Particle size distributions in Earth Sciences: a review of techniques and a new procedure to match 2D and 3D analyses

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Supplementary material 1: Standard operating procedures for laser granulometry analysis

All grain size analyses were performed using a Mastersizer 3000 (Malvern Panalytical) optical granulometer, coupled with an Aero S analysis unit, using air as dispersant medium. For the analyzed samples, analyses were repeated on 5 different sample aliquots to provide an average grain size distribution curve, mean particle diameter, and associated standard deviation. The adoption of air instead of liquid dispersants allowed to minimize sample alteration during the analysis. To further reduce the chance to have biased analyses related to sample alteration, we performed several tests to identify the correct analytical-instrumental parameters to be used during the final sample analysis. All tests were made in compliance with the workflow methodology proposed by Storti and Balsamo (2010). The operated tests were aimed to define the correct granular sample amount to be analyzed (and related laser obscuration), the negative air pressure applied to the sample, and the feed rate of the sample hooper-holder. All these parameters are discussed below and are summarized in Table S1:

1- The sample amount plays a key role in defining the correct grain size distribution. Before the analysis, all samples were spit in smaller sub-samples from the initial total amount (~500 g) through riffler splitters. This procedure allowed to gain sub-samples representative of the original grain size. We adjusted the sample quantity according to the detected laser obscuration. In particular, the laser power must be reduced in an interval from 0.1 to 15% of

the initial intensity due to flowing granular material inside the analysis cell. This guarantees the optimal calculation of particle volume through laser diffraction technique (Mie diffraction theory). In our analyses, the laser obscuration ranged from 0.64 to 2.84%. To attain such laser obscuration values, sample quantities comprised from 0.84 to 1.27 g were used per each analysis and test (table S1).

2- The negative air pressure applied to the sample may vary between 0.1 and 4 bar and is necessary to carry the granular materials inside the analysis cell. Air pressure must be set cautiously according to sample mineralogical composition and overall resistance. In the case of relatively weak samples, high air pressure values may induce severe fragmentation due to high energy impacts between particles. At the same time, high negative air pressure can be useful to break particle aggregates and to analyze their constitutive elementary particles. In our samples we set the air pressure to the maximum (4.0 bar) for LIM1 and PAR1 samples, while it was lowered down to 2.0 bar in PAR2 and to the minimum (0.1 bar) in PES1 and ACQ1 samples, which are mechanically weaker (table S1).

3- The feed rate of the sample holder modulates the initial flow of the sample, thus influencing the laser obscuration and the duration of the analysis. Sample feed in the analysis cell is provided by vibration of the steel sample holder. It must be adjusted to achieve a smooth and continuous flow of granular materials inside the analysis cell. In our case, we set the feed rate to 30% of the maximum intensity (table S1).

Table S1: Summary of analytical parameters adopted in laser granulometry analyses

Sample name	Sample weight (g)	Laser obscuration (%)	Air-pressure (bar)	Feed rate (%)
LIM1	0.98-1.05	0.64-0.75	4	30
PAR1	1.16-1.23	1.73-1.88	4	30
PAR2	1.21-1-27	1.69-1.79	2	30
PES1	0.98-1.08	1.29-3.02	0.1	30
ACQ1	0.84-0.94	2.57-2.84	0.1	30

Table S1: Summary of the analytical-instrumental parameters adopted in air-dispersed laser granulometry analysis.

Supplementary material 2: XRD diffraction patterns of analyzed sand samples
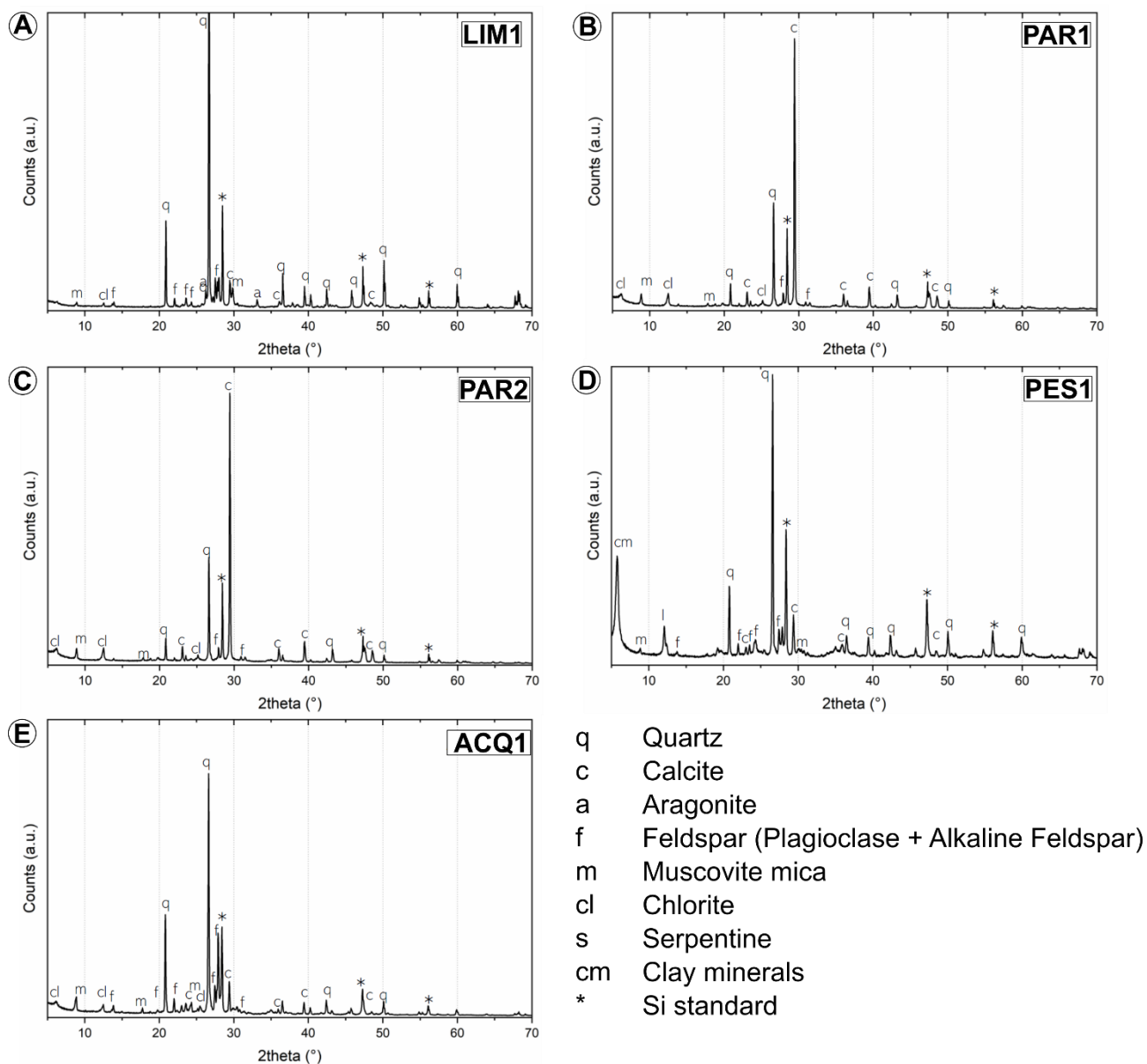
Fig. S1: Diffraction patters obtained from the analyzed sample powders with identification of principal mineralogical components from peak position. (**a**) LIM1 beach sample. (**b**) PAR1 base of fluvial sand bar. (**c**) PAR2 top of fluvial sand bar. (**d**) PES1 fluvial-reworked talus debris. (**e**) ACQ1 fluvial-deltaic sandstone.

Supplementary material 3: Detailed original and manually traced thin section scans.

We hereafter provide full-scale photomosaics (both original and binary) of thin sections shown in Fig.11 in the main text.

Fig. S2: Plane-polarized light photomosaic of LIM1 beach sample.
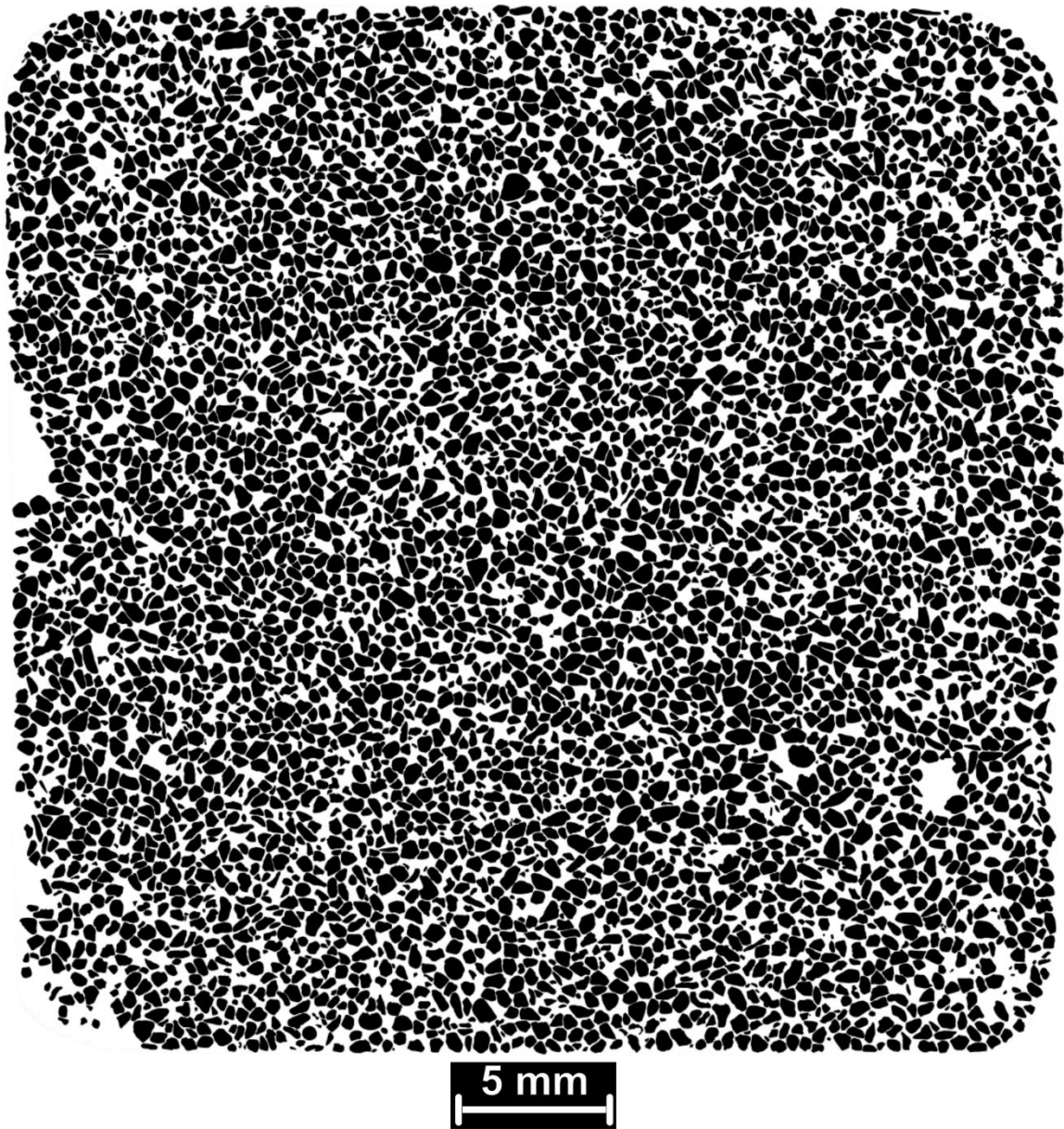
Fig. S3: Binary (black clasts on white background) photomosaic of LIM1 beach sample after manual digitization of clasts through ImageJ software.
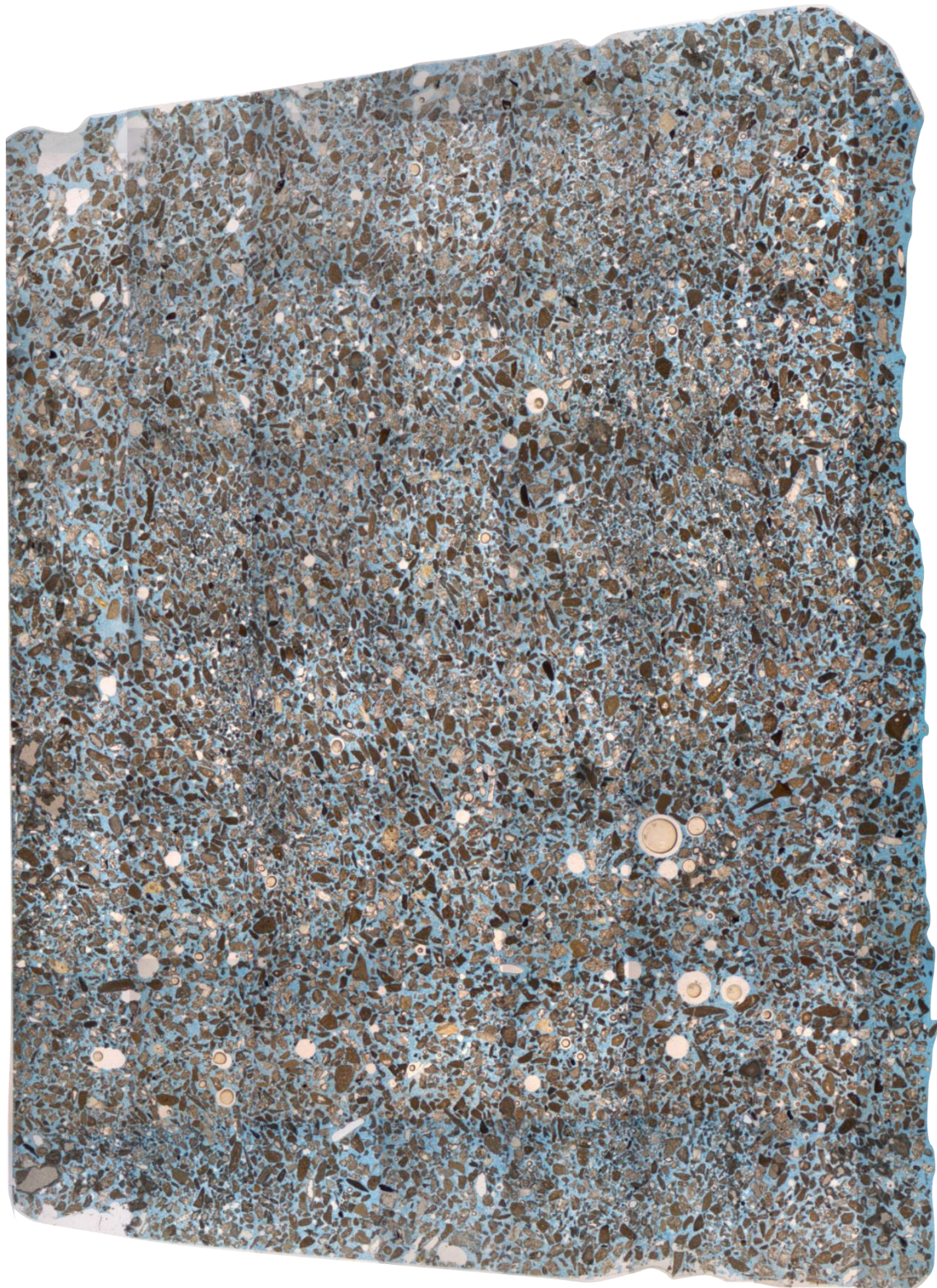
Fig. S4: Plane-polarized light photomosaic of PAR1 from the bottom of a fluvial sand bar.
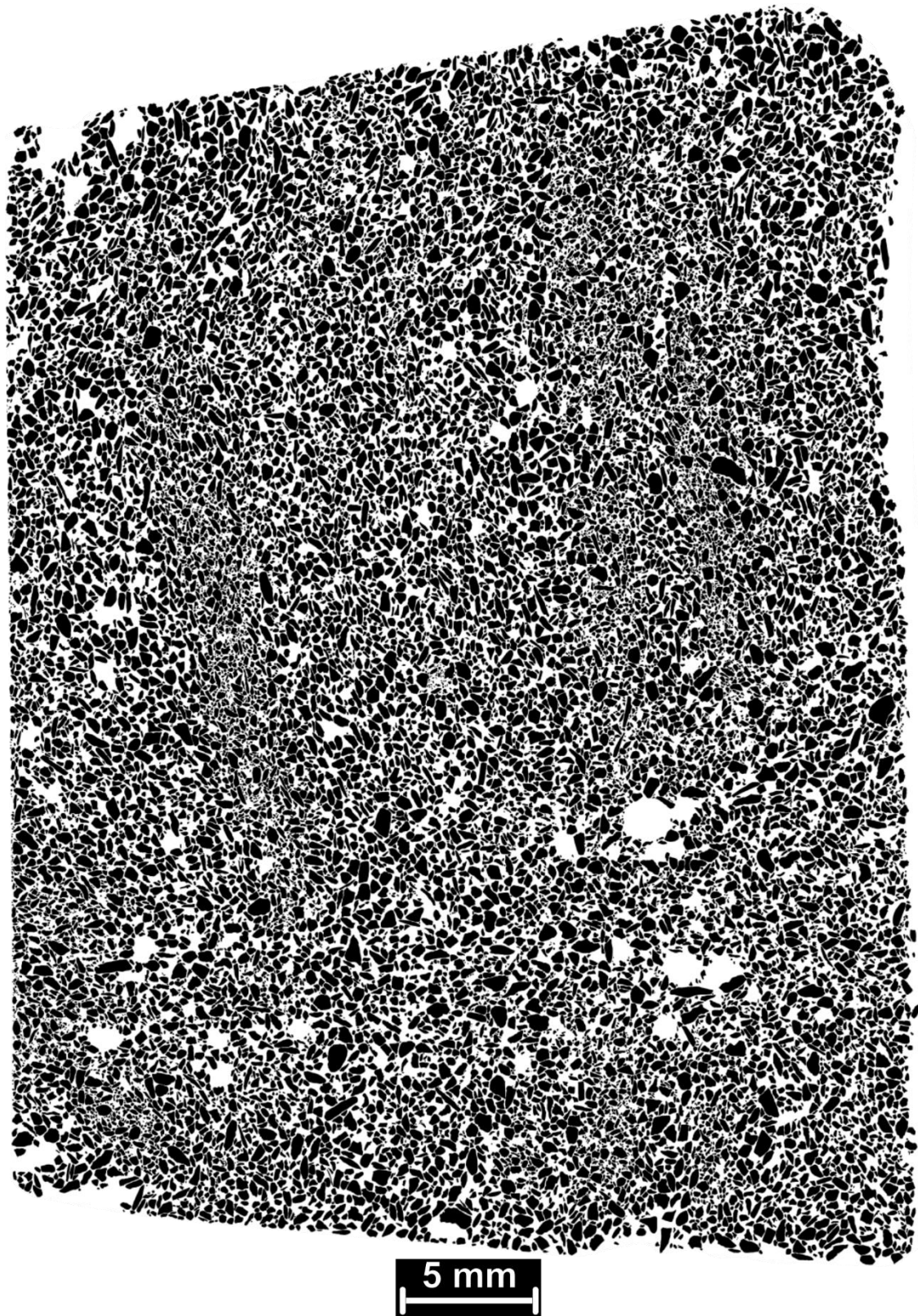
Fig. S5: Binary (black clasts on white background) photomosaic of PAR1 fluvial sand sample after manual digitization of clasts through ImageJ software.

Fig. S6: Plane-polarized light photomosaic of PAR2 from the top of a fluvial sand bar.
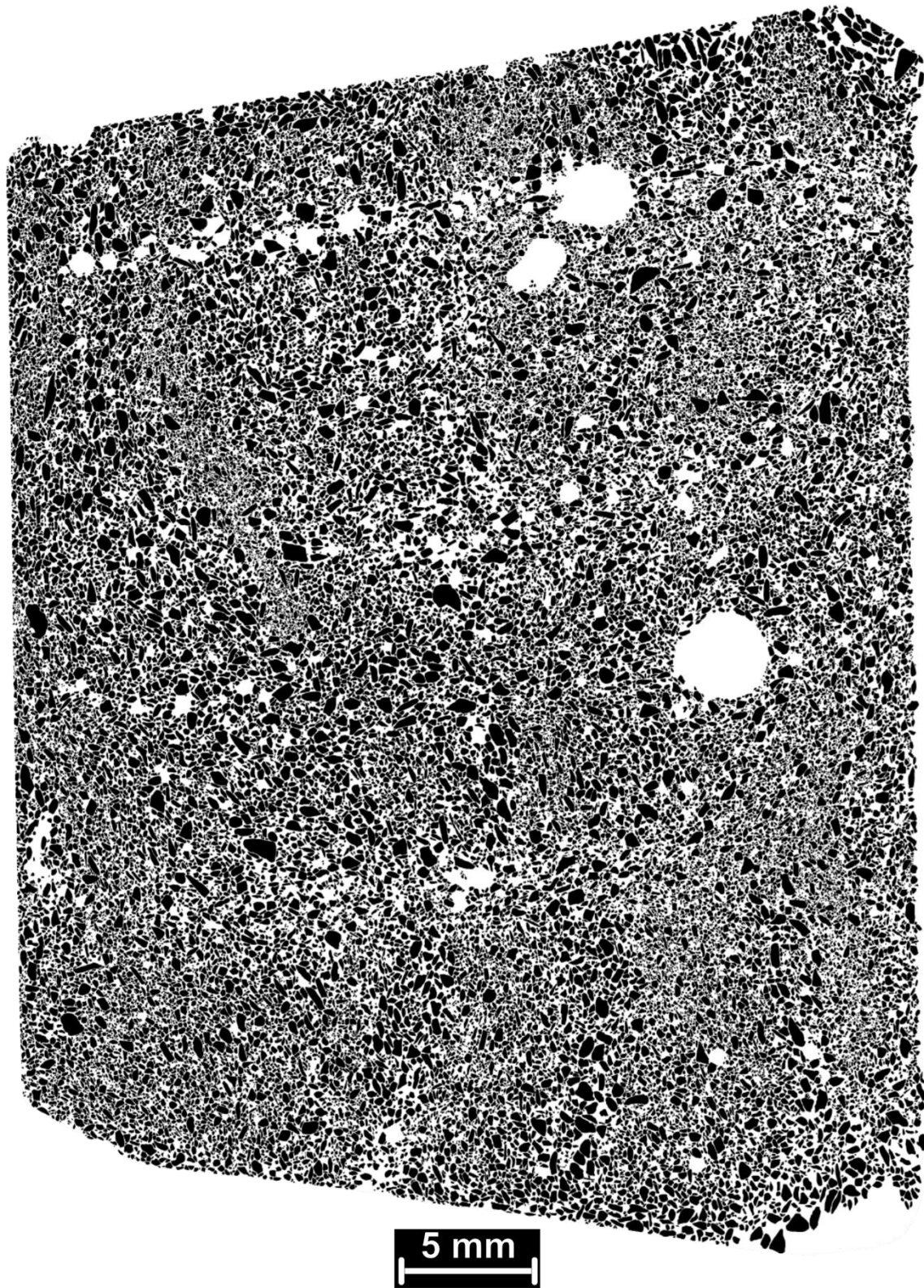
Fig. S7: Binary (black clasts on white background) photomosaic of PAR2 fluvial sand sample after manual digitization of clasts through ImageJ software.
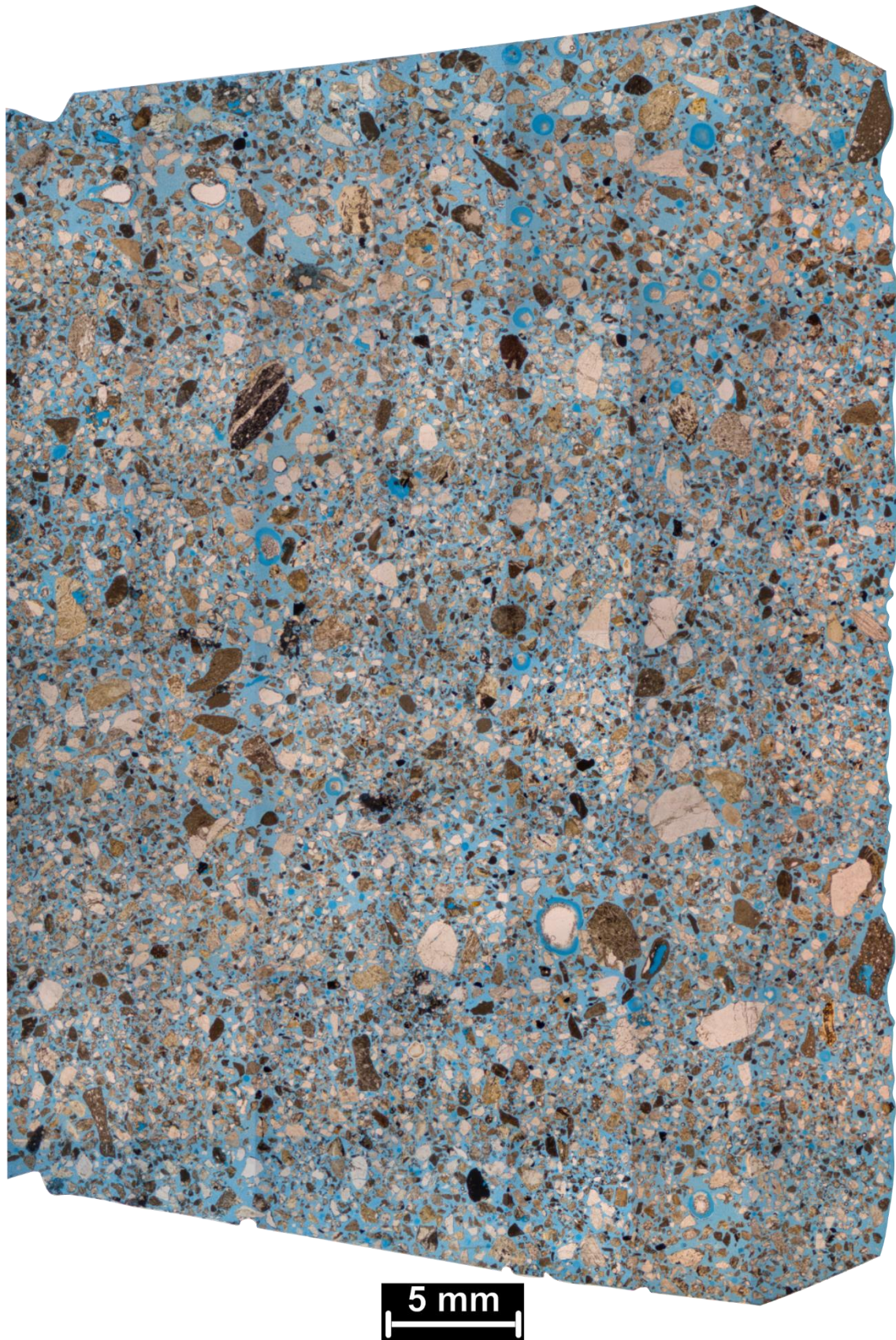
Fig. S8: Plane-polarized light photomosaic of PES1 from fluvial reworked talus debris.
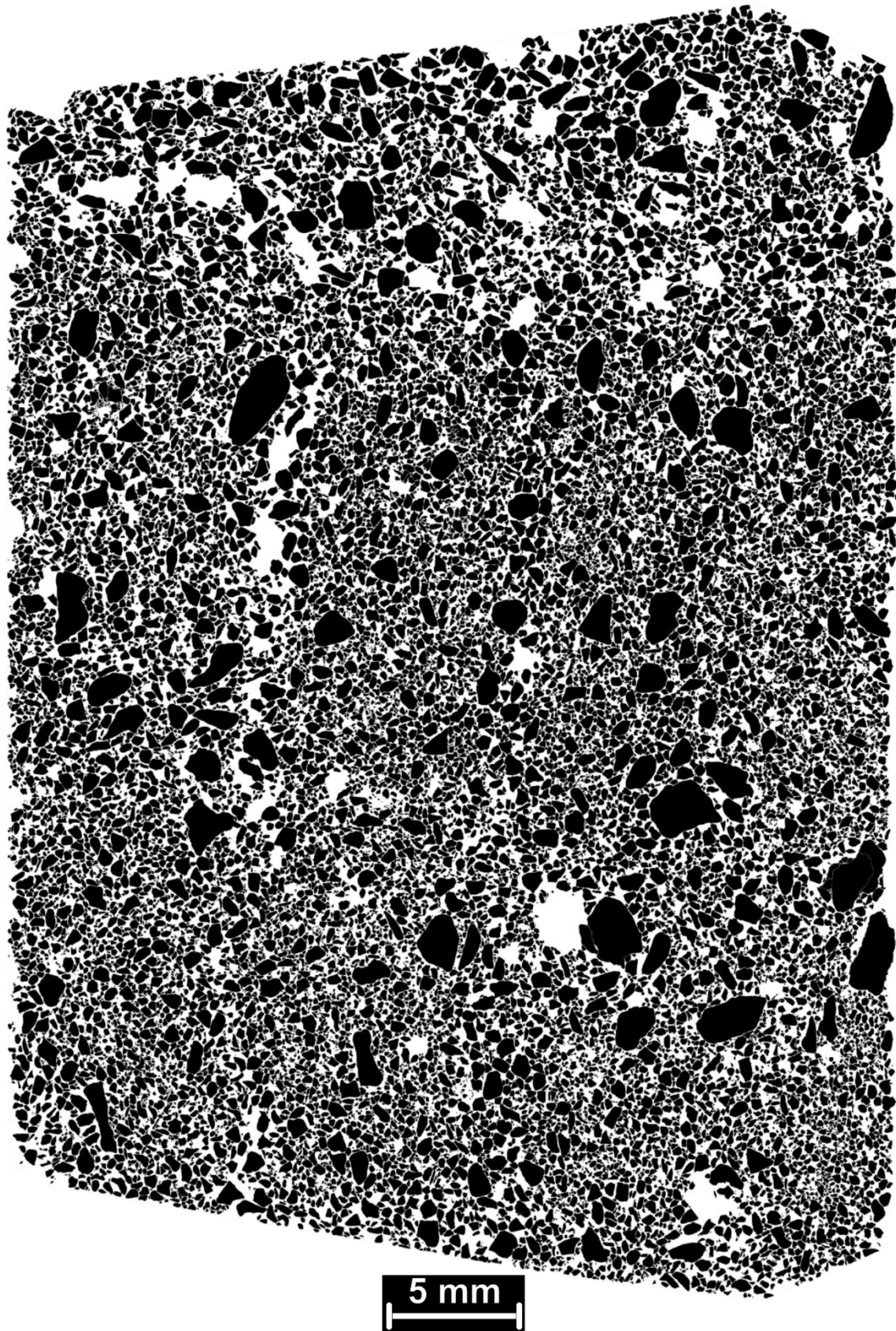
Fig. S9: Binary (black clasts on white background) photomosaic of PES1 fluvial-reworked talus debris sand sample after manual digitization of clasts through ImageJ software.
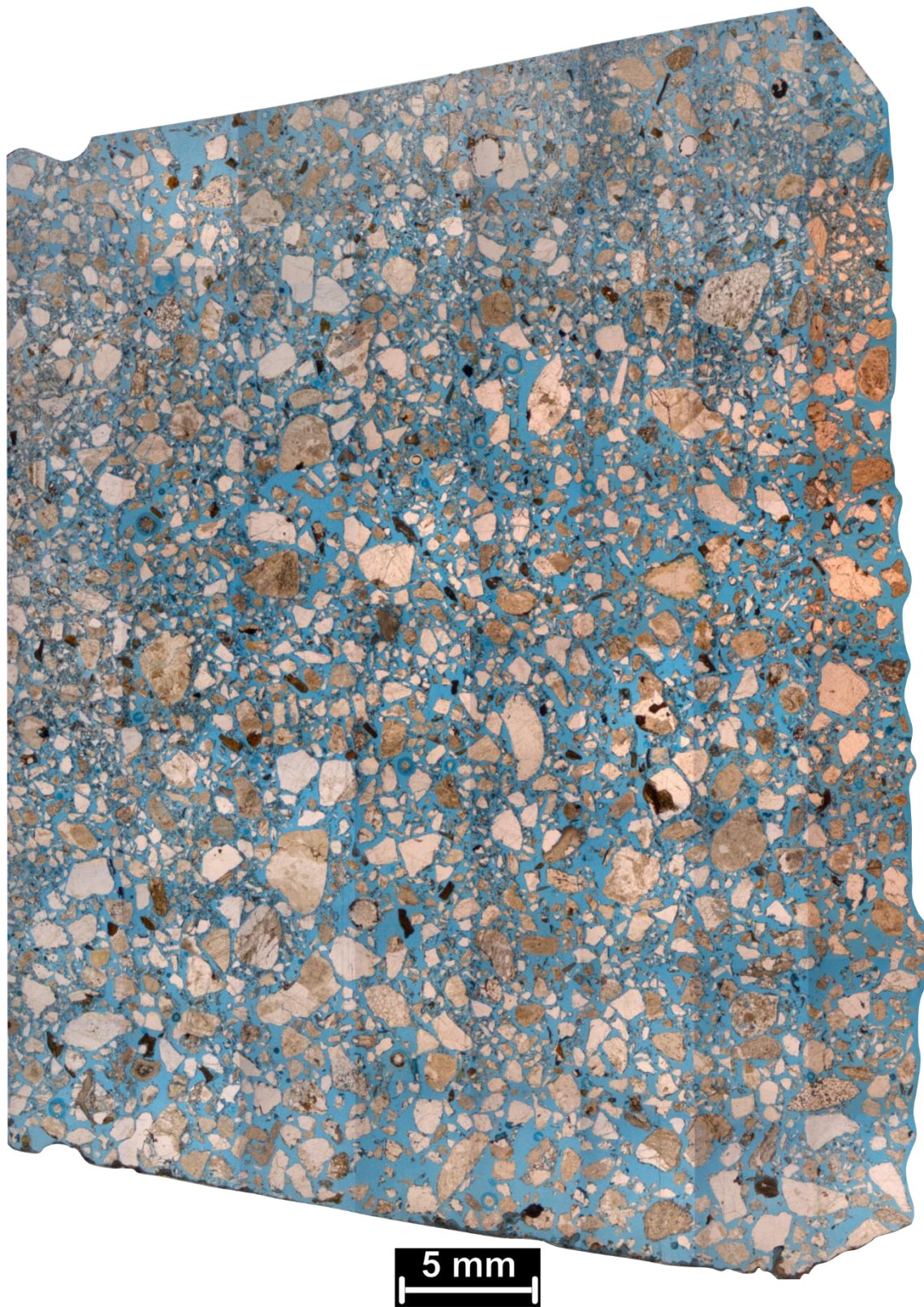
Fig. S10: Plane-polarized light photomosaic of ACQ1 fluvial-deltaic sandstone.
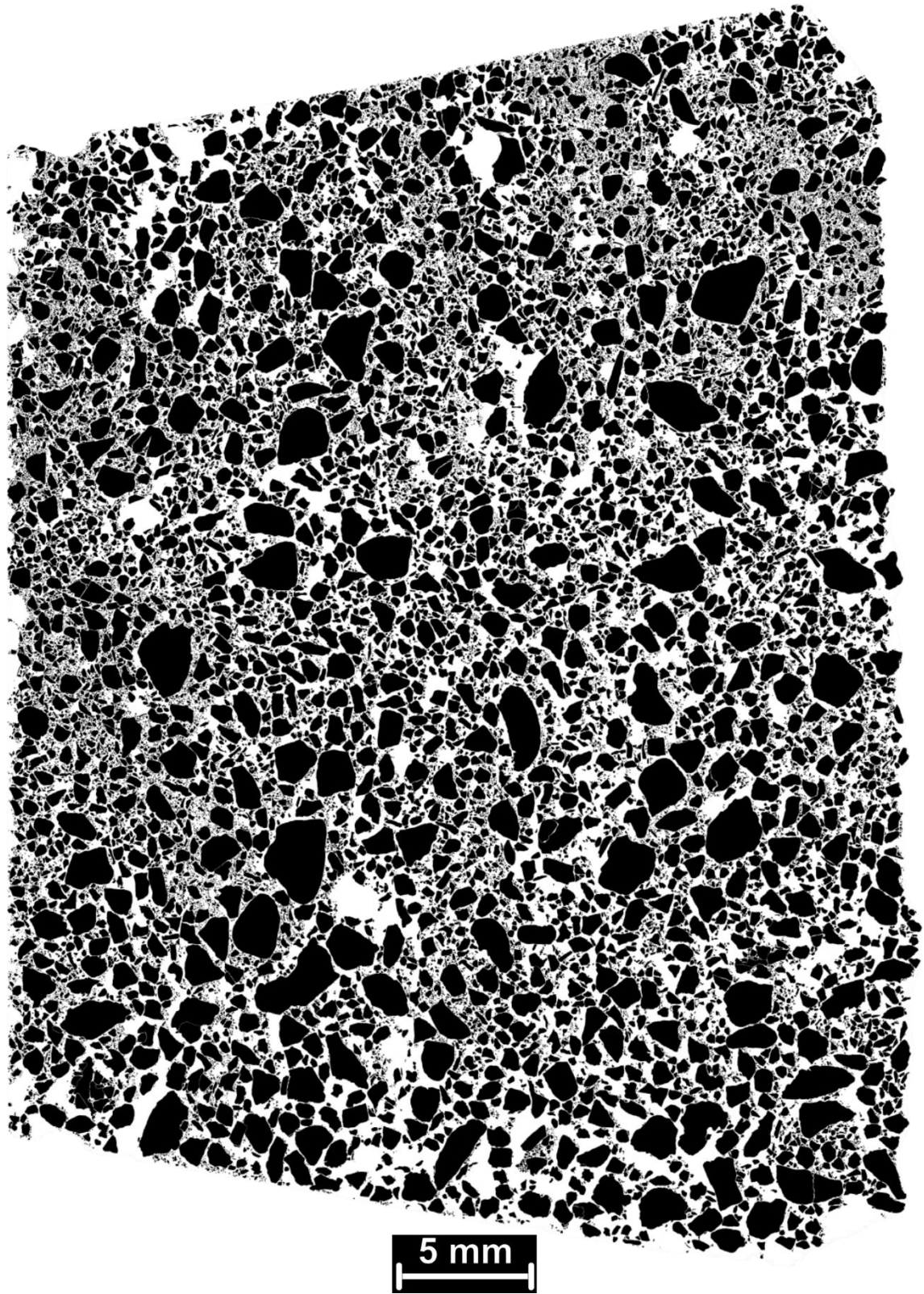
Fig. S11: Binary (black clasts on white background) photomosaic of ACQ1 fluvial-deltaic sandstone sand sample after manual digitization of clasts through ImageJ software.

References cited

Storti, F., Balsamo, F., 2010. Particle size distributions by laser diffraction: sensitivity of granular matter strength to analytical operating procedures. Solid Earth 1, 25–48. https://doi.org/10.5194/se-1-25-2010