al). A decrease in Ti and Al concentration between location B and A indicates a hydrothermal rim with relatively lower Al and Ti concentrations. This rim is also detectable in the Al and Ti elemental maps measured with EPMA (especially for Al at location F). Therefore, A and F were interpreted as hydrothermal, while B, C and D were interpreted as igneous magnetite. The remaining raster spot E was also assigned as igneous, since its isotopic value as well as its textural appearance correlate with the raster spots B, C and D.

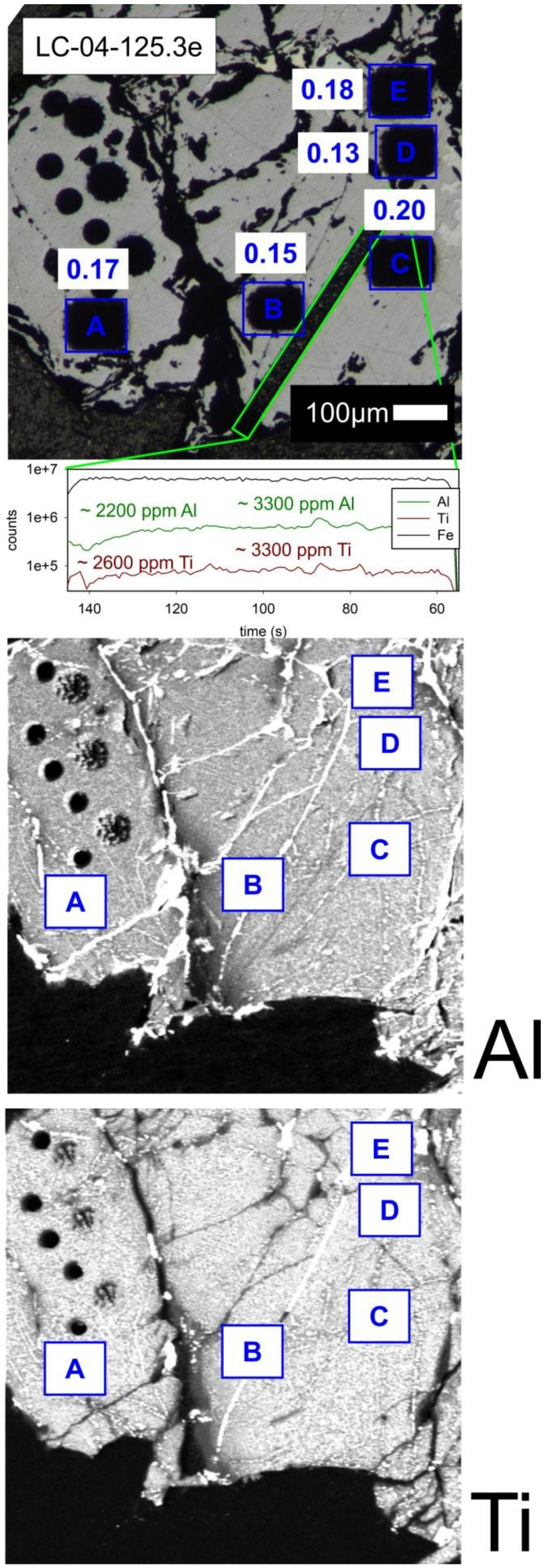

Fig. 5: Reflected light image of sample LC-04-125.3e including location of LA-ICP-MS trace element transect (highlighted in bright green) as well as location and values of in-situ δ^{56}Fe measurements (blue). Fe-isotope values of B and C were assigned to solely hydrothermal (blue) origin based on their relatively low Al and Ti concentration comparable to hydrothermal parts in the shallower sample LC-04-104.4c as well as their smooth texture and LA-ICP-MS trace element signal. A decrease in Al and Ti towards the rims may indicate here a cooling history of hydrothermal magnetite. The remaining raster spots A, D and E were also assigned as hydrothermal, since their isotopic values as well as their textural appearance correlate with the raster spots B and C.

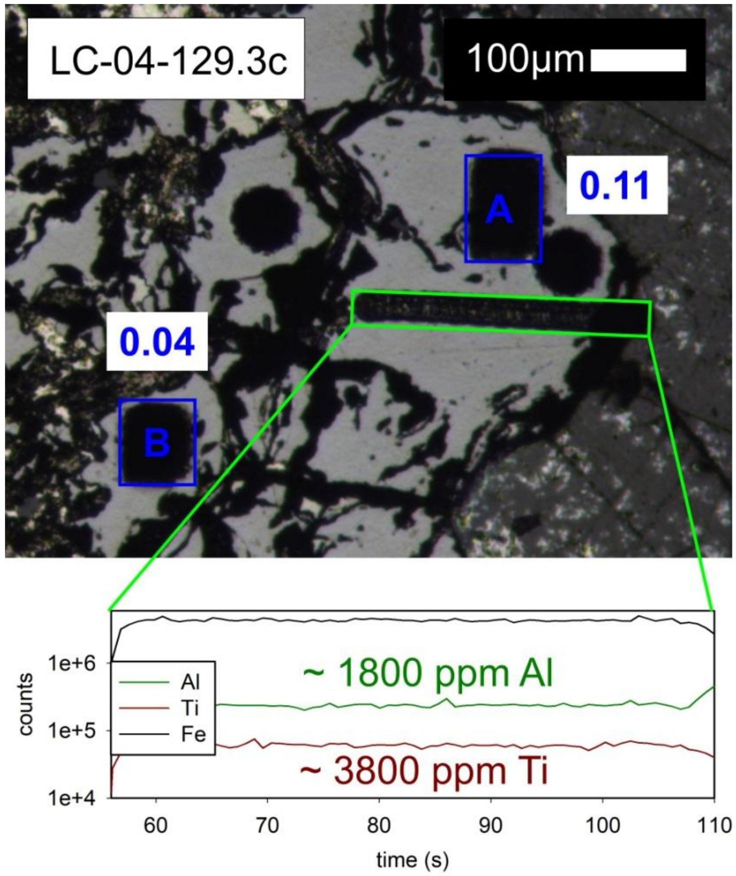

Fig. 6: Reflected light image of sample LC-04-129.3c including location of LA-ICP-MS trace element transect (highlighted in bright green) as well as location and values of in-situ δ^{56}Fe measurements (blue). Fe-isotope value of A was assigned to hydrothermal (blue) origin based on its relatively low Al and Ti concentration comparable to hydrothermal parts in shallower samples(LC-04-104.4c and LC-04-125.3e) and in contrast to an igneous sample of the same depth (LC-04-129.3d). The smooth texture and constant LA-ICP-MS trace element signal may also indicate a hydrothermal formation. The remaining raster spot B was also assigned as hydrothermal since its textural appearance correlate with raster spot A.

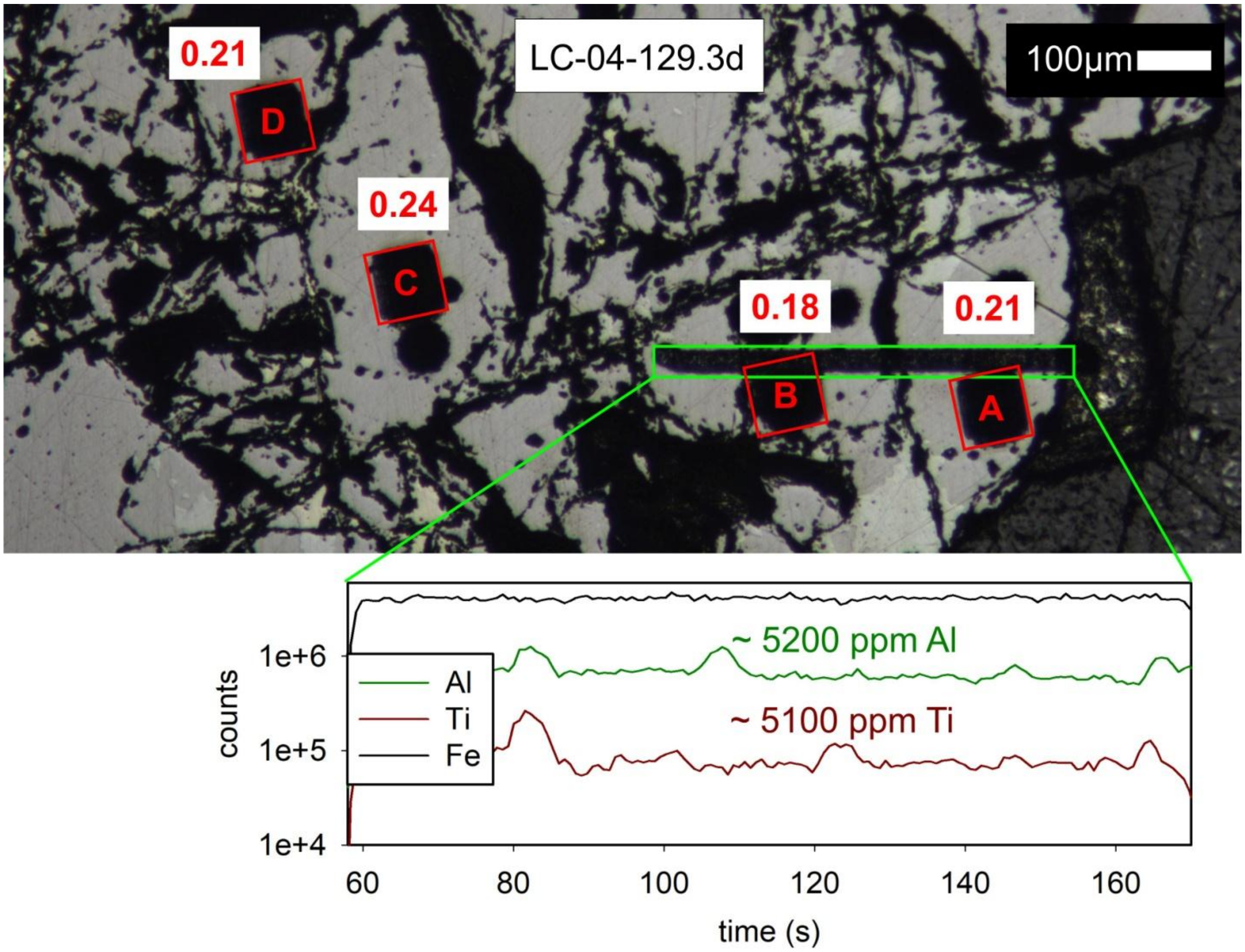

Fig. 7: Reflected light image of sample LC-04-129.3d including location of LA-ICP-MS trace element transect (highlighted in bright green) as well as location and values of in-situ δ^{56}Fe measurements (red). Fe-isotope value of A and B were assigned to igneous (red) origin based on their relatively high Al and Ti concentration in contrast to hydrothermal samples from the same depths (LC-04-129.3c and LC-04-129.3e). The remaining raster spots C and D were also assigned as igneous since their isotopic values as well as their textural appearance correlate with raster spot A and B.

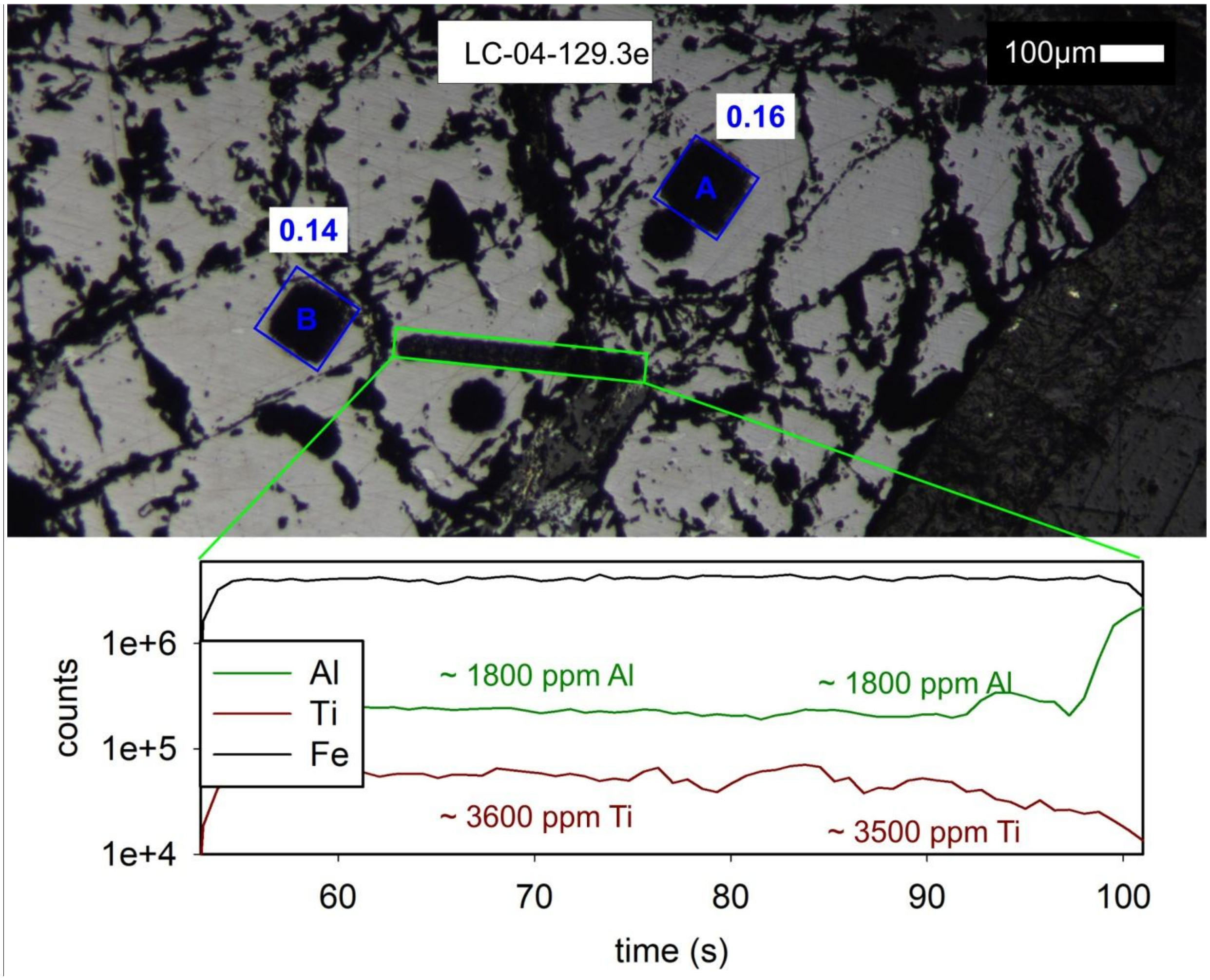

Fig. 8: Reflected light image of sample LC-04-129.3e including location of LA-ICP-MS trace element transect (highlighted in bright green) as well as location and values of in-situ δ^{56}Fe measurements (blue). Fe-isotope value of A and B were assigned to hydrothermal (blue) origin based on their relatively low Al and Ti concentration comparable to a hydrothermal sample (LC-04-129.3c) and in contrast to an igneous sample (LC-04-129.3d) from the same depths.

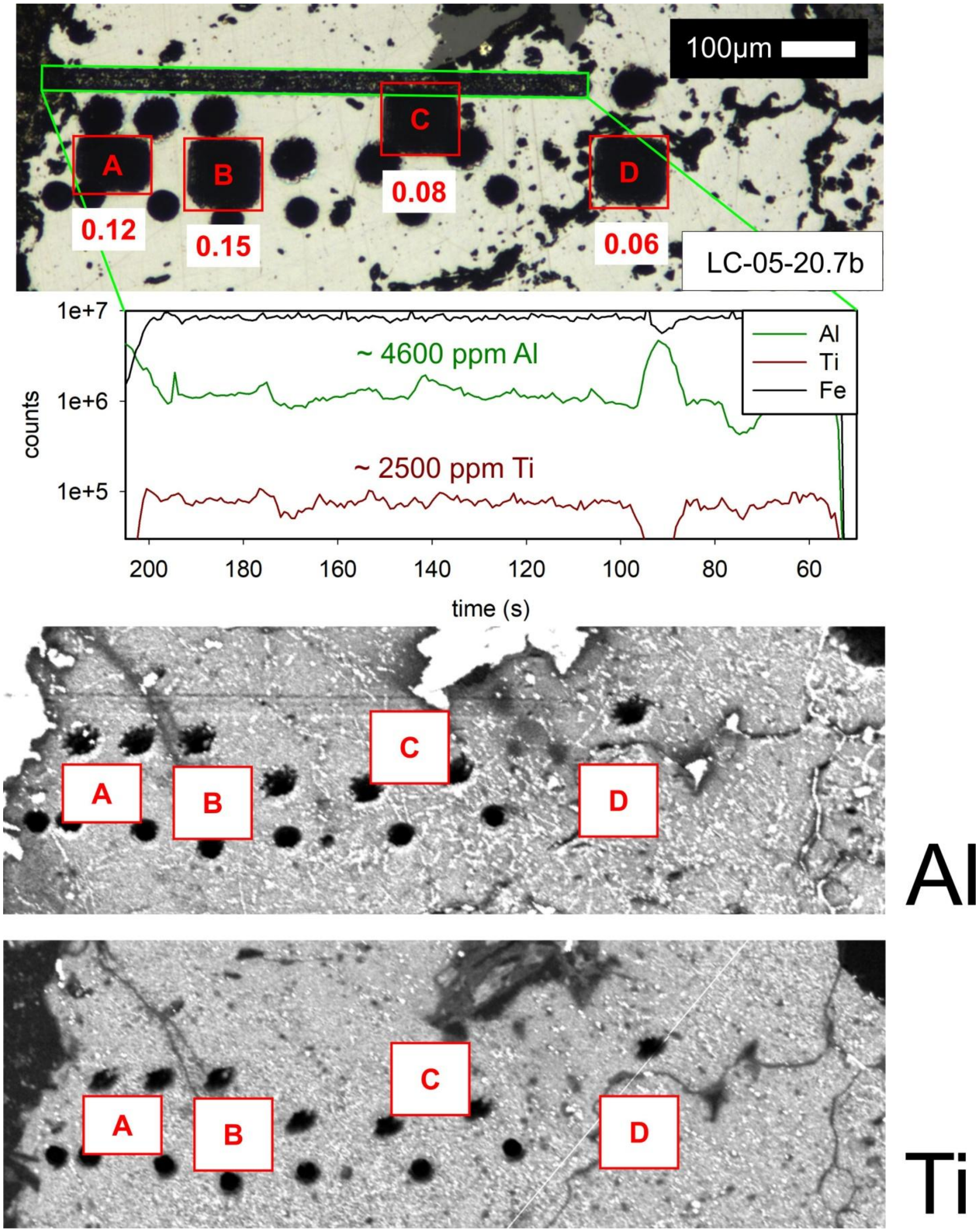

Fig. 9: Reflected light image of the shallowest sample of drill core LC-05 (LC-05-20.7b) including location of LA-ICP-MS trace element transect (highlighted in bright green) as well as location and values of in-situ δ^{56}Fe measurements (red). Fe-isotope value of A, B, C and D were assigned to igneous (red) origin based on their relatively high Al and Ti concentration comparable to igneous parts and in contrast to hydrothermal parts in the deeper sample LC-05-82.6a.

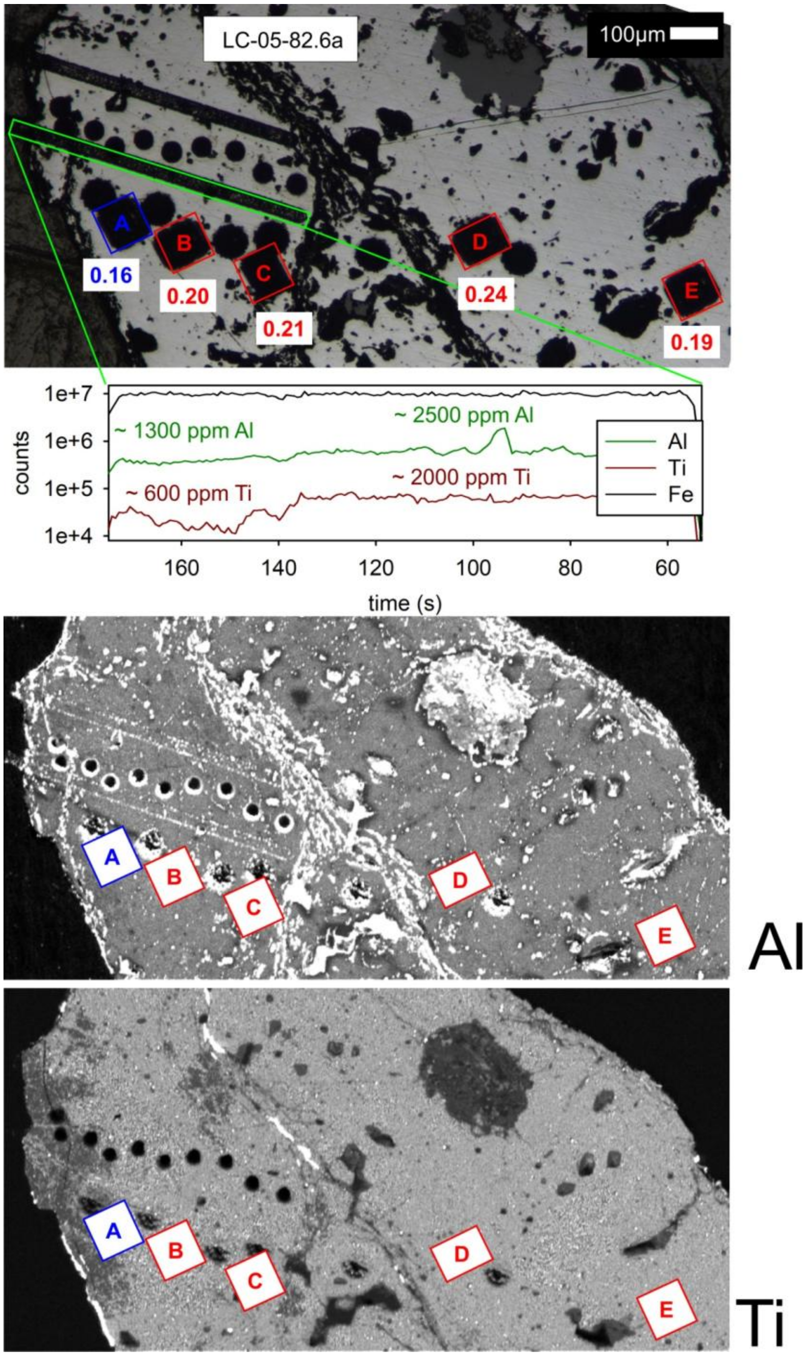

Fig. 10: Reflected light image of sample LC-05-82.6a including location of LA-ICP-MS trace element transect (highlighted in bright green) as well as location and values of in-situ δ^{56}Fe measurements (red or blue). Fe-isotope values were assigned to igneous (red) or hydrothermal origin (blue) based on measured trace element concentration (Ti and Al). A drop in Ti and Al between location B and A indicates a hydrothermal rim with relatively lower Al and Ti concentrations. This rim is also detectable in the Al and Ti elemental maps measured with EPMA (especially for Ti). Therefore, A was interpreted as hydrothermal, while B and C were interpreted as igneous magnetite. The remaining raster spots D and E were also assigned as igneous, since their isotopic value as well as their textural appearance correlate with the raster spots B and C.

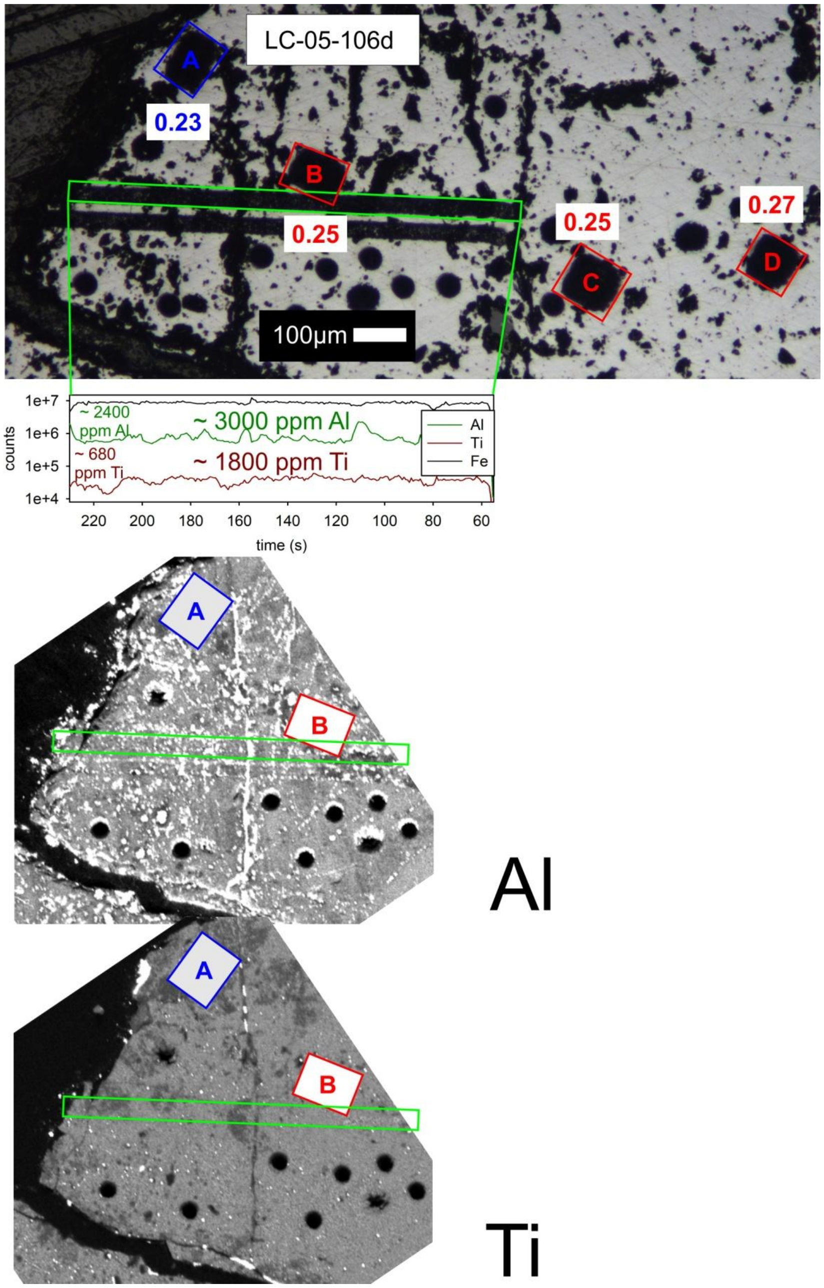

Fig. 11: Reflected light image of sample LC-05-106d including location of LA-ICP-MS trace element transect (highlighted in bright green) as well as location and values of in-situ $\delta^{56}Fe$ measurements (red or blue). Fe-isotope values were assigned to igneous (red) or hydrothermal origin (blue) based on measured trace element concentration (Ti and Al). A drop in Ti and Al between location B and A indicates a hydrothermal rim with relatively lower Al and Ti concentrations. This rim is also detectable in the Al and Ti elemental maps measured with EPMA (especially for Ti). Therefore, A was interpreted as hydrothermal, while B was interpreted as igneous magnetite. The remaining raster spots C and D were also assigned as igneous, since their isotopic values as well as their textural appearance correlate with the raster spot B.

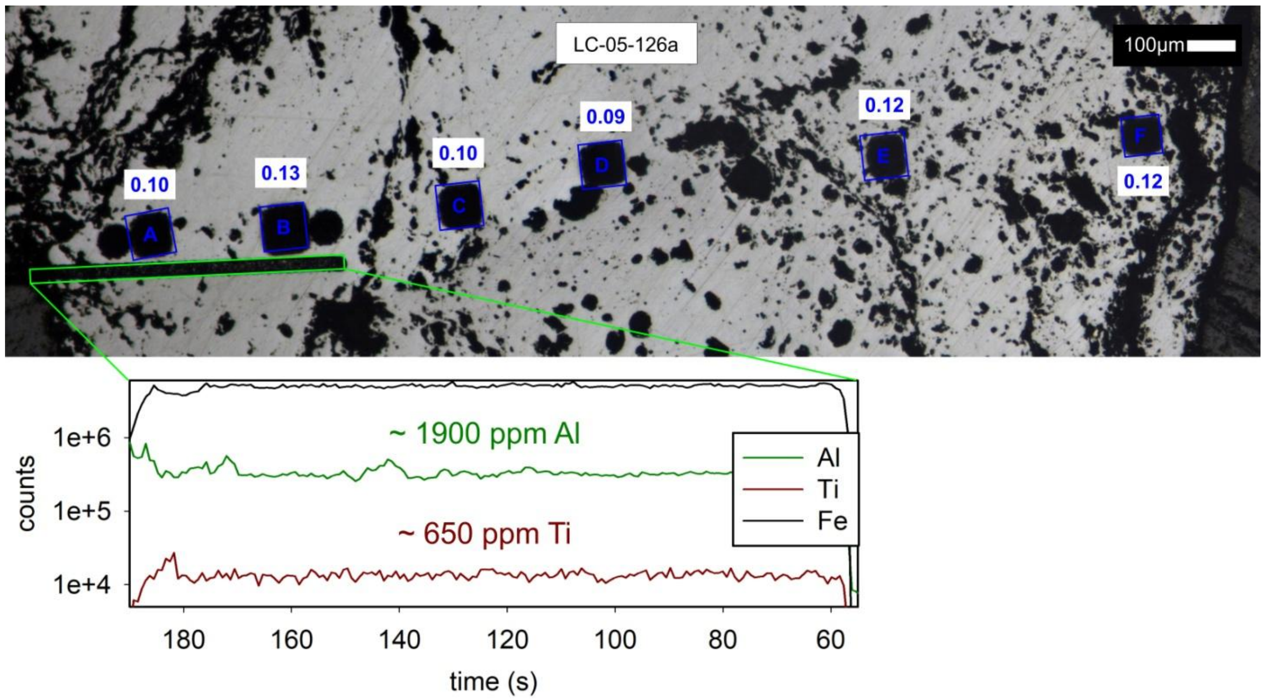

Fig. 12: Reflected light image of sample LC-05-126a including location of LA-ICP-MS trace element transect (highlighted in bright green) as well as location and values of in-situ δ^{56}Fe measurements (blue). Fe-isotope values of A and B were assigned to solely hydrothermal (blue) origin based on very low trace element concentration (Ti and Al) comparable to hydrothermal parts in the shallower samples (LC-05-82.6a and LC-05-106d) as well as a relatively smooth texture and LA-ICP-MS trace element signal. The remaining raster spots C, D, E and F were also assigned as hydrothermal, since their isotopic values correlate very good with the raster spots A and B.

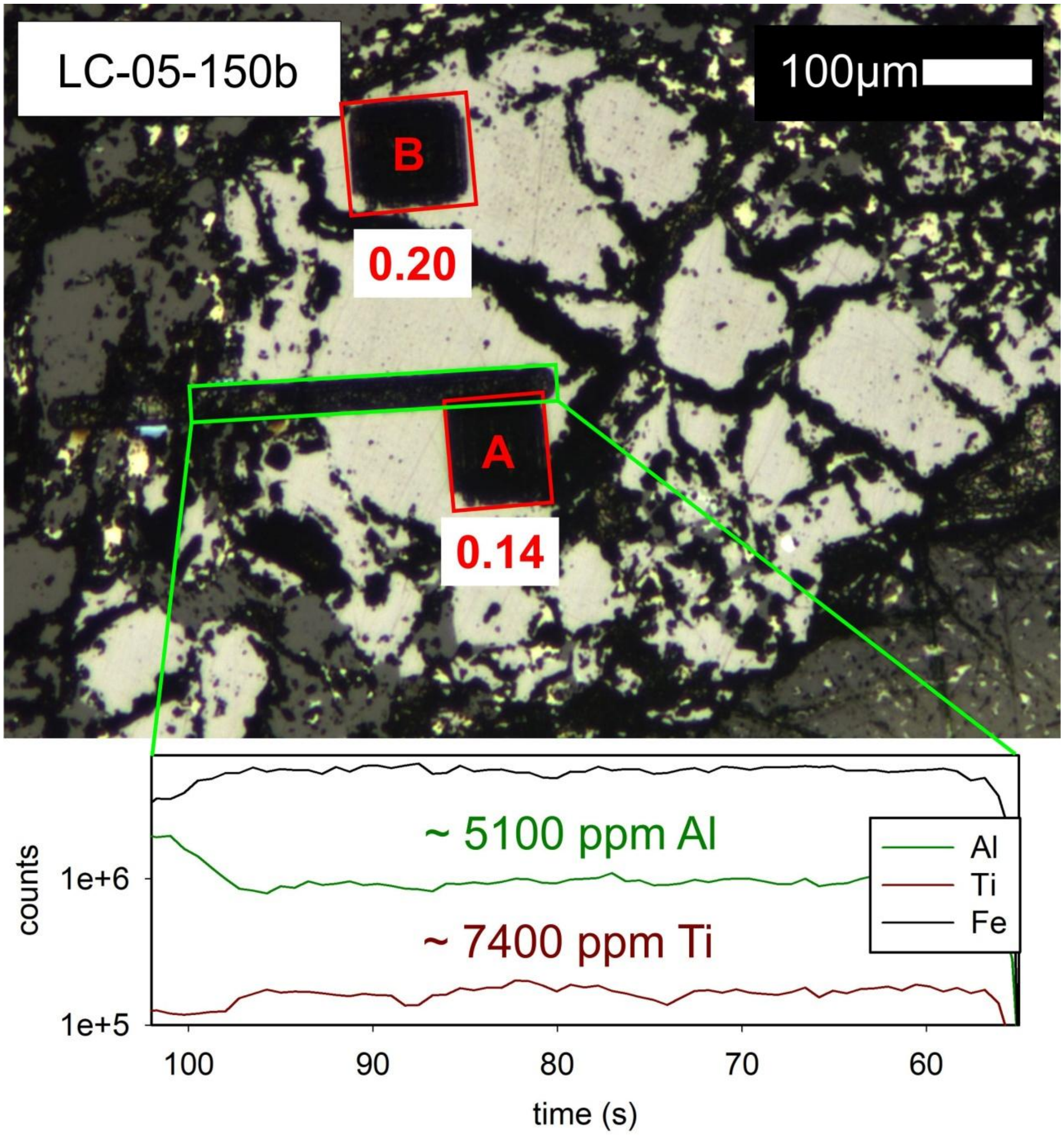

Fig. 13: Reflected light image of the deepest sample of drill core LC-05 (LC-05-150b) including location of LA-ICP-MS trace element transect (highlighted in bright green) as well as location and values of in-situ δ^{56}Fe measurements (red). Fe-isotope values of A and B were assigned to igneous (red) origin based on the highest measured Al and Ti concentration when compared to all other samples from Los Colorados.