Computed X-ray tomography data in multiple linear regression analysis on tight rocks for permeability estimation

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Abstract. Kozeny presents one of the most useful relations between the permeability, porosity and specific surface area, assuming that the rock consists of a bundle of straight capillary tubes (porosity) and cement. But what if tight sandstone or limestone is the object of the interest? The assumption for Kozeny equation is not valid. Researches are still looking for the new equations to obtain permeability in not invasive way: by calculation or using fluid flow simulations. In the paper the equation for permeability estimation was presented based on computed X-ray tomography (CT) data and multiple linear regression analysis (MLR). Usually, most of the parameters, as SVgr in Kozeny equation, were calculated from capillary data or petrographic image analysis. Combination of high resolution laboratory technique as CT and statistical method allowed determining equation for permeability in tight reservoirs. Analysis was carried out on 60 samples of tight (low porosity and low permeability) sandstones, mudstones, limestones and dolomites (unconventional reservoirs) to get representative, general equation, free from lithology influence. Firstly, CT images for each sample were analysed quantitatively. Following parameters were calculated for objects (pores) in each sample: volume, surface area, equivalent diameter, maximum, minimum, mean, standard deviation of thickness, anisotropy, elongation, flatness, Euler number, minimum, maximum of Feret diameter, Feret Breadth, Feret Shape, ShapeVa3D, moments of inertia: I1, I2, I3, sphericity and combinations of this parameters. Summarizing, for the statistical analysis 291 parameters from CT images of pore space were analysed in each sample. In each sample analysis of: maximum, minimum, average, standard deviation, median, percentile 10, percentile 90, lower quartile, upper quartile values were carried out on all objects (pores), e.g. calculation of average value of thickness mean on all objects in the samples. Additionally, extraction of all parameters for the largest object in the sample was also made. Next, data sets for all samples, consisted of one statistical parameters and all available parameters from CT were prepared for linear correlation and MLR analysis. MLR provided the equation for permeability estimation using following parameters: Feret breadth/volume, flatness/anisotropy (from upper quartile), maximum Feret diameter/flatness, moments of inertia around middle principal axis/moments of inertia around longest principal axis, anisotropy/flatness, flatness/anisotropy (percentile 90). MLR correlation coefficient for permeability equation was 0.82, while determination coefficient was equal to 0.67. Results of MLR were compared with results of pulse and pressure decay permeability measurements on all core samples.