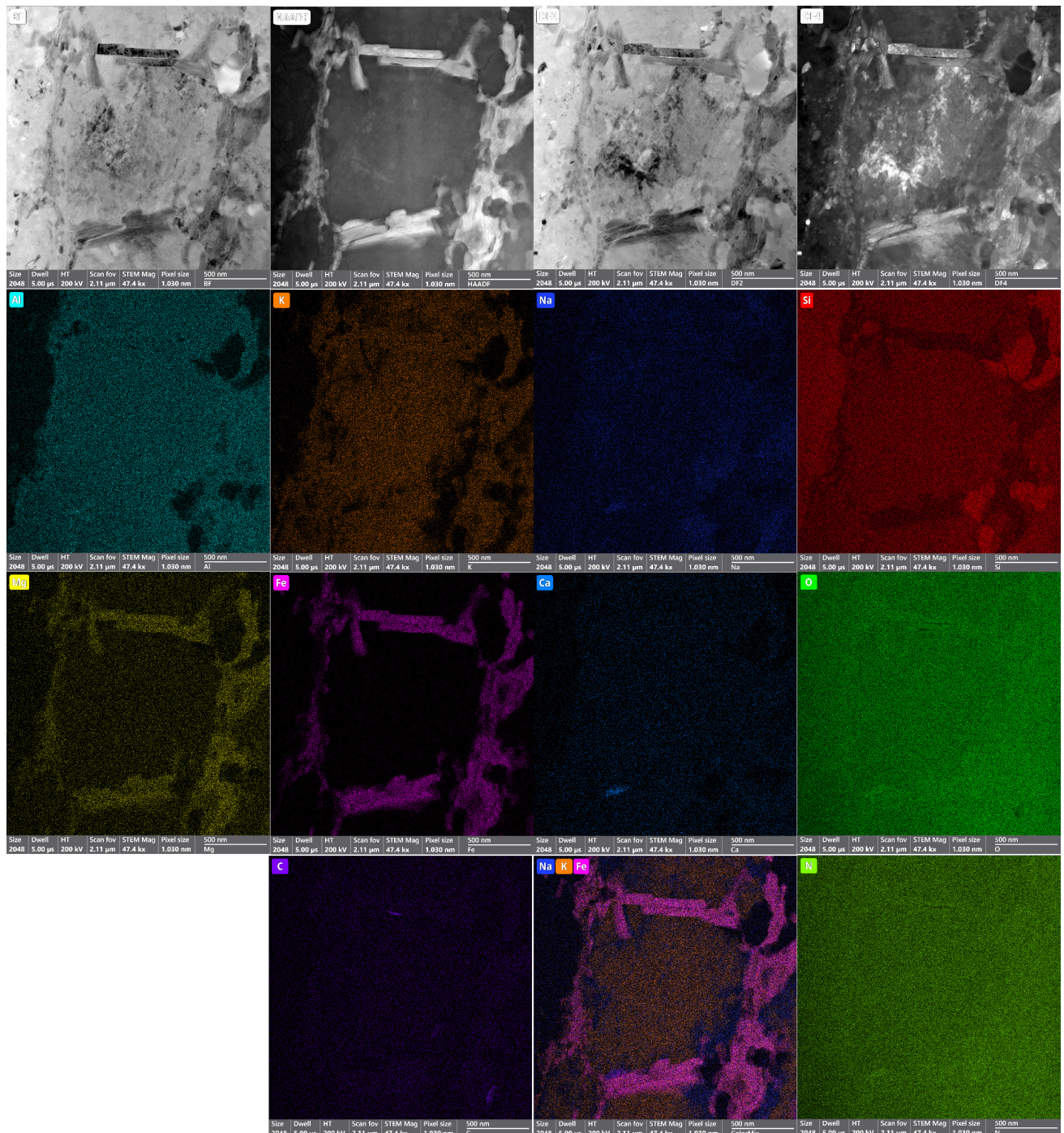
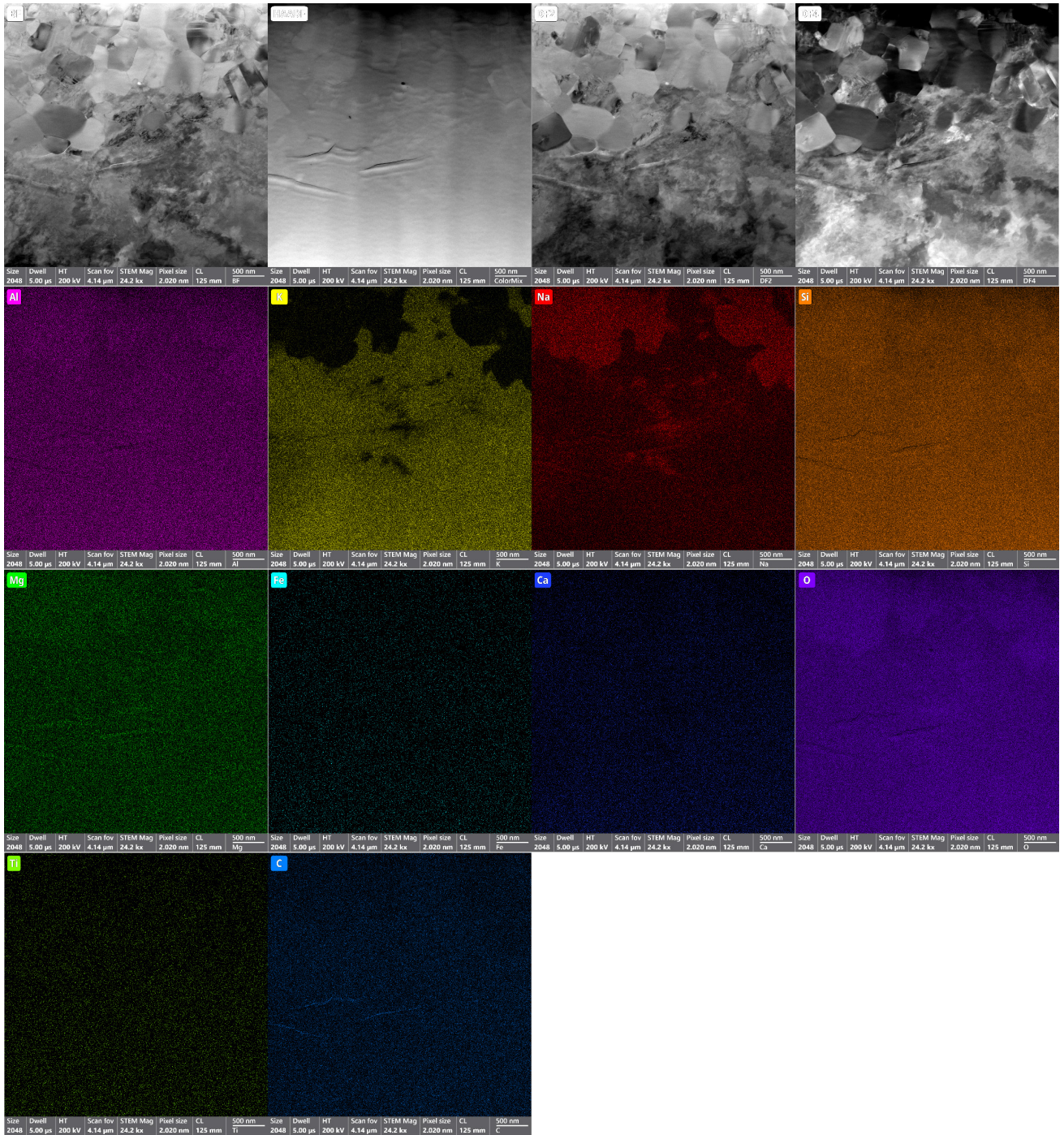
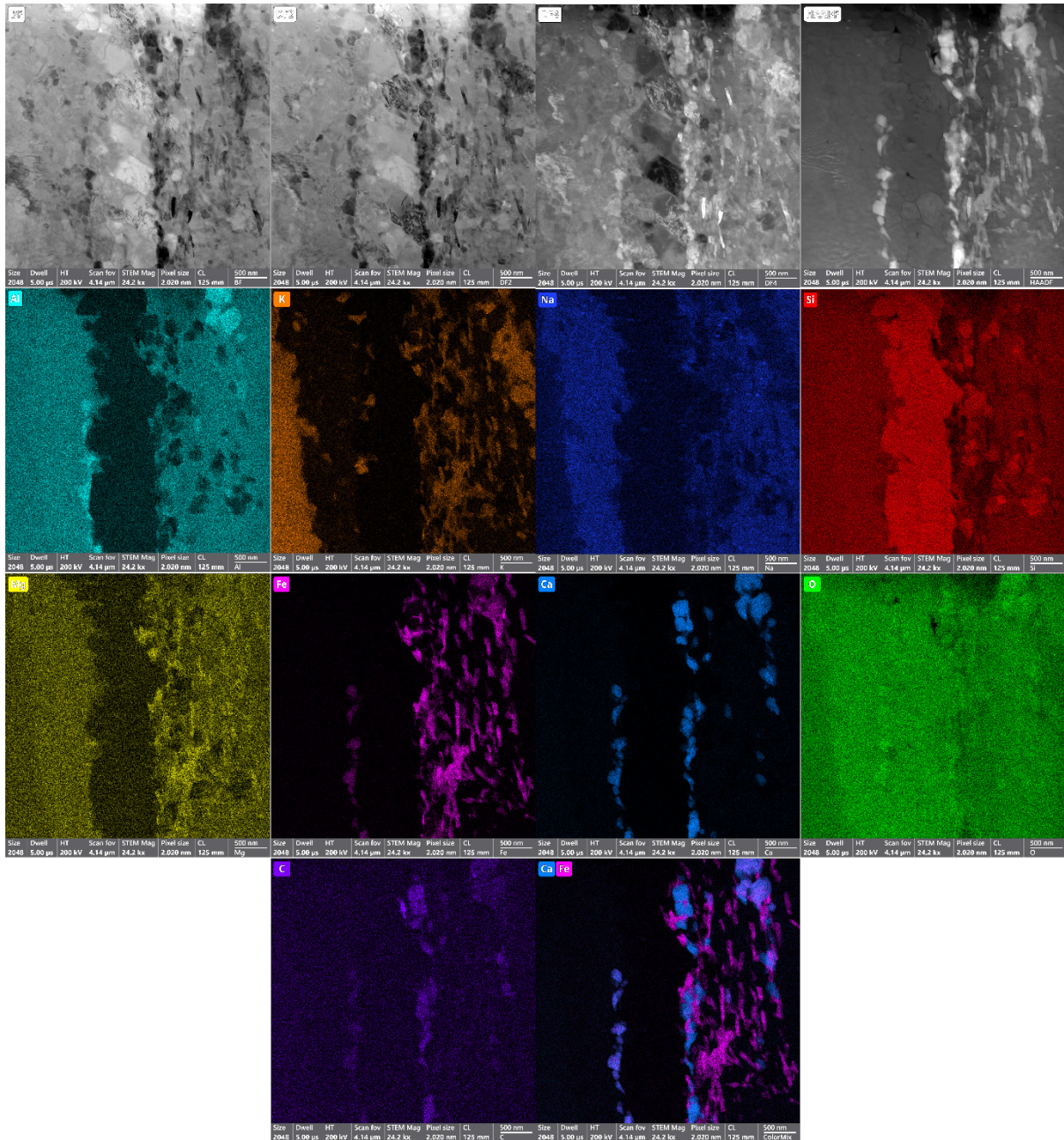
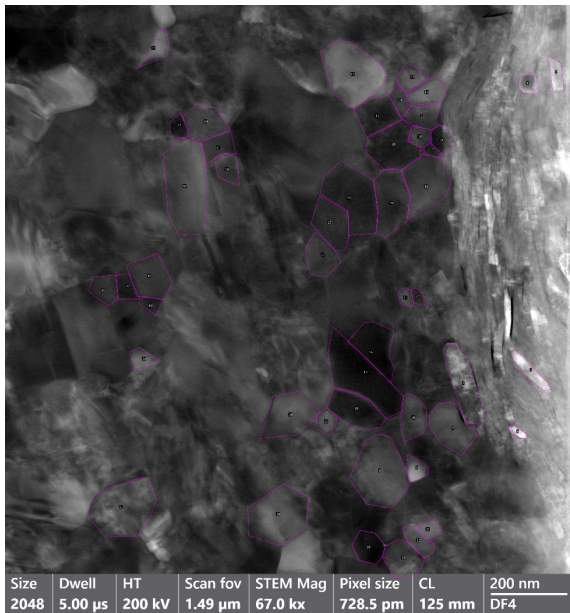
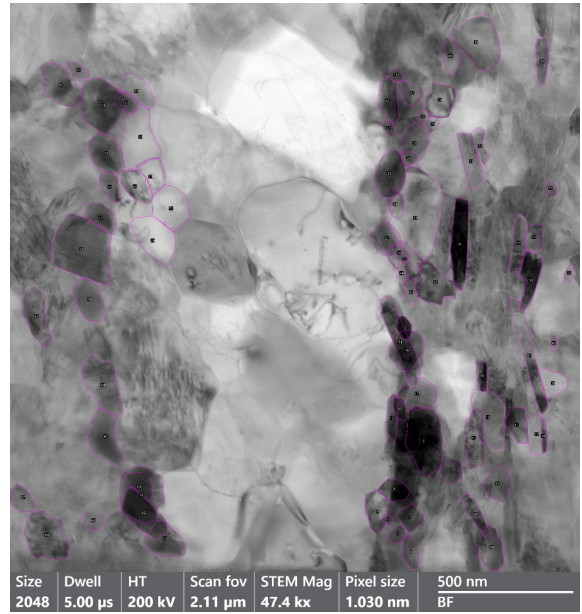
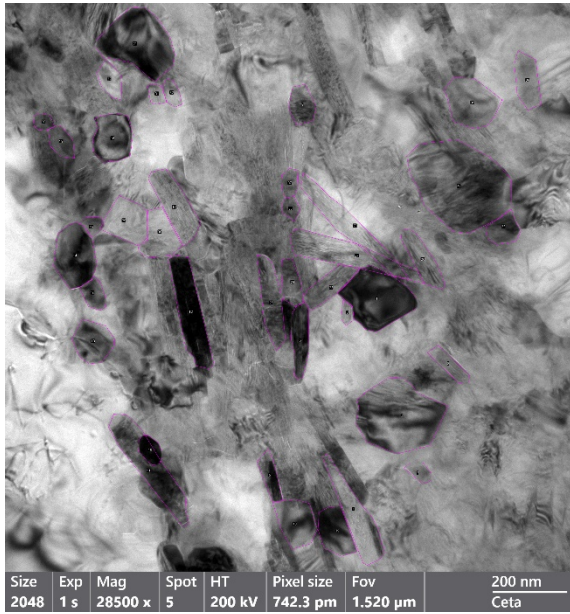
Supplementary for "Dissolution-precipitation creep in polymineralic granitoid shear zones in experiments part I: Strain localization mechanisms"

Supplementary 1:   TEM XRD maps used for interpretations

Supplementary Figure 1: STEM Map in foil 1 used for Fig. 6. Experiment No. 618NW, Type I with pre-fracture. Key observation is the chemical changes occurring to the K-fsp grain overgrown by biotite. Note that the K-fsp must be a primary grain, as it has inherited a high dislocation density.

Supplementary Figure 2: STEM Map used for Fig. 8. Experiment No. 670NW, Type II without pre-fracture. The chemical maps show that at the boundary of albite and K-feldspar, new equigranular grains with little dislocation density have formed. Furthermore, chemical changes of K-depletion and Na-enrichment occur to the primary K-feldspar grain.

Supplementary Figure 3: Additional chemical maps from STEM in sample 618NW (TEM foil location 1, as indicated in Fig. 6). This is an example, where a lense of coarser quartz is surrounded by fine-grained nucleated Ca- and Fe-rich minerals that nucleated during the experiment. Note also the alignment of elongated grains parallel to the shear zone orientation.

Size	Exp	Mag	Spot	HT	Pixel size	Fov		200 nm
2048	1 s	28500 x	5	200 kV	742.3 pm	1.520 µm		Ceta

Size	Dwell	HT	Scan fov	STEM Mag	Pixel size		500 nm
2048	5.00 µs	200 kV	2.11 µm	47.4 kx	1.030 nm		BF

Size	Dwell	HT	Scan fov	STEM Mag	Pixel size	CL	200 nm
2048	5.00 µs	200 kV	1.49 µm	67.0 kx	728.5 pm	125 mm	DF4

Supplementary Figure 4: Example STEM images for grain size analysis of medium to high strain samples, in experimental sample 618NW (TEM foil location 1, as indicated in Fig. 6).

Supplementary 2: Melt or no melt

Petrological (melting) experiments predict that granitic rocks may melt at 1.2 GPa and 650°C with the presence of water (Holtz, 2001). For melting to occur, a eutectic composition is necessary: quartz, albite, K-feldspar, and water in contact. In our experiments, it is rarely the case that all these components are in contact at a grain triple junction. No melt-pockets at such locations have been observed. Mostly, albite and K-feldspar are in contact, and the melting temperature of these feldspathic systems is higher (>700°C). Therefore, eutectic melting of the ultramylonite is excluded as it is not observed on the nanometer scale.

Several granitic studies reported melt or partially amorphous material in granitic systems, but mostly at higher P,T-conditions (Dell`Angelo et al., 1987; Dell'Angelo and Tullis, 1988; Pec et al., 2016; Pec and Al Nasser, 2021). There are several reasons why in our samples melt was not detected and has no influence on the strength or microstructural evolution. As in, e.g., Young et al. (2022), recrystallized pseudotachylites are distinguished from ultramylonites by 12 criteria (Young et al., 2022), none of which are observed in our experiments. On the contrary, all the grains are crystalline and show typical ultramylonitic microstructures down to 10´s of nanometers, as has been confirmed through TEM imaging (Figs. 6, 8). Not even partially amorphous material was identified (as in Pec et al., 2016; Pec and Al Nasser, 2021). The only amorphous grain boundaries that were observed in TEM images (in supplementary) occurred post deformation during imaging by beam amorphization. The main reason why amorphous material is absent in our samples is most likely given by the far lower differential stresses in our experiments compared to those by Pec (2016) and Al Nasser, (2021). The mechanical amorphization is favored by high stresses.

Additionally, an additional experiment was performed with an increased added H_2O amount of 0.5wt% (exp. 654NN, Appendix Table in PhD Thesis Nevskaya, 2024). Theoretically, the increased H_2O amount should have increased the melt content, making it easier to see. Also here, no evidence for melt was found after thorough SEM-investigations.

The absence of melt is in agreement with other deformation experiments on granitoid rocks at similar P,T-conditions, where no melt has been documented (Tullis, 2002; Tullis et al., 1990). Even if there were melt pockets that were overseen during high resolution and high magnification imaging, there is no evidence for throughgoing melt films that would influence the rheology significantly. We cannot exclude melt in an initial stage, which could have been produced by local stress concentrations but crystallized instantly due to its kinetics. Even if this kind of melt has been produced, it would crystallize as soon as there is a slight stress drop and would not influence the deformation. Therefore, we do not consider any influence of melt on our experimental observations.