Summary

Natural hydraulic lime and natural cement have been used in the building industry for centuries. These inorganic hydraulic binders are called “traditional” or “alternative” because they can, in some cases, substitute modern Portland cement. The recent increased interest in these binders is due not only to their use in restoration practices, but also because their production and use is less energetically demanding than in modern cements.

Historically, many types of hydraulic binders were produced in the regions of Bohemia and Moravia. However, much information has been lost about their manufacturing process, which raw materials were used, and we are uncertain of the exact character and properties of the burned material.

To date, studies have only addressed the impact of the chemical composition of raw material on the parameters of the burned material – all this is well known for Portland cement, much less for other types of hydraulic binders.

The aim of this dissertation was to study the various types of raw materials (limestone containing non-carbon admixtures) and to understand the characteristics of their respective hydraulic lime and natural cement. This was done by analyzing the impact of conditions (highest achieved burning temperature and time of burning) and the mineral and chemical composition of the primary raw materials on the formation of new phase compositions.

Therefore, this study used detailed mineralogical, petrographic and chemical analyses, putting special emphasis on detailed phase composition analysis in the experimentally generated binders and understanding the effect of technological factors thereon. Furthermore, mechanical tests were done on mortar moulds of the experimentally created binder.

In total, 33 samples of limestone were taken from 12 locations in the Czech Republic both from active quarries and from sites where there had been quarrying and processing of raw material for hydraulic lime or natural cement production in the past.

An array of analytical methods was used. Mineralogical and petrographic analyses were done using optical microscopy, cathodoluminescence and SEM/EDS. Silicate analysis was used to investigate chemical composition and non-carbonate admixtures were investigated by leaching and X-ray powder diffraction. The burned material was studied in detail by X-ray diffraction and SEM/EDS. Lastly, a mortar mould was created from selected burned or commercially available binder specimens. These were tested after 7, 28, 90 and 182 for flexural and compressive strength.

The majority of the specimens were impure, micritic limestone types. The most frequent carbonate mineral was calcite, less frequent was dolomite. The proportion of non-carbonate admixtures was between 4.53 to 34.14 percent mass, with the most frequent admixture being quartz (and other forms of SiO_2) and clay minerals (illite, kaolinite and chlorite). Accessory minerals were feldspar grains (sodium and potassium), apatite, pyrite, hematite and other minerals. The chemical composition of samples was therefore variable in both feebly hydraulic and eminently hydraulic materials. In burned samples, free lime and calcium silicates (larnite and wollastonite) dominated. Less frequent were other new-formed phases (portlandite, gehlenite and brownmillerite) and mineral relicts (e.g.: quartz and SiO_2). Mortar moulds created from burned Dvorce-Prokop lm. was strongly hydraulic and had the highest flexural and compressive strength. Samples processed from burned Radotín and Přídolí lm. were mostly moderately hydraulic. The lowest mechanical strength was typical for mortar molds processed from burned Kurovice lm. and of commercial binders NHL 3.5 and NHL 5.

This study has created a library of the properties of raw and burned limestone. It has been confirmed that the type and distribution of non-carbonate admixtures in the raw materials, together with the temperature and burning time, have a significant and direct effect on the properties and phase

composition of the burned product. These variables in turn affected the chemical reactions that lead to the generation of new phase compositions and to the continuing presence of mineral relicts. The study also confirmed the interconnectedness of individual processes, but also the problematics of working with materials with variable composition.