Calcium aluminate cements (CACs) are the most important type special cements which are used in refractory ceramics. The chemistry of CACs can be considered in the system $CaO-Al_2O_3$. The hydraulic cementitious minerals are $CaAl_2O_4$, $CaAl_4O_7$ and $Ca_{12}Al_{14}O_{33}$ that undergo chemical reactions in contact with water forming matrix of the hydration products belonging to the $CaO-Al_2O_3-H_2O$ phase diagram. Generally, at early hydration times and low temperatures thermodynamically unstable CAH_{10}, C_2AH_8, C_4AH_{13} and C_4AH_{19} (C = CaO, A = Al_2O_3, H = H_2O) hexagonal hydrates can be formed. At elevated temperatures the hexagonal hydrated calcium aluminates undergo a transformation into the hydrogarnet phase (C_3AH_6) and gibbsite (AH_3). Many factors are known to affect the kinetics of composite cement hydration, including dissolution of the cement grains, saturation of the solution, and presence of nucleation sites initiating precipitation and growth of hydration products. More specifically, when calcium aluminates are placed in water calcium ions (Ca^{2+}) and aluminate ions ($Al(OH)_4^-$) dissolve in the water to give a solution. Different structural states of hydrates i.e. microcrystalline, submicrocrystalline, nanocrystalline and amorphous can be formed. The hydration of inorganic binders (composite cements and other hydraulic phases) showing different phase and chemical composition is an exothermic process, accompanied by the release of heat of hydration.

The large research opportunities exhibit still the not well recognized hydraulic phases from the $CaO-Al_2O_3-ZrO_2$, $BaO-Al_2O_3$ and $SrO-Al_2O_3$ phase diagrams. According to the present research results of the author's project, calcium zirconium aluminate ($Ca_7ZrAl_6O_{18}$) as the only aluminate phase containing Zr in contact with water transforms into a hydrated state i.e. calcium aluminate hydrates and $CaZrO_3$ with perovskite-like structure. This is due to the disruption of the weak chemical bonds Al-O-Zr, existing besides stronger the Ca-O-Al and Ca-O-Zr chemical bonds in the $Ca_7ZrAl_6O_{18}$ crystal structure. Moreover, barium- and strontium aluminate cements are considered to be promising materials for high-performance heavy density refractory concretes that provide effective shielding in electromagnetic radiation, mainly gamma radiation and X-rays (heavy aggregate shield). However, investigations on these cements have either not been conducted so far or are currently not publicly accessible in Poland. Taking the above into consideration, especially the nuclear power development in Poland and progress in materials science, the Author of the project offer to develop the innovative group of special cements i.e. hydraulic binders with mineral composition belonging to the $CaO-Al_2O_3-ZrO_2$ doped with metal cations of different valencies. The objective of this research project is to determine the effect of ionic charge and ionic radius depending on the position of elements on the periodic table on the properties of synthesized phases. The main idea of this research project involves conviction that by doping with different metals can influence the process of hydration cementitious minerals from the system $CaO-Al_2O_3-ZrO_2$, that they will be also able to applicable to special use. The main objective is primarily to determine the role of elements within a certain group, including the elements characterized by the large absorption cross-section for neutrons and elements with the high mass absorption coefficient mainly lanthanides (La^{3+}, Dy^{3+}, Gd^{3+}, Sm^{3+}, Er^{3+}, Eu^{3+}) and other trivalent Fe^{3+}, Y^{3+}, Cr^{3+}, Bi^{3+} metal cations, divalent mainly Ba^{2+} and Sr^{2+}, and Mg^{2+}, Zn^{2+}, Cu^{2+}, Ni^{2+}, Mn^{2+}, Co^{2+} in the modelling of hydraulic properties of abovementioned aluminate phases. This will be used as the starting point for creation of new class of shielding materials.

From the point of view of basic research, scientific analysis of materials with modifiers will learn the basic physicochemical properties of cements with complex phase composition. This will mainly determine the effect of modifying elements on changes in structural parameters of cementitious compounds, structure and microstructure of hydrated binding matrix and getting to know the possibilities of their use in the technology of special refractories for the construction associated with nuclear power.

The preliminary research on this matter allow to draw first conclusions that calcium zirconium aluminate phase can be modified over a wide range of strontium concentration in total dissolved solids, i.e. $(Ca,Sr)_7ZrAl_6O_{18}$. Therefore, the fundamental conviction that the family of solid solutions within the $CaO-Al_2O_3-ZrO_2$ system as a result of compositional flexibility can be synthesised. These composite cements exhibiting various hydraulic properties could be use in high-density concrete for special applications. Some of them may be also formed during the synthesis under reducing conditions or other under specific experimental conditions. Thus, the following thesis has been already put: there is a close relationship between the type of modifying cation and impedance characteristics of hydrating systems, types of structural ordering of atoms (crystalline or amorphous structures of hydrates) and the thermal stability of hydrated matrices. From the point of view of the progresses in materials science it will be important to determine the conditions which favour the formation of hydraulic compounds doped with heavy metals. These results will allow for a better understanding of solid phase transformation kinetics in reliable determination, assessment of phase diagrams, to gain knowledge on cementitious minerals and composite cements. Results will help to broaden knowledge of multicomponent oxide systems. At this moment in time, the available technical data on special cements for shielding constructions in nuclear power plants are limited or incomplete. Thus, the experience of Polish scientists is necessary in this in this field.