Ƀ ɀ Ⱥɇ ɆɃȸɆɃ ɄɃȿ Ɉ ɇ Ⱥɉ Ɂ ȺɆɃ

ȹɆ ɇ ɀ ¢ ɀ ȷ ɇ ɆȾɃ ɄɅɃõɅ ɀ ɀ ȷ ɀ Ⱥɇ ȷ Ʉɇ Ɉ ɉ Ɇ Ⱦɋ Ɂ
ɆɄɃɈ ȹɋ Ɂ (ȹ.Ʉ.ɀ .Ɇ.):

"ȺɄɆɆɇ ¢ ɀ ¢ Ⱦȷ Ɫɇ Ⱥɉ ɁɃȿ ɃõɆ Ɉȿ ɆȾɋ Ɂ"

ȷ ɁɆɃɄɃɆ¢ Ɇ¢ ȷ ɄɃɅɅɆɀ ȷ ɇ ɋ Ɂ ȾɃɄ¢ Ɇ
ɀ ȷ Ʌɀ ȷ ɅɃɈ Ⱦȷ Ɫȷ ɆȸȺɆɇ Ƀȿ ɆŪɆȾɋ Ɂ
ȷ ȹɅȷ Ɂɋ Ɂ ɆȺ ɄȺɅɆȸȷ ȿ ȿ ɃɁɇ ɆȾ ȺɆ
Ⱥū ȷ Ʌɀ Ƀõ ȺɆ

ɀ Ⱥɇ ȷ Ʉɇ Ɉ ɉ Ɇ Ⱦ ¢ ȺɅõȷ ɆɆ

Ⱥȿ ȺɁ ¢ Ɇ ȸɃ ɅɅɆɆ¢
ȹɘ ɚɤ ɛŬŰɞɨ ɢɞɡ ɉ ɖɛɜɞɨ ɀ ɖɢŬɜɜɞɨ Ⱥ.ɀ .Ʉ.

ȺɄɆȸȿ ȺɊ¢ :
ȷ . ɀ ɃɈ ɇ Ɇȷ ɇ ɆɃɈ
ȾŬɖɗɝɐŰɉ ɜŬ Ⱥ.ɀ .Ʉ.

ȷ Ū¢ Ɂȷ , Ɇɛɨ ɚɜɛɠ 2012

Ƀ ɀ ȺɇɆɃȡȾɃ ɄɃȘ Ɉɇ Ⱥɉ ʔȺȾɃ
ȹȽ ɇɀ ȼɀ ȷ ɇȾȾɃ ɄɅɃũɅɉ ɀ ɀ ȷ ɀ Ⱥɇȷ ɄɇɈ ɉ Ƚ ȾȽ ʔ
ɆɄɃɈ ȹȽ ʔ (ȹ.Ʉ.ɀ .Ɇ.):

"ȺɄȾɆɇȼɀ ȼ ȾȷȽɇȺɉ ʔɃȘɃũȽ ɈȘȾȾȽ ʔ"

ȷ ʔȾɃɄɃȾȼ Ɇȼ ȷ ɄɃɅɅȽɀ ȷ ɇȽ ʔ ȾɃɄȼ Ɇ ɀ ȷ Ʌɀ ȷ ɅɃɈ Ⱦȷ Ƚȷ ɆȡȺɆɇɃȘ ȾŪȾȾȽ ʔ ȷ ȹɅȷ ʔȽ ʔ ɆȺ ɄȺɅȾȡȷ Ș Ș Ƀ ʔɇ ȾȾ ȺɆ Ⱥū ȷ Ʌɀ ɃũȺɆ

ɀ Ⱥɇȷ Ʉɇ Ɉ ɉ Ƚ Ⱦȼ ȺɅũȷ ɆȽ

ȺȘ Ⱥʔȼ Ɇ ȡɃɅɅȾɆȼ
ȹɜ əɤ ɛŬŰɞɨ ɢɞɡ ɉ ɖɛɚɞɨ ɀ ɖɢŬɜɚɞɨ Ⱥ.ɀ .Ʉ.

ɇɅȾɀ Ⱥ ȘȼɆ Ⱥʔ Ⱥɇȷ Ɇɇ Ⱦȼ ȺɄȾɇ ɅɃɄȼ :
ȷ . ɀ ɃɈ ɇɆȷ ɇɆɃɈ , ȾŬɗɖɔɐŰɕŬȺ.ɀ .Ʉ.
Ⱦ. ɇɆȷ Ⱦȷ Ș ȷ Ⱦȼ Ɇ, ȾŬɗɖɔɖŰɐɠȺ.ɀ .Ʉ.
Ⱦ. ȾɃɅȹȷ ɇɃɆ, Ⱥ΄ ȹ. ȾŬɗɖɔɖŰɐɠȺ.ɀ .Ʉ.

ȷ Ūȼ ʔȷ , Ⱦɚɨ əɕɚɠ 2012

¢ ´Ŭɟɕɨ ůŬɛŮŰŰ Űɠɢɘŭɘɐ ŭɘ´ɚɤ ɛŬŰɞɐ Ůɟ ɔŬůɗŬ Ůɘ´ɕɜɐɗɗɘŮůŰɞ Ƌɟ ɔŬůŰɐɟɛ ɟ ɜɧɟ ɔŬɞɗɠ ɘŬɘ ɟ ɜŬɚɡŰɞɐɠ ɟ ɗɛŬɗŬɠ Űɞɡ ɇɕɛɣŬ Ŀ ɟ ɗɛɚɩ ɜ Ƌ´ɘůŰɗɛɩ ɜ Űɗɠ Ɇɢɕɚɐɠ ɟ ɗɛɚɩ ɜ ɀ ɗɢŬɜɚɩ ɜ Űɞɡ Ƌɗɜɚɕɨ ɀ Űůɦɡɞɡ Ʉɕɚɡŭɞɜŭɞɡ ɘŬŰŸ Űɞ ŬɘŬůɗɛŬɐɦ ɣŰɞɠ 2011-2012 ůŰŬ ´ɚŬůɘŬ Űɗɠ ɕɚɕɚɐɟɤůɗɠ Űɞɡ ɢɘŬŰɛɗɛŬŰɞɕɨ Ʉɟɕɔɟ Ÿɛɛ Űɞɠ ɀ ŰŰŬ Űɠɢɘŭɘɩ ɜ Ɇ´ɕɡŭɩ ɜ «Ƌ´ɘůŰɐɛɗ ɘŬ ɇŰɞɜɕɚɕɔŬŰɤ ɜ Ŀ ɚɩ ɜ».

ŬŬ ɐɗŮɘŬ ɜŬ Ůɘŭɟ Ÿůɤ Űɠɗ ɗŬɟɛɣɠ ɛɕɡ Ůɠɢ Ŭɟ ɘůŰɗŬɠ ůŮ ɧɚɕɡɠ ŮɘŮɞɕɡɠ ´ɕɡ ůɡɜɣɓŬɚŬɜ ůŰɗ ŭɘŮɘ´Ůɟ Ŭɤ ůɗ ŬɡŰɐɠ Űɗɠ Ůɟ ɔŬůɗŬɠ.

Ɇɡɔɘ Ůɟ ɛɣɜŬ, ůŰɗɜ Ů ɓɚɣ´ɕɡůŬ Ɽ Ŭɗɔɐ Űɟ ɘŬɘŬ ɟ ɔɔŮɞɐ ɀ ɕɡŰŸ Űůɕɡ ɔɘŬ Űɗɜ ŬɜŸɗŮůɗ Űɗɠ Ůɟ ɔŬůɗŬɠ, Űɗɜ ɘŬɗɕɟ ɘůŰɞɐ ɘŬɗɕŭɐɔɗůɗ ɘŬ Űɞ ɕɡůɘŬůŰɞɧ ŮɜŭɘŬůɣɟɕɜ ´ɕɡ ɡ´ɣŭɞŮɘŬɗô ɧɚɗ Űɗ ŭɘŸɟ ɘŮɘŬ, Ůɘɚ Ÿ ɘŬ Űɠɗ´ɕɚɡŰɛɣɠ ůɡɛɓɕɡɚɣɠ Űɗɠ Űɧůɕ ůŮŬŭŬɗɛŬɧ ɧůɕ ɘŬůŮŬɜɗɟ ɩ ´ɞɕ Ů ɑ Űɕ.

ŬŬ ɐɗŮɘŬ ɜŬ ŮɡɢŬɟ ɘůŰɐůɤ Űɗɜ Ŀ´ɕɤɐŰɘŬ ɗŭŸɘŰɛɟŬ ɘŬ Ɇɕůŭ ŭ Ŭɟ ɛŸɘɗ, ɛɣɟɕɠ Űɗɠ ŭɘŭŬɘŰɛɟɩɐɠ ŭɘŬɟɓɐɠ Űɗɠ ɕ´ɕɗɟ Ŭ ɕŰɘŮɗɗ ´Ŭɟɕɨ ůŬɛŮŰŰ Űɠɢɘŭɘɐ Ůɟ ɔŬůɗŬ, ɔɘŬ Ű ůɡɜŮɟ ɔŬůɗŬ ɘŬ Űɞ Ůɜŭɘůɕɣɟɕɜ Űɗɠ.

Ƌɚɚɩɟɜ Ůɠɡ ŮɡɢŬɟ ɘůŰŰɞɡ ɢɟɤ ůŰ ůŰɗɜ ɗɘŭŸɘŰɛɟŬ ŷ ɚɔŬ Ɽ Ŭɟ ŬŸůɗ, Űɗɜ Ŀ´ɕɤɐůɘŬ ɗɘŭŸɘŰɛɟŬ ɘŬ ɟ ɟ ɘůŰɞŬ-ɟ ɛŬɘŬ ɗɟ ɧůɕɡ ɘŬ Ůɜ Ŀ´ɕɤɐůɛ ɗɘŭŸɘŰɛɟŬ ɘ. ¢ ɚŬ ɀ ŬůŬɓɣŰ ɔɘŬ Űɗɜ ´Ÿɜ Ůɚɩɟɛɐ Űɕɡɠ ŭɘŸɗŮůɗ ɔɘŬ ɓɕɐɗŬ. ɇɕ ɧɛɕɟ ɡɕ ɘɚɛ Ŭ ůɡɜŮɟ ɔŬůɗŬɠ, ɗ Ŭɛɣɟ ɘůŰɗ ůɡɛ´Ŭɟ Ÿ ůŰŰɞɐ Űɗɠ, ɗ ŭɚɩɐ Űɗɠ ŭɘŸɗůɗ ɘŬɘɕɜ ůɡɛɓɕɡɚɣɠ Űɗɠ ŭɘŮɡɚɗɚɡɜŬɜ ɘŬɗɕɟ ɘůŰɞ Ÿ Űɗɜ ´ɟɕů ´ŸɗŮ Ÿɛɛɗ.

Ʉɕɚɣɠ ŮɡɢŬɟ ɘůŰɞůɡɡ ɗŬ ɐɗŮɘŬ, Ŭɧɛɗ, ɜŬ ŭɘ ůɤ ůŰɗɜ Ŀ´ɕɤɐůɘŬ ɗɘŭŸɘŰɛɟŬ ɘŬ ɟ ŭɟɕŭɗŰ ?Űɕɕɔɜɗ ɘŬ ůŰɗɜ Ŀ´ɕɤɐůɘŬ ɗɘŭŸɘŰɛɟŬ ɘŬ ɀ ɧɜɚɘ ŬȻŬ ɓŸɗ ɔɘŬ Űɗ ´ɕɨ Űɞɛɗ ɓɕɐɗɘŸ Űɠɢɡ ɘŬŰŸ Űɗɜ ´Ůɟ Ŭɛ Űɞɐ ŭŸɗ Űɗɠ Ůɟ ɔŬůɗŬɠ ɛɕɠ.

ɗŮɜ ɗŬ ɐɗŮɘŬ ɜŬ ´Ŭɟ ɘŮɤɤ ɜŬ ɢɟŬɟɘůŰɐůɤ Űɕɡɠ Ŀ´ɕɤɐůɛɕɡɠ ɗɘŭŸɘŰɛɟŬ ɘŬ ŭɘŮɤɟɔŬ ɗŬɟɘŭŸ ɘŬ Ƌɚɣɜɗ Ɽ ŰůŰɕɘŬ ɘ. ŭɚ ɟɔɕ ş Űɜŭɕ ɘŬɘŭɕ ɔɘŬ Űɞ ɢɘŸɟ ɘůŰɞ ɘɚɕ ɘŬ Űɧɗ Űɕɠ Ůɟ ɔŬůɗɟ ɕɠ.

ƋɢɕŬɟ ɘůŰŰ ɗŬɟɛŸ Űɠ ŭɕɕŬɠ ɛɕɠ Ƌɚɣɜɗ ɟ ɜɕɚŰɛŸŰɗ ɘŬ ɀ Ŭɟɘ ŸɜɜŬ ɇɟɘ Ÿɜɛɠ ɔɘŬ Űɠ ɢɟɘŸ ɘůŰŰɠ ůŰɛɣɐ ɘŬ Űɗ Ŭ ɟɚɡ ɘůŰɗ ůɡɛ´Ŭɟ ɘŸůŰɗ Űɠɡ ŭŸɗ Űɤ ɜ ů´ɕɡŭɩ ɜ ɛɕɠ.

ɇɣɚɕɠ, ɗŬ ɐɗŮɘŬ ɜŬ ɢɟɤɐůɤ ´ɕɨ Űɗɜ ɕɜɕɜɣɜŬŸ ɛɕɠ ɔɘŬ Űɗ ɔ´ɕůŰɐɟɛɗ Űɠɡ ɘŬ ůŬ Ŭɡɧ Ű ɘɕɛɛ Ÿ Űɗɠ ɛɤ ɐɠ ɛɕɠ.

ɟ ɗɛɜŬ, Ŀɐɨ ɚɕɡ 2012

ɗɕɟɟɕůɗ Ƌɚɣɜɗ

[illegible]

[illegible]

[illegible] (Pb, Cd, Zn [illegible] Cu).

[illegible] 100 mg/L [illegible] 5 mg/L [illegible] <90 [illegible]m, 90-315 [illegible]m, 315-1000 [illegible]m [illegible] 1000-4000 [illegible]m, [illegible] 315-1000 [illegible]m. [illegible]

[illegible] 1 mm. [illegible] XRD, XRF, TG, [illegible]

[illegible] 95%. [illegible] Pb [illegible] Cu, [illegible] Zn [illegible] Cd [illegible]

[illegible] 93%, [illegible]

[illegible]

[illegible] Pb>Cd>Zn=Cu. [illegible] Zn [illegible] Cu [illegible] Cd [illegible] Pb [illegible] Cd [illegible]

[illegible]

Overpopulation and expansion of industrial activities of recent years has led to a steadily increasing pollution of water supplies with heavy metals. With the rapid development of industries such as metal plating facilities, mining operations, fertilizer industries, tanneries, batteries, paper industries and pesticides, etc., heavy metals wastewaters are directly or indirectly discharged into the environment increasingly, especially in developing countries. Faced with more and more stringent regulations, nowadays heavy metals are the environmental priority pollutants and are becoming one of the most serious environmental problems. So these toxic heavy metals should be removed from the wastewater to protect the people and the environment. Unlike organic contaminants, heavy metals are not biodegradable and tend to accumulate in living organisms and many heavy metal ions are known to be toxic or carcinogenic. As a consequence, these toxic elements is necessary to be eliminated in the effluents so as people and environment to be protected.

Adsorption is one of the most interesting methods because of its high efficiency in removing heavy metals from different fluxes. A lot of studies have been held in order to be found effective organic and inorganic adsorbents. These materials are abundant and possess, generally, strong affinity and high capacity, two of the most basic properties of adsorbents. The removal of heavy metals that is based on their sorption on mineral surfaces is constitutes an alternative. Carbonate minerals and rocks strongly interact with metallic ions removing them from aqueous solutions. Calcite, magnesite and dolomite have been studied as potential adsorbents of heavy metals from solutions. The interaction mechanism seems to be a combination of ion exchange and precipitation on the carbonate surface.

The main objective of the present work is the study of dolomite and dolomitic marble are studied as cheap and effective inorganic adsorbents as a function of the particle size distribution and the fluw conditions of watewaters with ions of heavy metals and toxic metallic ions (Pb, Cd, Zn and Cu).

Particularly, batch and column sorption experiments were conducted aiming at determining the retention capacity for the above metals in stable and continuous flow conditions, respectively. For comparison reasons, in the case of column experiments, calcitic marble is also studied. The adsorption of metals is examined either in monometallic solutions of each metal, or in their polymetallic solution, with concentrations of 100 mg/L for both zinc and copper and 5 mg/L for lead and cadmium. More precisely, in the adsorption under stable flow conditions both types of solutions are used, while in the adsorption under continuous flow conditions only polymetallic solutions is implemented. Basic parameter of the study is particle size distribution as well. In the case of stable flow conditions, dolomite is examined in different particle fractions, <90 εm, 90-315 εm, 315-1000 εm əŬэ 1000-4000 εm, while dolomitic marble only in that of 315-1000 εm. In the case of continuous flow conditions, the adsorbentsô particle size is <1 mm. The investigation of the mechanism of the adsorption is held through the leachability of the adsorbents. The implementation of analysis methods of XRD, XRF, TG, as well as of chemical analysis and the determination of loss of ignition and z-potential gives the ability of characterizing adsorbents not only before but also after the process of adsorption.

...rimental data show that under stable flow conditions ...y satisfactory adsorption capacity in the studied particle size distribution for all the metals, with adsorption percentages generally beyond 95%. On the contrary, in common aqueous environment, the metallic ions behave differently for both adsorbents. In particular, retention of Pb and Cu is considerably favored, while that of Zn and Cd is much reduced.

In the case of adsorption under continuous flow conditions, the three adsorbents appear high levels of retention, beyond 93%, for all the metallic ions. Besides, the maximum adsorption performance tends to be achieved directly for all the metals.

In both cases of flow it is noticed that the difference in the mineralogical tissue between dolomite and dolomitic marble, i.e. the bigger particle size of the grains (crystals) and the preferred direction of the carbonate crystals of dolomitic marble, as well as the more massive structure of the marble do not seem to differentiate the adsorption capacity of the adsorbents.

The study of leachability of adsorbents which come from stable and continuous flow conditions show that it is greater in fixed beds and in both cases the leachability order followed is Pb>Cd>Zn=Cu. Experimental data conclude that in stable flow conditions lead and cadmium, except for ionexchange, complexation and precipitation as basic adsorption mechanisms, are expected to be physically adsorbed on the surface and be trapped in small percentage, while the retention of zinc and copper is attributed to adsorption through ion exchange and formation of carbonate salts through complexation. In the case of fixed beds, adsorption through ion exchange, surface complexation and precipitation is indicated as retention mechanism of Zn and Cu cations, while for Pb and Cd, apart from adsorption through surface precipitation and ion exchange, physical sorption also takes place.

Last but not least, the characterization of the adsorbents derived from the fixed beds reveals the formation of new substance during the process of adsorption, which are the same for the dolomite and the dolomitic marble and different for the calcitic marble.

ŪȺq Λ¢ ȼ ŁȾɃ ζ ȺΛɃɆ

[illegible]

1.1 [illegible]

1.1.1 [illegible]

[illegible] $(CO_3)^{2-}$ [1]. [illegible] CO_3 [illegible] C-O [illegible] 1,25-1,35 Å [illegible] O-C-O [illegible] 120°. [illegible] CO_3 [illegible] CO_3 [illegible] [2]. [illegible] $(CO_3)^{2-}$ [illegible] [3].

[illegible] Ca^{2+}, Mg^{2+}, Ba^{2+}, Sr^{2+}, Pb^{2+}, Fe^{2+}, Mn^{2+}, Zn^{2+}, [illegible] [4]. [illegible] 150 [illegible] [2]. [illegible] [1].

[illegible] [2,3,5]. [illegible] [5]. [illegible] Ca, Mg, Fe, Mn [illegible] Zn [illegible] $(CO_3)^{2-}$ [illegible] Ca [illegible] Mg, Fe [illegible] Mn [illegible] [5].

1.1.2 [illegible]

[illegible] (... 1.1). [illegible] 1.1 [illegible] [2].

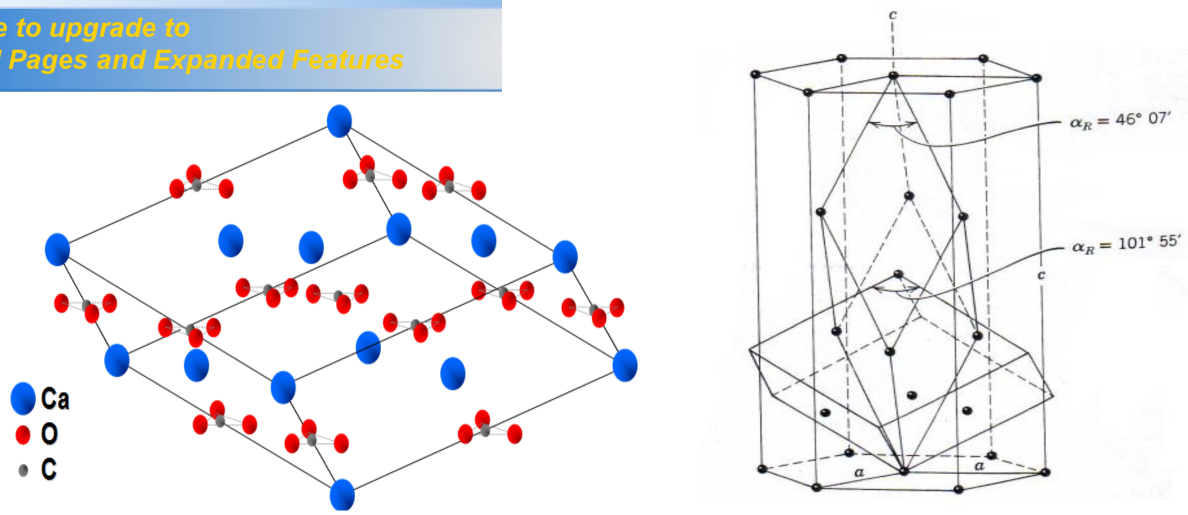
ɘǗᴕɑɨ Ǘ ´ ɑg ǙᴈɗʝǙᴕᴔ Ƴ ɑʝ gɘǗƳ [2].

			ɸɘǗűǗƳűǗ ǯɘgɣ Ǘᴕǐ Ǘ ǯ (Å)		ɸǗᴕǗ ǯ ŭɘƳɗɘǗűɗǯ	
			a	c	ɤ	Ů
ɟ ůɓǗűǗǯɗǯ	$CaCO_3$	2.71	4.989	17.061	1.658	1.486
ɀ Ǘᴈɗůɗǯ	$MgCO_3$	3.00	4.632	15.012	1.700	1.509
Ɇɜŭɗɟ ɗǯ	$FeCO_3$	3.97	4.691	15.379	1.875	1.635
Ʌɜŭɕɕɟ ɤ ůɗǯ	$MnCO_3$	3.70	4.768	15.635	1.816	1.597
Ɇɛ ɘɗůɕᴈɗǯ	$ZnCO_3$	4.43	4.652	15.025	1.850	1.625
Otavite	$CdCO_3$	4.96	4.923	16.787	1.828	1.607
Gaspéite	$NiCO_3$	4.39	4.608	14.805	1.930	1.721

ɇ Ǘ ɛ ɏɘɗ Ǘ gǗɐ ǯ Ǘɗǯ ɕ ɛ ƳũǗ ǯ ǗᴕǗᴕ ɘǗɕŭɕɛ ᴕ Ƴ ɛ Ůǯɗᴈ ɕ ɛ ƳũǗ ůgɛ ɛ Ǘǯ ɗǗ ǯ ɩ ɟ ɕg R3c. ȼ ŭɕɛ ɐ Ǘɕg Ǘůɓ ǗűǗɗ, ɛ ɘǗ Ǘ ɧ Ǘǯ ´ ɟ ɩ Ǘǯ ŭɕ ɛ ɏǯ ´ ɕg ɛ ǗᴕǗɐ ɗɗɘǗᴕ ɛ ɏůɤ Ǘɤ ᴈ ǗᴕǗᴕɤ ᴈ X Ǘ ɧ Ǘɕᴈ W. L. Bragg Ǘɕ 1914 (Ʌᴔ ɧᴈ Ǘ 1.2), ɛ ´ ɕɟ Ǘᴈ ᴈ Ǘ ɗǗɤ ɟ ɗɗǗɤ ǯ ɏᴈ Ǘ ´ Ǘɟ Ƴ ɔɤ ɔɕ Ǘɗǯ ŭɕ ɛ ɐ ǯ Ǘɕg NaCl ůǗɗᴈ ɕ ´ ɕ ɗǗ Ǘɟ ᴔ ɤ ᴈ ᴔ ɏǯ ɕ ɛ ƳũǗ ǯ (CO_3) ǗᴈǗᴕ Ǘɗɘ ůǗ ɨ ᴈ Ǘɕ ůűǗɟ ᴔ ɧ Cl ɘǗᴕ Ǘɕ Ca ɘǗǗᴕ ɘǗ ɛ ɓƳᴈ Ǘᴕ Ǘɗ ɗɏůɗ Ǘɕg Na. ɇ ɕ Ǘɟ ᴔ ɤ ᴈ ᴔ ɧ ůɢɛ Ǘ Ǘɤ ᴈ ɕ ɛ Ƴɤ ᴈ (CO_3) ɏɢǗᴕ ɤ ǯ Ǘ ɕǗɏɘ Ǘ ɛ Ǘ ɗ ´ ɟ ɕɘ ɨ ´ Ǘɕ g ů Ǘ ŭɕ ɛ ɐ ᴈ Ǘ ǗᴈǗᴕ ɟ ɕ ɛ ɓɕ Ǘɟ ᴔ ɐ ǗᴈǗ ɔ ɘ Ǘ ɘ ŭɕ ɛ Ǘɟ ᴔ ɐ ɧ ´ ɤ ǯ ů g ɛ ɓǗᴈǗᴕ ůǗɕ NaCl [3]. ɇ Ǘ ƳǗɕ ɛ Ǘ Ca ɓɟ ɗůɘɕᴈ ǗǗᴕ ůǗǯ ɘɕɟ gűɏǯ Ǘᴈ ɧ ǯ Ǘɟ ɕ ɘǗᴈ Ǘɟ ɤ ɛ ɏᴈ ɕ g ɟ ɕ ɛ ɓɕ ɏŭɟ ɕ g. ɇ Ǘ ɕ ɧ ᴈ Ǘ CO_3 ǗᴈǗᴕ Ǘɕ ´ ɕ ɗǗǗɗ ɛ ɏᴈ Ǘ ůǗɕ ɛ ɏůɕ Ǘɗǯ Ǘ ɧ ůǗǗ ůɗǯ ɛ ǗǗǗᴕɨ Ǘɤ ᴈ Ǘɧ ɛ ɤ ᴈ Ca ɘǗǗƳ ɛ ɐ ɘɕǯ ůǗɟ ɩ ᴈ ´ Ǘɟ Ƴɘ ɘɗ ɘɤ ᴈ ůǗǯ ɟ ɕ ɛ ɓɕ Ǘɟ ᴔ ɏǯ Ǘᴕ ɛ ɏǯ Ǘɕg ůɢɘ ů ɛ ɕɨ , Ǘᴈ ɩ ɛ ɘǗ ɕ ɛ ƳũǗ CO_3 ɓɟ ɗůɘǗǗᴕ ůǗɕ ɘɏᴈ Ǘɟ ɕ Ǘɗǯ ɟ ɕ ɛ ɓɕ ɏŭɟ ɕ g [6].

Ʌᴔ ɧᴈ Ǘ 1.1: ɟ ůɓǗűǗɗǯ [37].

ȼ ŭɕ ɛ ɐ Ǘɕg Ǘůɓ ǗűǗɗ ɢǗɟ ǗᴕǗɟ ɕǗǗᴕ Ǘ ɧ ǗᴈǗᴕ ɘǗůɧ ɛ Ǘᴈ Ǘ ůǗɟ ɩ ɛ ǗǗǗ Ǘ ɧ ƳǗɕ ɛ Ǘ Ca ɘǗᴕ ɕ ɛ ƳũǗ ǯ CO_3 ɘǗǗƳ ɛ ɐ ɘɕɕǯ Ǘɕg Ƴᴈɕ ᴈ Ǘ c, Ǘᴈ ɩ ɛ ǗǗǗᴕɨ ŭɘǗɕɕᴔ ɩ ᴈ ůǗɟ ɤ ɛ ƳǗɤ ᴈ ɕᴔ ɕ ɛ ƳũǗ ǯ CO_3 ɏɢɕ gᴈ ǗᴈǗɗǗǗɕ gǯ ´ ɟ ɕůǗᴈǗǗɕ ɘᴔ ů ɛ ɕɨ ǯ [2]. ɇ Ǘ ɧ ᴈ Ǘ CO_3 ǗᴈǗᴕ Ǘɟ ᴔ ɤ ᴈ ᴔ ɐ ǯ ɛ ɕɟ űɐ ǯ, Ǘ ɑ ǗűǗ ´ Ǘɟ Ƴɘ ɘɗ ɘǗ ůǗɕ {0001} ɘǗᴕ ɘƳɗǗ ɕ ɛ ƳũǗ ɏɢǗᴕ ůgůǗɟ ǗŭǗᴕ 60° ůǗ ůɢɏůɗ ɛ Ǘ Ǘɗᴈ Ǘ ɧ ɛ Ǘᴈ ɗ [6]. Ƀᴔ ɕ ɛ ƳũǗ ǯ (CO_3) ɓɟ ɗůɘɕᴈ ǗǗᴕ ůǗǗ ɑ ǗűǗ, ůǗɕɟ ɗɏǯ ɔɤ ᴈ ɗǗ ǯ ɤ ǯ ´ ɟ ɕǯ Ǘɕᴈ 3 Ƴᴈɕ ᴈ Ǘ ´ Ǘɢɐ ǯ - (c) (Ʌᴔ ɧᴈ Ǘ 1.2) ɘǗᴕ ɘƳɗǗ ɛ ɘǗ ´ Ǘɟ ɖƳɘɘǗǗᴕ Ǘ ɧ ɏᴈᴔ ƳǗɕ ɛ Ǘ Ca [2,6]. ȚǗ ɖᴈ Ǘ Ca, ůǗ ǗᴈǗᴕ ɘǗůɧ ɛ Ǘᴈ Ǘ Ǘ ɑ ǗűǗ, ɓɟ ɗůɘɕᴈ ǗǗᴕ ůǗ ůgᴈ Ǘɕᴈ ɘ ɛ ɧ ɛ Ǘ 6 ɕᴈ gɔɧᴈ Ǘ Ǘɤ ᴈ ɕ ɛ Ƴɤ ᴈ (CO_3). ȶ ƳɗǗ ɕᴈ gɔɧᴈ ɕ ǗᴈǗᴕ ůgᴈ Ǘɕᴈ ɘ ɛ ɏᴈ ɕ ɛ Ǘ ŭɨ ɕ ɖᴈ Ǘ Ca ɘǗɩ ǯ ɘǗᴕ ɛ Ǘɏᴈ Ǘ ɖᴈ Ƴᴈɗɟ ǗᴕǗ ůǗɕ ɘɏᴈ Ǘɟ ɕ Ǘɗǯ ɕ ɛ ƳũǗ ǯ (CO_3) [3].



(a) (b)

ÆÞ ฏ3Ũ 1.2 : (a) [illegible] $CaCO_3$, (b) H [illegible] [3,38].

[illegible] (ÆÞ ฏ3Ũ 1.2), [illegible] {10$\bar{1}$1} [illegible]

(a) (b)

ÆÞ ฏ3Ũ 1.3: (a) [illegible] (b) [illegible] [37].

[illegible] (ÆÞ ฏ3Ũ 2). [illegible] Ca:O (=0.714) [illegible] $CaCO_3$ [illegible] 6- [illegible] 8- (=0.732) [illegible]

... ɨ ɠ Ű ´ ɞɡɠ: Ű ɜ ǓŭƂŮŭŰŰɖ ɛŮ6-ůɡɜŰɜɿůɛɦ Űɡ Ca ɛŮŰ ... Ca ɛŮŰ Ƀ [3].

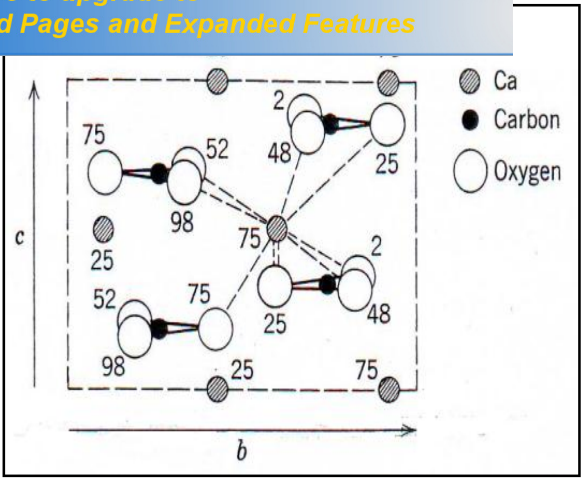
... Ƴ ɤƠ ɑƳɦɠ ůɡůɕŰŰůɛɦɠ ɛŰŰɨ Űɡ ɛɐɑɡɠ ŭŰŮɛɨ ɛŮŰ ... ɑƳɦɠ ŭɡ MO$_6$ ... c/a. Ƀ ... Ƀ otavite ɑƳ gaspéite ... [2].

1.1.3 ... ɛɐ ƳŭŰ Űɡ Ų Ųɤ ɜɖ

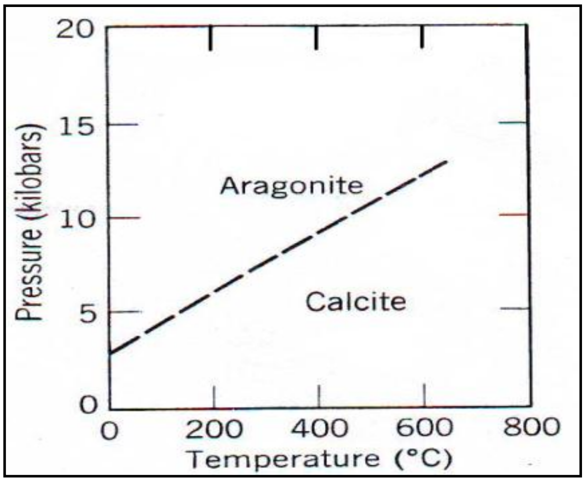
ȳ Ű ɖ ɞɛ ƳŭŰ (CO_3) ... 1.0 Å), ... ɛŮ 6-ůɡɜŰɜɿůɛɦ. ... (Ƃ ɜŰ 1.5a) ... Pmcn. ... $CaCO_3$ ... Ca ... 6-ůɡɜŰɜɿůɛɦ ... 9-ůɡɜŰɜɿůɛɦ. Ƀ ... $CaCO_3$ ... (Ƃ ɜŰ 1.5b). ... $BaCO_3$, $SrCO_3$ ɑƳ $PbCO_3$, ... [3]. ... 1.2 ... [2].

Ƃ ɦɜŰ 1.4: ... [37,43].

Ƀ ... $CaCO_3$ ... [2]. ... (CO_3), ... c, ... (CO_3) ... (CO_3) ... [3]. ... {001} ... [2]. ... [3].



(a)



(b)

Ãºº·Õè 1.5 : (a) H ùeεε Ûg Ųǆ Übɤ 3dűɖ $CaCO_3$, ɧ´ɤ ɠ´ɟ εбŸǝǝŮŬbǓ ɧ Űɞ (100). ɇ ǓŸɞεǓ´eg dǓɏ´ɟ Ů ŮɜǓ ´ɟ εǓɞɏeeg3 ɏeeg3 ɔɑǓɞeɟ ǓŰŸεǓεŰŰŰɧ´ ɔűd. Bǝ Ųɟ ɖεeaǓɞǓɞ ɟeůɤ´ Ůeg3 ŰŰɨɣd Űɤ 3 Űɞεǝǝɩ 3 dɏůŰɤ 3 ´ŸɜɤǓ ɧ Űɞ Ů ά Ůɞe ´ɟeɏǝŲɠůdɖ ůdεǓɞɤ εɏ3ǓůŮůeɏůd εŮŰɞ3 a. To ůǝǓɞŮɞeεεɏ3e ´ŲǓɞǝdǝɧɔɟ Ǔεεe ůǝǝǓɞɟ ŰɨŮŰɖ εe3ŰǝǓŰǝgɣǓɞɑŬ ɄŲɟ egůǝŸe3ŰǓ Ůɑůdɖ eǝŭŮεeaCa-O ǝǓɞ(b) H ǝŰŰŸ´ɟ eůɏɔɔǝůd dɏůd Űɤ 3 ´Ųɟ ǓεŰǓɞŸ´ɟ eůǝeɟ ǝůεɏ3ɤ 3 ´Ųǝeɩ 3 ůŰŰdŲ ɧŰɖŰɠŰɞg ǓɞбŰůŰǓɖ ǝǓɞŰɞg Ųǆ Übɤ 3dűɖ [3].

ȚŸdŮ eεŸũǓ (CO_3) Űɞ´edŮŰŰůŰŰǓɞ εŮŰŰǓɞɨ ɏǝǝ ǓŰɟεɤ 3 Ca, ǓǝǝŸ ůǝŮɠdŮŰŰůŰŰǓɞ εŮ ŰɏŰɞǝ Ųɧ´e ɩ ůŰŰǝŸdŮŸŰɞεe B 3Ŭ ůg3ůɏŰŰǓɞ εŮŲǆ dǓ ŸŰɞεǓCa, Ǔɞɩ ůŰɞ3 ǓɞбŰůŰɖ ǝŸdŮB ůg3ůɏŰŰǓɞ εŮŭɨe ŸŰɞεǓ Ca [6]. ȚŸdŮ ŸŰɞεe ǓɞбŰůŰɞg ´ŲɠŸǝǝŮŰŰǓɞǓ ɧ Ǔɞ3ǝŸ ůg3Űɞ3ɔůεɏ3Ǔ ŸŰɞεǓ e3gɔɧ3eg, ůdǝǓŭε Űɞ ǓɞбɏůŰɞ бɟ ɑůǝŰŰǓɞǝǓɞ´Ÿǝǝ ůŮeǝŰŰŲ ɡɧ ůg3Űɞ3ɔůεɧ εŮŰɞ e3gɔɧ3e [3,6].

ɄɑǓɞǓŲ 1.2: ɟ ɟ Ǔbe3ǝŰɞeɨ Ű´eg Ǔɞdɟ Ǔɞǝ Ÿeɟ gǝŰŸ [2].

ỹ 3eεǓ	ɇ ɨ ´eg	Ãǔǝɧ бŸɟ eg	ɕǓŮŰŸůǓɠ ǝgɣ Ǔɞɑŭǔɠ (Å)			ɕǓɞŰɠ ůǝŸdǝǓůdɖ		
			a	b	c	Ǔ	б	ɔ
ɟ ɟ Ǔbɤ 3dűɖ	$CaCO_3$	2.95	4.960	7.964	5.738	1.531	1.681	1.684
ȨŲ e3ŰǓǓɞdűɖ	$SrCO_3$	3.7	5.090	8.358	5.997	1.517	1.661	1.667
bǝdŲ dűɖ	$BaCO_3$	4.3	5.312	8.896	6.428	1.529	1.676	1.677
ȚŲ gůdűɖ	$PbCO_3$	6.55	5.180	8.492	6.134	1.803	2.074	2.076

ȨŰŲ ŮŸ ůǝǓɞɨ εŰŰ ůŰɖ3 ŲǆǓbe3ǝŰɞε eεŸũǓ ǓɑǓɞ ǝŸ ɤ ɠ´ɞ ´Ųɞɟ ɔůεɏ3d ůŮůeɏůd εŮŰɖ3 ǝǓɞůǝŰɞε eεŸũǓ ǝǓɞ ǓɑǓɞ Ǔɞůǝŭɏɟ e3 3Ŭ ůdεǓɞɤ dŰɞ ɧŰɞ Űɞ Ca ǝǓɞ Űɞ Ba , Űɞ εǝɟ ɧŰŲe ǝǓɞ Űɞ εŮǓɞɨ ŰŲe ɧ3 ůŰɖ3 eεŸũǓ ǓɞŰŭŰɞɜŬ, ůedεŰŰɞeg3 Űɖ ůǝŰŰŰŰbεɏ3d ɏ3ɤ ůd barytocalcite, $BaCa(CO_3)_2$, ǓɞŸǝe3d εŮŰɖ3 Ǔɛ űŸ3ɔůd Űɞg ůeǝεεdűɖ $CaMg(CO_3)_2$ ůŰɞ ůɨ ůŰɖεǓ$CaCO_3$-$MgCO_3$. Bǝ ůǝŭŭeɟ ɏɠ ůŰɠ ŭgůǝɏɠ ɔũɧŰɖŰɠ Űɖɠ Ųǆ Ǔbe3ǝŰɞεɠ eεŸũǓɠ Ǔ eŭɑe3ŰǓɞ ǝgɟ ɑ ɠ ůŰŬ ǝŰŰɧ3ŰŬ Ȩg3Ů ɩ ɠ, Űɞ Ǔɞŭǝɧ бŸɟ egɠ ǓɑǓɞ ůeŰŰɧ3 ǓɞŸǝe3e εŮ Űɞ Űɞεǝɧ бŸɟ egɠ Űɤ 3 εŰŰǓɞǝǝɩ 3 ɧ3Űɤ 3 (ɄɑǓɞǓŲ 1.2).

ÆÜ ücaæcεsöêcı Ü cg cɟ gaÜr, c ücaæcεdűűğ aÜø c Üåaǚ dűűğ ÜaÜø ŰŰ ´æ ůdεÜöŰæŸ cɟ gaÜŸ (ŦaÜøŰğ 1.3). Ōcgcз εaÜ Űğɟ ŮdŰ aÜø ÜaŰŰåe ´Űɟ cgůdŰ ůŰŰ æ dεÜŰåɔÜåe ůŰɟ ι εŰŰŰ aÜø ŰŰ εŮŰŰεcɟ ű ɣ εɏзŰ Üådɟ ÜaæŸ ´Űŭɟι εŰŰŰ. ɇŰ Ÿaæ Ű ǚi c Üådɟ ÜaæŸ cɟ gaŰŸ ücaæcεsöêcı Ű ´cg, kutnahorite aÜø minrecordite, üÜå ÜaÜø ůgзεdd, Ûι ÜεűÜåacзŰÜø ůŰŰзŸ ůgзüŰŰÜεɏзŰ εŮ Űå üca æcεdŰŰ [2].

ɇŰ cɟ gaŰŸ ŰgŰεğ Űdğ cεŸüŰğ ɏcgз Űdз dŰaŰ ücεe εŮŰdз cεŸüŰ ůgεŮŰɟ dŰğ ɢι ɟcg R3̅. ¢ üca æcεsöêe ücεe ´ɟcaı ´ŰÜaŰ ɦ Űdз aÜåcзæe ÜåÜøŰŰŸŰŰŰůd Űɤ з ÜåÜaæŰůŰεÜåɣ з ŰŰεɣ з Űåg Ca ůŰåз ŰůbŰůŰŰd Ű ɦ Ÿaæ Ű üsůdÜåe εɏŰŰaæŰ, ůgзεdɤ ğ Mg, Fe, Zn e Mn. ɀ ŮŰgŰɦз Űåз Űɟɦ´c, ´ɟcaı ´ŰÜaůŰɟ ι εŰŰåg ÜåɦğεŮŰŸaæcg, Űå c´cœ ÜaæcgdŮŰŰÜaŰ ɦ ɏзŰÜådɟ Üaæɦ ůŰɟ ι εŰ, ´cg εŮŰd ůŰɟ Ÿ Űåg ÜacæcgdŮŰŰÜa Ű ɦ ůŰɟ ι εŰ Űåg Ÿaæcg εŰŰŸaæcg. ɟ gŰe d üsŰůŰɟ ɣ εŸŰɤ ůd ɏcÜø Űd εcɟ űe [3,19,20]:

|ɟ |CO3|B|CO3|ɟ |CO3|B|CO3|ɟ |CO3|B|é

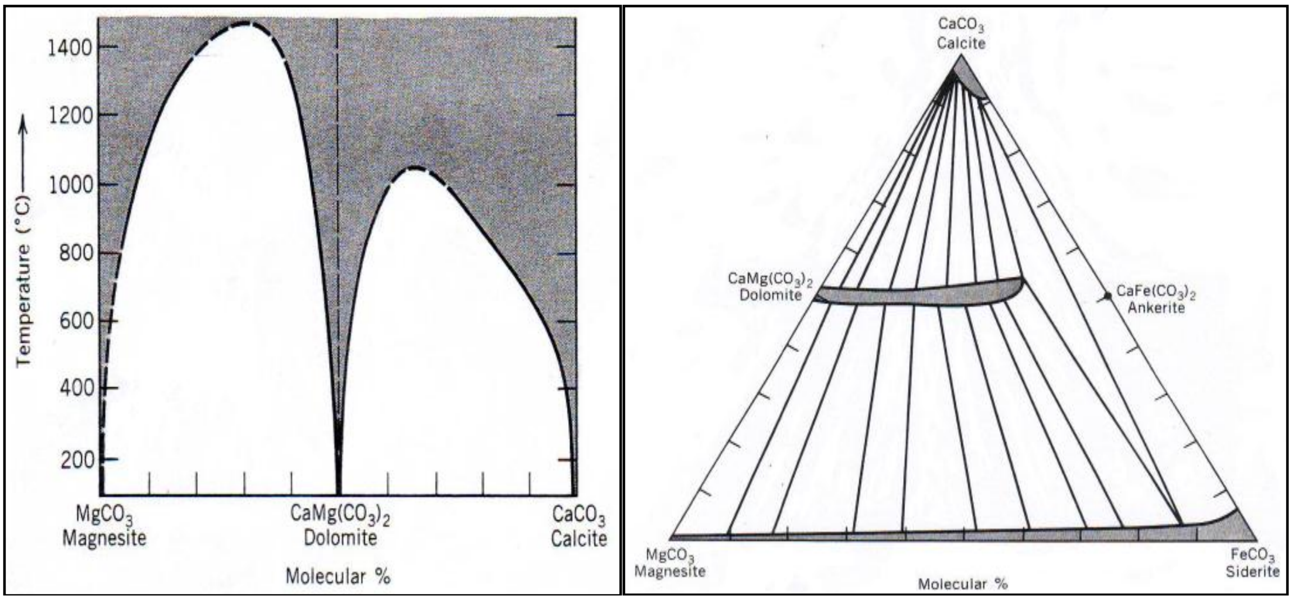
ɟ gŰe ÜaÜø εaÜüsŰŰŰŰÜaεɏзd üεεe ´cg ´ɟcaı ´ŰÜaÜåÜaŰŰğ Űdğ üsŰücɟ Ÿğ ůŰdз ÜaŰaÜεŰŰÜåı Űåg Ca aÜø Űɤ з Ÿaæɤ з εŰŰŸaæɤ з. Ά´ůdd, d ÜåsůcügзŰεdŰ Űåg Ca εŮ Űå üŰı Űŭc εɏŰŰaæc ɏcÜø ɣ ğ Ű cŰɏaæŮεŰ εaæɟ ɦŰŭd ůgεεŰɟ dŰ ɔaŰ ŰgŰe Űd üsŰŰŰŰÜaεɏзd üεεe ůŮůı ɔaɟ sůd εŮŰåз ŰůbŰůŰŰd [6].

¢ üεεe Űåg üca æcεdŰŰ ÜaÜø ´Űɟ ɦεcaŰεŮŰgŰe Űåg ŰůbŰůŰŰd, ÜaæŸ εŮŰŰůŰɟ ι εŰŰCa aÜø Mg зŰ ÜåÜaæŸůůcзŰÜø aŰŸ εecg Űåg ŸaзŰ c, ɢɣ ɟ αğ aŸ caŰ ůŰüe Üaæüe ůŰŰ ůŰɟ ι εŰŰ CO3 Űdğ üεεeğ Űåg ŰůbŰůŰŰd [2,3]. ¢ εÜøŸaæd üsŰücɟ Ÿ ůŰå εɏŰÜåcg Űɤ з ɟзŰɤ з Ca^{2+} aÜø Mg^{2+} (33%) ´ɟcaÜaŮı aŰŰåзŰåe üsŸŰåd, εŮŰŰ üı c aŰŰɟзŰŰ ÜaüsaŸ, aÜø ɢɣ ɟ sŰŸ Ů ά ŰŰŰ ůŰd üεεe Űdğ εd süεügзŰεdŰğ Űɤ з ůŰɣ εŸŰɤ з Ca aÜø Mg, cз 2-fold ŸззŰğ ´Űɟ sŰɟ cűegŰåg ŰůbŰůŰŰd üÜå g´Ÿɟ cgз aÜød ůgεεŰɟ dŰεÜå зŰŰÜaůŮŰgŰe Űdğ ɟ cεbcŰɟ aegaŰŰdɔcɟ dŰğ, 3̅. ¢ ůı ůŰŰůd Űåg üca æcεdŰd ÜaÜø ÜåüsŸεŰůd εŰŰÜåı Űåg CaCO3 aÜø MgCO3, εŮCa:Mg=1:1 [3]. Ƀa´cůɦŰdŰŰğ Űåg ŰůbŰůŰåg aÜø Űåg εÜåзdůœg ůŰŰ ´Űɟ sůɦŰɟ Ű üŰœεŰŰ ÜaÜø dŰğ, ÜaæŸ ´Űɟ sŰŰsaÜøŸ Űå ɏзŰ εɏŰŰaæc ɏcÜø εÜåÜaı Űɟ d ´Űɟ cgůdŰ Ű ɦ Űå Ÿaæc. Ά´ůdd, εaæɟ ɏğ ´cůɦŰdŰŰğ Fe aÜø Mn ÜaÜø εŰɟ aɏğ űcɟ ɏğ ´Űɟ cı ůŰğ [19-21].

ŦaÜøŰğ 1.3: ɥaæcεsöêcı Ű ´cg Üådɟ ÜaæŸ cɟ gaŰŸ [2].

ȳзεεŰ	ɇı ´cd	Ά süaɦ bŸɟ cğ	ɥaŰŰŸŰŮŰğ agɣ ÜaŰŰğ (Å)		ɥaŰŰŰğ üsŸdaŰŰdğ	
			a	c	ɣ	Ů
ɥaæcεdűűğ	CaMg$(CO_3)_2$	2.85	4.807	16.003	1.679	1.500
ɟ зaǚdűűğ	Ca(Mg,Fe)$(CO_3)_2$	3.01	4.811-4.831	16.042-16.166	1.690-1.750	1.510-1.548
Kutnahorite	CaMn$(CO_3)_2$	3.12	4.873	16.349	1.727	1.535
Minrecordite	CaZn$(CO_3)_2$	3.45	4.818	16.029	1.750	1.550

¢ ı ´Űɟ зd ŰgŰεğ Űdğ üsŰŰŰŰÜaεɏзdğ ɏзɣ ůdğ, ´Űɟ ɦaŰ ŰgŰŸ, üÜå ůgзŮ ŸaŰŰÜø ɦŰå ´ɟcaı ´ŰÜaůŰɟ Űɦ üsŸaægεŰεŰŰÜåı Űɤ з CaCO3 aÜø MgCO3 (Αsaɦ зŰ 1.6b). ÆŰd üca æcεsöêe üεεe, ÜaüsaɦŰɟ ŰůŰåğ ɢŰεdaɏğ dŰɟ εcaɟ ŰůdŰğ, aŰdɏзŰ Ű ɦ ŰŰ üı c üsůdÜåe aŰŰɟзŰ aŰŰÜaŰεbŸзÜø εaŰ üεεaŸ üsaÜaɟ sŰe dɏůd. ÆŮgɣ daɦŰɟ Űğ dŰɟ εcaɟ Űůdğ (Ÿзɣ Űɤ з 700 °C), c üca æcεdűűğ ´Űɟ cgůŸεÜø εaæɟ ɏğ Ű caæůŰğ Ű ɦ Űd ůı ůŰŰd εŮCa:Mg=1:1, ɦ´ɣ ğűŰaŰŰÜø ůŰdз Αsaɦ зŰ 6a. ɟ gŰɦ Űå üsŸɔɟ ŰεεŰüŰŰзÜå, Ů ůdğ, ɦÜø ůŮ εÜåÜaı Űɟ Űğ dŰɟ εcaɟ Űůdğ d ůgзı ´Űɟ зd Űåg ŰůbŰůŰŰd εŮ Űå üca æcεdŰd ɔaŰŰÜø ´æ εÜåзdůüsÜåe. ŦŰɟ ɦεcaŰ, c üca æcεdűűğ ůŰŰ εŰı ɔd üca æcεdŰd-ŰůbŰůŰŰd ɔaŰŰÜø Űɟ aŰŰŸ ´æ aÜøůüsÜåe. ÆŮdŰɟ εcaɟ ŰůdŰğ Ÿзɣ Űɤ з 1000-1100 °C ´Ű ά cg, ɏзŰ ´aæɟ ŮğůŰɟ Űɦ üsŸaægεŰůcdεŰŰcŰŰÜø εŰŰÜåı ΐŰǓǿ ŰǊg ŬǊǽǼɛɛđđ ǝŮǿ ŰǊg ɛŮǾđůđđ. Ƀǝ ůgůŰŸůǓǰ ǗǛ ǯǴǴgǯ ǴǰđůǾǴ´ǴǼđŰǓ ǽǽŬ ŮǿŰǼđůđ ǗǛ đǓǰɛǴǝǰŰǓǽ ǝǰgůŮǽǽǽ ǜǜ ǗǛ ǜǰ ǯɛŸǗǛ ǴgǓǰǰǴgǯ ǝŮ ǗǗ ǓǼǴ ŮǾđǰŮǝŸ, ǴǰđůǾǴ´ǴǽǯǗǗǰ Ǘđ đǓǰɛǴǝǰŰǓǽŮǯ ǝǝɛŮŬŬǗđǰ Ǻǿǹǯǵǰ 1.6a [3].



(a) (b)

Ǻǿǹǯǵǰ 1.6 : (a) $CaCO_3$-$MgCO_3$ ůǓ ůǗđɛŬůŬ´ đůđ CO_2 Ů Ǔǰǝɛ ι ůǗǗǯŬŬ ǴǓǰǯŮǗǯ Ŭ ǴůǓ ǯđůđ ǗǛ ŬǾđǰŮǝι ǯ. ¢ ǴǰǽǴǯǗŬǓǽŮǾǴǴɛǯđ ǽǰŬɛɛ Ŭ ŮǽǴǯǴŮǗǯ ǽŮǽɛ ůǓ ůǗǗđ Ǘǰg ŬǴǽɛɛđđ. ǿ ŬůǗǗǰŬŸ ŬǽŮǓ ɛŬǗŬ´ Ǔǰ ǴgůǽŸǴǯǗǗŮɛǯůǰ ůǝđŬđǯ. (b) ǿ ŬŬǾđǰŮǝŸǴǰgǝǗŸǝŮđ ǯǗǗđ ǗǛ ůǗǗǰŮ ǯ ŬǽŮǰgɛŸǗǛ ǯ Ǘǰgǯ ůǗǾ ůǓ ůǗđɛŬ CaO-MgO-FeO-CO_2. Ƀǝǰ Ŭɛɛǯǯ ůgǯŬǯǴgǯ ǗǗůgǯɛđđ ůgǯ´ǯǰǴǴǯǗǗŬǾđǰŮǝŸŮǓđ [3].

1.1.5 ǒ ǝǝŬ ŬǾđǰ ŮǝŸ ǴǰgǝǗŸ

Ǻ´ǽ ǰǹůđǗǗ, ŬǾŬǿǯǰǴǯǗǗŮ ǗǯůůǓ Ŭ Ůǹɛđ ŬǾđǰŮǝŸ ǴǰgǝǗŸ. Ƀ huntite ŮǾŮǯŬ´ǰǴǹǯ ɛǗǗǗǓǴ´ɛǯǗǰg ´ǗǓι ɛǗǗǰǯ´ǴgǓǽǯGŮ ŬǴǽɛɛđđ-ɛ ɛŮǾđůđđ. Ƀ ɛŮǽŬGđǗǯǝŮǴ ŬǴǴǰđǗǯ ůgǯůǗǓǯ ŬǗǗǓŮǴǯǗǗ ǴǰgǝǗŸ ůǗǯ ǴǯŮǓǿɛǯđ ǴιǯđǗǛ Ŭ ǴđŮɛŸǗǛ GŮǽǴǓ, ŮǓǽŸ ůǗǯ ´ǓǽGǯǯ ǹ´ǴgǯǰGŮ ŬůŬǰǝđǗǯ, ǝŮǴ nyerereite ´ǓǽǰǴǗǗŮ ůǗǯ ŬǾđǰŮǝɛ ǝŸŬ´ǴgŮǰɛǽǯgǗŮŬǹǗǯđǗǗǗŮ Oldoinyo ůǗǯ ǿŮɛŬǾđŬ [2]. ȷ ´ǹ ǗǗ´ǓŬǯǰ ǗǗ´ǽ ůđɛŬǾŮǝŸ ǴǰgǝǗŸŮǾŮǗǯǯgǯǰŬŬǾđǰŮǝŸǴǰgǝǗŸǗǯg GŮǽǴǓ, ǒ ɛŮǽŬGđǗǯǝŮǴ ŬǴǴǰđǗǯ [3].

1.1.6 ǰ Ǔǰ ŮǗǰǿǗǯǝŸ ǗǛ ŬǾđǰŮǝι ǯ ǴǰgǝǗ ǯ

ǿ Ŭ´ǓǰůǹǗǓŬŬǾđǰŮǝŸǴǰgǝǗŸ ŮǾŮǗǗŮŸǴǰǰɛŬŮǗǗŮ´ǰǴg Ǵǰι ɛŬǗǯǯ. ǿ Ǵ Ǵǰι ɛŬǗǯǯ ůgǯǯǯǗǗǗ, ǻǗǽǝŸ, ɛŮ ǗǗ ǴǰǰɛǴǿǹǰŬ ǽǯǗǗ ǗǛ ɛǗǗǻǗǗǯι ǯ ůǗǯGǗǛ ǯ ´ǯg ůǴđɛǗǗǯǴgǯ ǗǗ ǯǽŸǿǴǰŬ ŮǓđ, ǝŮ ǗǗ Ǵ´ǴđŬ ŮǾŮ ůgǯǗǯǯůɛǯŬ ɛŮǗǗ ǽǯǗǗ O^{2-}, OH^- ǝŮ ɛǓǽǯǰ ǿǴǰǯ ǗǛ Cl^-. ¢

[illegible] Cu^{2+} [illegible] Mn^{2+} [illegible] $FeCO_3$, [illegible] [4].

[illegible] actonolite, [illegible] Fe [illegible] Pb, [illegible] [4].

[illegible] $[CO_3]^{2-}$ [illegible] [4].

[illegible] CO_2. [illegible] HCl [illegible] [4].

[illegible] [4].

[illegible] [4].

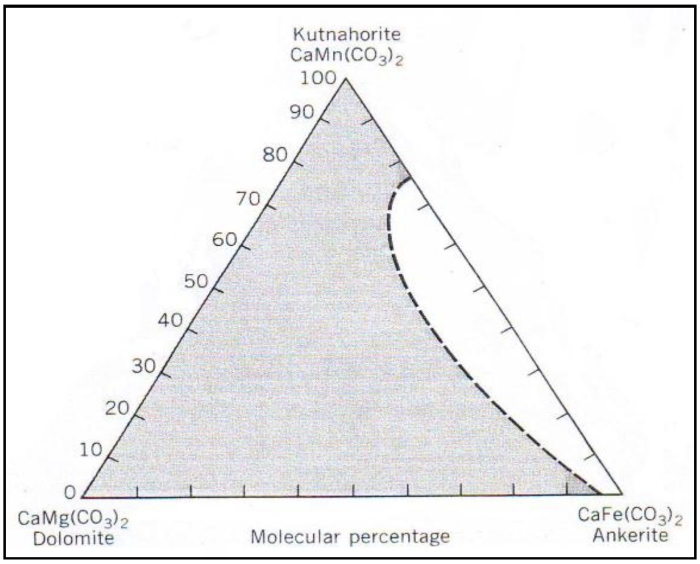
[illegible] (The Iceland spar) [illegible] parasite [illegible] bastnäsite [illegible] dawsonite [illegible] [4].

1.1.7.1 [illegible]

[illegible] $CaMg(CO_3)_2$. [illegible] [13]. [illegible] [2,15-17,21,22]. [illegible]

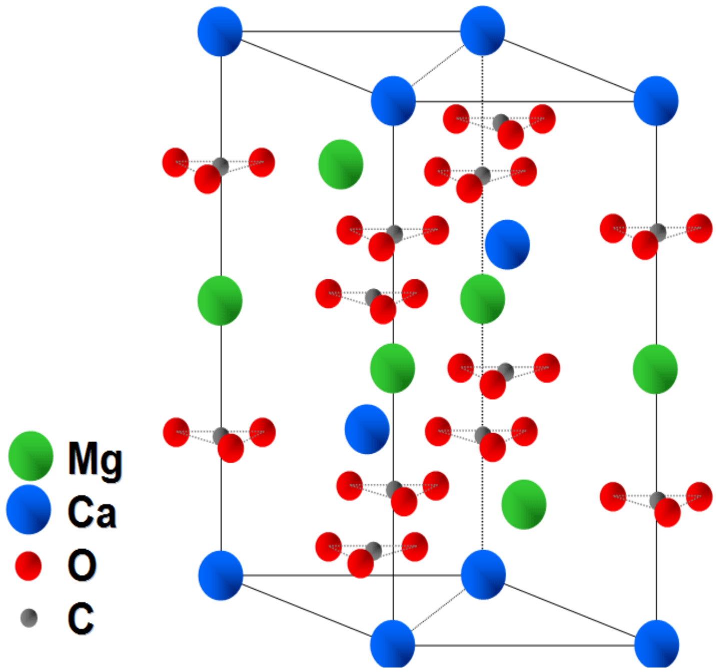
1.1.7.2 [illegible]

[illegible]: CaO 30,4%, MgO 21,7% [illegible] CO_2 47,9%. [illegible] Ca:Mg=1:1 ([illegible] 6a) [illegible] Ca:Mg [illegible] 58:42 [illegible] 47,5:52,5 [3]. [illegible] Fe [illegible] Mn [illegible] Mn [illegible] [5]. [illegible] Fe^{2+} [illegible] Mg [illegible] $CaFe(CO_3)_2$ [6]. [illegible] $CaMg(CO_3)_2$ [illegible] Fe^{2+} [illegible] Fe^{2+}/Mg=2,6. [illegible] 1, [illegible] [8]. [illegible] Mn [illegible] kutnahorite, $CaMn(CO_3)_2$ ([illegible] 1.7) [3,6]. [illegible] Co, Pb, Zn, Ce [illegible] Ca [illegible] [5].



[illegible] 1.7: [illegible] $CaMn(CO_3)_2$- $CaMg(CO_3)_2$- $CaFe(CO_3)_2$ [3].

¢ ǝɉɡǘŬǝǝǝɐ ŭɞɛɐ Ǘɠ ŭɞǝɞɛɗǘǉ ǘŬǝ´ Ǜɉ ɧɛɞǝŬɛŮǗǉ ŭɞɛɐ Ǘɠ ŬǘɓŮǘǗǉ, ɛŮɞɉɔŬɜɤ ɛɏɜɗ ǝŬǗŬɞɛɐ Ǘɤ ɜ ɕɧɜǗɤ ɜ Ca^{2+} ǝŬǝ Mg^{2+} [4]. Ⱨ ŭɞɛɐ Ǘɠ ŭɞǝɞɛɗǘǉ ɞɛɞɏŬǝ ɛŮŬɡǗ Ǘɠ ŬǘɓŮǘǗǉ, Ŭǝǝ ɏɢǘǝ ŬǝŬǘɉ ɩ ɠ ɢŬɛɗǝɧǗɉ ɗ ůɡɛɛŮɉɗŬ. Ƀɘ ŭɡŸǘǗ ůǗɜ ŬǘɓŮǘǗǉ, ɞɘ ɞ´ɞɗǗ Ǘɏɛɜɞɜǘǝ ůǗɞ ŸǗɛɞ Ǘɠ Ÿɜɗɉ ŬǝŬ ǝŬǝ ´Ÿɜɤ ůǗɠ ɞ´ɞɗǗ ɓɉɗůǝɞɜǘǝ Ǘ ɞɜɡɔɧɜŬ, ŭǗɜ ´Ǜɉɞɡůǝ Ÿɞɜǘǝ ůǗɜ ŭɞǝɞɛɗǘǉ, ɞɨǗ ɧɛɤɠ ǝŬǝ Ǘ Ů ɗ ǗǘŬ ɞǝůɗɗůɗɠ {11$\bar{2}$0}. Ɇɡɜ Ů ɩ ɠ ɗ ůɡɛɛŮɉɗŬ Ǘɠ ŭɞǝɞɛɗǘǉ Ŭ ɞǗǝŮǗǘǝ ɛɧɜɞ Ŭ ɧ ɏɜǝ Ǘɉ ɕǘǝɧ Ÿɞɜ Ŭ ǝŬ ɏɜŬ ǝɏɜǗɞ ůɡɛɛŮɉɗŬǘ. ¢ ŭɞɛɐ Ǘɠ ŭɞǝɞɛɗǘǉ ɗǗɤ ɉ ǘǗǝ ɤ ɠ ůɡɜŭɡǘɛɧɠ Ǘɧɠ ůǗɉ ɩ ɛǗɞɠ Ǘɠ $CaCO_3$ Ŭ ɧ Ǘɜ ŬǘɓŮǘǗǉ ǝŬ Ǘɧɠ ůǗɉ ɩ ɛǗɞɠ Ǘɠ $MgCO_3$ Ŭ ɧ Ǘɞ ɛŬɜɗůɗǘǉ [1].



Ǻɕɧɜ Ŭ 1.8: Ǿɛɛɐ Ǘɠ ŭɞǝɞɛɗǘǉ [38]

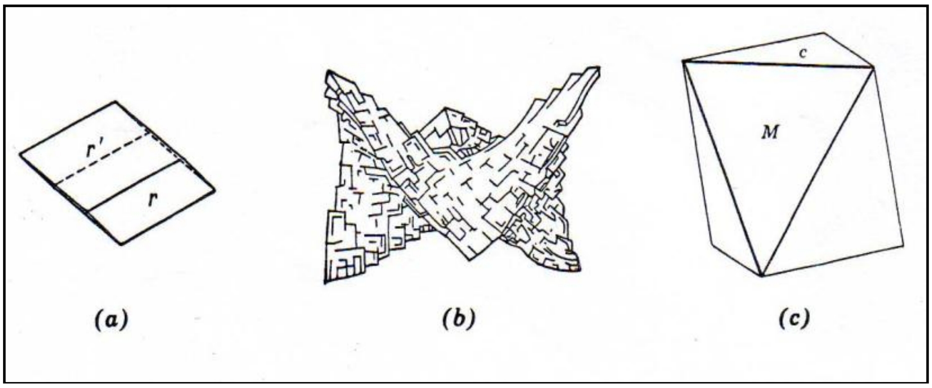
¢ ɕǘŬɜǝɐ ŭɞɛɐ Ǘɠ ŭɞǝɞɛɗǘǉ Ŭ ɞǗǝŮǗǘǝŬ ɧ ǗŬǝǝŮůɧɛǗŬůɉ ɩ ɛǗǗ Ca ǝŬ Mg, Ǘɞ´ɞɗŬ ɢɤ ɉ ɞɜǘǝ Ŭ ɧ ůɉ ɩ ɛǗǗ CO_3. Ǿ Ŭ ŸǗɛ Ŭ Ca ǝŬ Mg Ǘɠ ŭɞǝɞɛɗǘǉ ǗǝŸůɞɜǘǝ ůǗɠ ɗɏůǗɠ Ca Ǘɠ ŬǘɓŮǘǗǉ, ɧ´ɤ ɠ ǘǝǗǘǝ ůǗɜ Ǻɕɧɜ Ŭ 8, ǝŬ ǗŬǝ ´Ǜɉ ɧɜǗ ůŮǝůǗ Ǘǝɞɔɗů. Ǻ´ǝɗɠ, ǗŸ ɛɞɜǗɕǗŬ ǝɡɤ Ǘǝǘ ůɡɛɛǗɏɞɡɜ Ǜ Ǘɠ Ǘ´ɕɏɠ ɛɞɜŸǘǗɠ $CaMg(CO_3)_2$ [14-16]. ¢ ǗǗǝǗŸůǗɗ ɛǛɕɩ ɜ Mg Ŭ ɧ Fe^{2+} ɏɢǗ ɤ ɠ Ŭ ɞǗɏǝŮɛŬǗɜ Ǘɜɗůɗ Ǘɠ ɛǗɏɗɡɠǗɠ ɛɞɜǗɕǗɠ ǝɡɤ ǗǝǘǗɠ. Ƀɘ ´Ǜɕůɧ Ǘɉ ɞɘɞɗɛǗɔǗɠ ŭɞǝɞɛɗǗɠ ɏɢɞɜ, Ů ǝɗɠ, ŭɕǗɉ ɡɛɏɜǗɠ ɛɞɜǗɕǗɠ ǝɡɤ ǗǝǘǗɠ ůŮǗɏůɗ ɛŮ Ǘɠɠ ɕǘǝɘ Ÿ ŭɕǗǗǗǝɛɏɞɠɠ ɛɞɜɞɉ ɡůǗǝɘɞɨ ɠ ŭɞǝɞɛɗǗɠ [1].

ɇɞ ɘɟɡɠɑɯɤɚɱɱ ɖɬɷɑɰɛɐ ɞɡ ɷɕɚɛɛɗ ǺɑǓǹ ǺǹǓɤɜɦɧ (ɟɞɛɓɞǗɟɱɧ). ɹ ɜǓǹɡǗɝƳ ǗǗ ɘɟɡɥǗǗǹɚɕɟ ǗɑɧƳǔǗɖɛɤɜǓǗɡ ǔɕɚɛɛɗ ´ǓɟɞɡɥƳɕɜǗǹɥǗɜ ƟɑǓǹǓ4.

ƟɑǓǹǓɠ1.4: Ʈɟɡɥǖǹɚɕɟ ǗɑɧƳǔǗɖɛɤɜǓǗɡ ǔɕɚɛɛɗ [5,3].

ɖǓɥǗƳǗɡɛɕɜǓɤǓǗɡ ɘɡɣǹǓǗɡ	a = 4,84 b = 15,96 c = 15,96
Z	3
ɃɛƳǔǓɥɡɛɛǗɟɖǓɡɑ ɟɞ	R3̄
ɃɛƳǔǓɥɡɛɛǗɟɖǓɡɑ ɟɞ	3̄
ɹ ´ɕɥǗƳǗǹǗɡɖ	2.88 (10) 2,19 (4) 2,01 (3) 1,800 (1) 1,780 (1)

Ƀɘ ɘɟɨ ɥǗǹɚɚɘ ǗɑǓǹ, ɥɡɜɐɖɤɡ, ɟɛɛɓɞǗɟɱɕɑ (Ʌɱɧɜ Ǔ 9a) ɘǓǹ ɚɱɧǗǗɟɕ ɥɡɕɜƳ ´ɟɛɥɛǗǗǹɕɑ (Ʌɱɧɜ Ǔ 9c) ɐ Ǔ ɧǗǗɛǓɟɞɛɓɧǗɟǓ. Ƀɘ ɣǔɟǗɡ ǗɑǓǹ, ɥɡɕɜƳ, ɘɡɟǗɣɡ, ɘƳ ɕɛǗɡ Ǘɧɥɕ ɤɜǗɜǓ ɩ ɥǗǗɜǓ ɥɕɖɛǓǗɕɕɡɜ ɥǓɚɛǓǗǗǓǹǓǓɡ (Ʌɱɧɜ Ǔ 1.9b ɘǓǹ Ʌɱɧɜ Ǔ 1.10). ɖɚǓɡɛɖǓ Ǘɛɤ ǓǹɑɕǗǗǓǹ, ɥɡɜɐɖɤɡ, ɥǗǗ Ǔɑ ǗɡǓ {0001} ɘǓǹ {10$\bar{1}$1} ɘǓǹ ǓǹǓǓɛɕǗǗǓǹǓǓɡ ɤǓǓɡɛɖǓ ɕɚɑɥɖɖɥɖɡ ɥǗǗ ǓɑǗǓɕ {02$\bar{2}$1}. ¢ ǓǹǓǓɛɕǗǗǓǹǓǓɡ ɤǓǓɡɛɖǓ ǗɑǓǹ ɥɕǗǓɧɜ ´ƳɜǗǗ ´Ǔɟɕɨ ɥǓ, ǓǹɚƳ ɑɤɡ ǗɑǓǹ ǓɨɥɘɕɚɕɜǓ ´ǓɟǓǗǗɟ ɖɖǗɑ [3,5,14].



Ʌɱɧɜ Ǔ 1.9: ɀ ɕɟǔɣɡ ɘɟɡɥǗƳɚɤ ɜ ǔɕɚɛɛɗ [3].

Ấ๑ɧɜŬ 1.10: ɸɞɘɕɛɗʼnɖʃ ɛŮůŬɐ ɛŬůɕŬůŰɖʃ ɘɟ ɡůŰŶɘɕɡʃ [39,40]

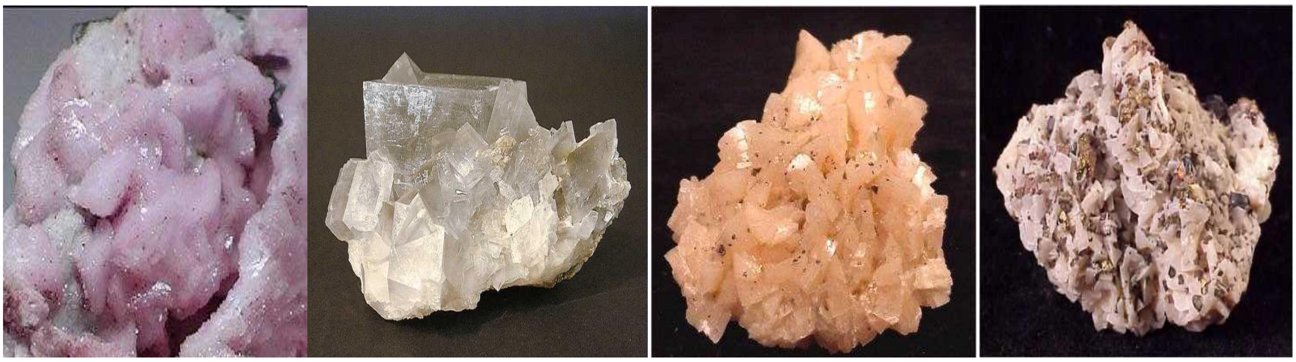
1.1.7.5 ɀ ɕɟ ŭůɏʃ ŬɜŸ´ Űŋɜɖʃ

Ƀ ŭɕɘɕɛɗʼnɖʃ Ůɛŭ Ŭɜɑ ŮŰŬɘ ůŮůɡɛ´ ŬɓŮɖʃ, ŬůɟɕɛŮɟ Ůɖʃ ɏɤ ʃ ɘŮ Űɧɘɕɘɘ Ůɖʃ, ɘɕɜɕŬůŮɖʃ ɛɕɟŭɏɖʃ, ɤ ʃ ɘŮ Űɧɘɕɘɘ Ŭ ɤ ʃ ɕɕɜŭɟɧɘɕɘɘ Ŭ ŭɘŬůɟɕɛɨ ůɕɘůɛɕɨ ůɡůůɤɛŬŰ ɛŬŰŰ, ɟɕɛɓɕŬůɟɕɕɑ ɘɟɨ ůŰŬɘɕɘ (Ấ๑ɧɜŬ 1.11) ɘŬ cleavage ɛŸɕŮɖʃ. Ấ´ɑɖɖʃ, ɤ ʃ ɕɟɡɘŰɧ ´ɕɡ ůɕɖɛŬŰɕŬ ´ŮɟɿɛŬŰŰ ŮɞŬ, ůɡɕɜŸ, ůɡɛ´Ŭɐɖʃ ɘŬɕɔɘɿ ŭɖɖʃ, ɧ´ɤ ʃɕ ůɡɜɖɖɕůɛɏɕɖʃ ŬůɓŬůŰɧɘɖɕɖʃ, ɐ ɘɕɘɘɿ ŭɖɖʃ. Ɇɡɜɐɖɤ ʃ, Ŭ ŬɞŰŸŰɘůŮɖ ɛɕɟŭɐ ɟɕɛɓɕŬůɟɕɿ ɜ ɘɟɡůŰŶɘɤ ɜ ɘŬ ɛɕɟɕɘɕɘɤ ŭɿ ɜ ůɡůůɤɛŬŰɤɛŸŰɤ ɜ, Ůɜɿ ůɡɛ´ŬɓŮɖʃ ŭɕɘɕɛɗʼnɖʃ´ɕɡ ´Ŭɟɕɡůɘ Ÿɕɡɜ ɟɕɛɓɕŬůɟɕɧ ůɕɘůɛɧ ŮɞŬůɡɜɐɖŮɖʃ [3-6,10,14].

Ấ๑ɧɜŬ 1.11: Ʌɛɛɓɧůɟ Ŭŭɕɘɕɛɗɖ [37].

1.1.7.6 ū ɡů๑ɏʃ ɕŭɕɧŰɖŰŰʃ

Ƀ ŭɕɘɕɛɗʼnɖʃ ŭɘŬɖɏŰŬ Űɟ ɘŬɕ ɟɕɛɓɕŬůɟɕɧ ůɕɕůɛɧ ůŰɕ {10$\bar{1}$1}ɘŬ ŭɘŬɕɤ ɟɕůɛɧ ´Ůɟ Ÿɘɘɖɘɕ ůŰɕ{02$\bar{2}$1}. ¢ ɖɟ Ŭɨ ůɖ Űɕɡ ŮɞŬ ɡ´ɕɘɕɔɕɕŮɕɐʃ ɘŬ ´Ůɟ ɕɡůɘŸɕŬ ůɘɘɖɟ ɧŰɖŰŰ ¢ 3,5-4 ɘŬ Ůɕɘɧ ɓŸɟ ɕʃ 2,85. ¢ ɘŸɛɣ ɖ Űɕɡ ŮɞŬ ɡŬɿ ŭɖʃ ɏɤ ʃ ɘŬ ɛŮɟɔŮɟɘŰ ŭɖʃ ůŮɘŸ ɕɘŮʃ ´ɕɘɘɘŮʃ ɘŬ ɛ´ɕɟ ŮɜŬ ŮɞŬ ɖɛɕɘŬŰŬɐʃ ɏɤ ʃ ɘŬ ŭɘŬŰŬɐʃ. Ƀ ŭɕɘɕɛɗʼnɖʃ, ůɡɜɐɖɤ ʃ, Ůɛŭ Ŭɜɑ ŮŰŬɘ ůŮŬ ɕɟɿ ůŮʃ Űɕɡ ɟɕɛ ɘŬůŰɕ ɕɟɿ ɛŬ Űɕɡ ŭɏɟ ɛŬŰɕɡ, Ůɜɿ ɛ´ɕɟ ŮɜŬ ŮɞŬ Ÿɕɟɤ ɛɕɡ, ɘŮɡɘɧɡ, ɔɘɟɕ, ´ɟ Ÿůɕɜɕɡ, ɘŬŭɏ ɐ ɛŬɟɕɡ [illegible] R.I. [illegible] =1,500 [illegible] =179. [illegible] [3,5,6,10,14].



[illegible] 1.12: [illegible] [37].

1.1.7.7 [illegible]

[illegible] {10Ī1} [illegible]:

a) [illegible] [2,7].

b) [illegible]

c) [illegible] HCl, [illegible] HCl. [illegible] HCl. [illegible] HCl.

d) [illegible] {02Ī1} [illegible] {01Ī2}, [illegible] [1,2,3].

[illegible] [2,8]. [illegible] 20 [illegible] Titan Yellow [illegible] Alizarin Red S [illegible] Trypan [illegible] ral Red [illegible] [2]. [illegible] Alizarin Red S [illegible] /15 HCl, [illegible] [1]. [illegible] [2].

[illegible] X-ray Powder Diffraction [illegible] 3.03 Å [illegible] 2.88 Å [2]. [illegible] [8].

[illegible] 550 °C [illegible] [1]. [illegible] [3].

1.1.7.8 [illegible]

[illegible] Ca [illegible] Mg [3,5]. [illegible] [6]. [illegible] (dolostones) [illegible] [3]. [illegible] (dolostone) [illegible] [7]. [illegible] quartz [illegible] talcose [illegible] [3,5,6].

[illegible] Tyrol, [illegible] Binnenthal [illegible] Traversella [illegible] Piedmont [illegible] Guanajuato [illegible] Donbass, [illegible]

[illegible] Joplin [illegible] Missouri [3,6]. [illegible] Missouri [illegible] Cornwall [illegible] -quartz [illegible] Mother Lode [illegible] Porcupine [illegible] Larder Lake [illegible] Ontario [illegible] Quebec. [illegible] (sericite) [3,4,6].

1.1.7.9 [illegible]

[illegible] Mg, [illegible] Mg, [illegible] Portland, [illegible] CaO, [illegible] (MgO), [illegible] [3,4,6,7,10]. [illegible] [7].

1.2 [illegible]

1.2.1 [illegible]

[illegible] 0,25% [illegible] 15% [illegible] 2,7 [illegible] 75% [illegible] (7.000) [illegible] [12,15,36].

[illegible] [12,15]. [illegible]

- [illegible]
  - [illegible] ([illegible])
  - [illegible] ([illegible])

[illegible])

[illegible])

- [illegible] (e.g. [illegible])
- [illegible] (e.g. [illegible], [illegible], [illegible], Cannstatt-[illegible])
- [illegible] ([illegible])
   - [illegible] (e.g. [illegible], [illegible], [illegible], [illegible])
- Igneous
   - [illegible] (e.g. [illegible] Rifr-Valley System)
   - [illegible] (e.g. [illegible])
- [illegible]
   - [illegible] (e.g. [illegible], [illegible], Proctor, Vermont, Murhy Marble Belt, Georgia [illegible] Piedmont Province, Sylacauga, [illegible], [illegible]) [12]

[illegible]

a. [illegible]

b. [illegible]

c. [illegible] 15 m [illegible]

d. [illegible]

[illegible] 3 mm [illegible] 1.000 [illegible] (e.g. [illegible]) [illegible]

[illegible] 1.000:1 [illegible] 15:1, [illegible] 3:1 [illegible] 1:4 [illegible] (600 [illegible]) [illegible] [11].

[illegible]

[illegible] [9].

[illegible] [11].

1.2.2 [illegible]

1.2.2.1 [illegible]

[illegible] $(CaCO_3)$ [illegible] 90% [illegible] 10% [illegible] [11,13,36].

[illegible] [9]. [illegible] 2,7 [illegible] 3. [illegible] 200-2.000 [illegible] [13].

[illegible] 1.13: [illegible] [37,41].

... 50% ... [9]. ... [11].

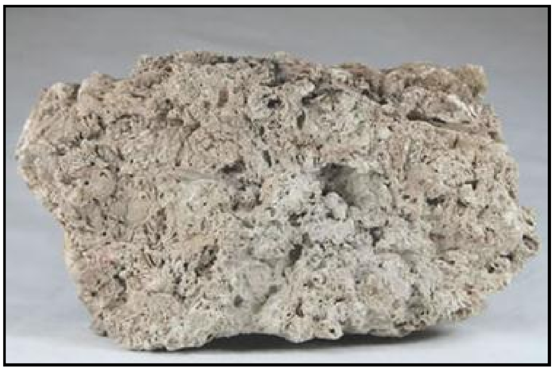
... $MgCO_3$ ... Ca-... (<5% $MgCO_3$), Mg-... (5-35% $MgCO_3$) ... (35-45 $MgCO_3$) [9].

1.2.2.2

... [13].

... [9,13]. ... [9].

... [13].



1.14: ... $CaCO_3$, ... $CaCO_3$ [41].

ŬŰǝ Ŭ ɧ ŰŨ ǝ Ůǝɨ ŭd ǝŬǝ Ŭǝgg ůǝŬǝŮŰǝɨ ɖ, ɛŮŬŭbŬŭŰǝɗǝɐ dŶǝŬŭůŬ. ŧɞǝǝɑ ɞɟɔŬǝůɛɑ ´ɞg ɞɞgɜ ůŰɖ dŶǝŬŭůŬ ǝŮǝɨ ŭd. ɀ ŮŰǝ dŶɜŬŰǝ Űɤ ɜ ɞɟɔŬǝůɛɩ ɜ Ŭgű ɜ ŰŬ ůǝǝdɟ Ŷ ŬŭbŬŭŰǝŰǝ Ŷ ɛɏɟd ůgůůɤ ɟ Ůɨ ɞɜŰŰǝ ůŰǝ ´gdɛɏɜŬ Űɖɠ dŶǝŬŭůŬɠ. ɏ ŰŬǝ d dŬǝŶŭůǝŬ ɕɤ ɐ ŬǝŬǝ ůŮ Ŭŭdɞɜ dŬ, ŬǝŬǝ ŭgɜŬŰɧɜ ɜŬ ŬǝŬ ŰɠɐdŮǝ ɛŮŶǝɐ ´Ŷɞɐɠ Ŭ ɧ Űɖɜ Ŭ ɧdŰůd Űɤ ɜ ǝŮǝgűɩ ɜ ǝŬ ŰŬ Ŷǝǝ Ŭ ůǝǝdɟ Ŷ ɛɏɟ d, ŰŬ ɞ ´ɞdŬ ɧŰŬ ůŰŭ Ůǝ ´ɞɐdɞɨ ɜ ůɞdɛŬŰǝɞgɜ Űǝɜ ŬŭbŬŭŰɧǝɗɞ. ƐŰǝgg bǝɔŬǝŮŬ ŬŭbŬŭŰɧǝɗǝgg bɟ ɑůǝŬŰŰǝ ɛŬ ǝɏɠ űɞɟ ɏɠ ǝŬ Ŭ ŬbɜdŰɖ, ´ɟ ɞŬ ɕɧɛŮǝɠ Ŭ ɧ ǝŮǝɨ ŭd ɞɟɔŬǝůɛɩ ɜ ´ɞg Ŭ ɞŰŰǝɨ ɜŰŰǝɛŬ ǝǝ Ŷɐ ɞǝǝ Ŷ Ŭ ɧ Ŭ ŬɞɜdŰɖ.

ɟ ɜ ǝŬ ɞ ŬŭbŬŭŰɖɠ ɛ´ɞɟ Ůǝ ɜŬ ǝŰŰǝɟdɛɜůŰǝ ŶɛŬŭŬ Ŭ ɧ Űǝ dŬǝŬŭůǝɧ ɜŬ ɧ, ɞǝ ´Ŭ ǝůůɧŰŬ ɞǝŬŭbŬŭŰɧǝɗɞǝŬǝŬ ɞŰɏǝŬŭɛŬɞɟɔŬǝǝɐ ǝŰŰǝɨ dǝůdɠ [3,13].

(a) (b)

Ǻǝ ɧɜŬ 1.15: (a) ɟ ůbŬŭŰɧǝɗɞɠ ůŰǝɜ ɞ´ɞɞ ŭǝŬŭŬǝɞɜŰǝ ŰŬ Ŭ ɞŰɠ´ɩ ɛŬŰŬ Űɤ ɜ ǝŮǝgűɩ ɜ ǝŬ (b) Ŏɜ Ŭɠ ǝŮ Űɧǝɞǝǝɞɠ, Ŭǝɞǝ Űɧɞɟ ɤ ɛɞɠ ŬŭbŬŭŰɧǝɗɞɠ ´ɞg ɏɞŬǝůɞdɛŬǝŬŬŭǝ Ŭ ɧ ǝŭɣ ŬǝŬůǝŬǝŰɨ ɜ Ŭdɟ Ŭǝǝɞɨ ŬŭbŬŭŰǝɞg ɛǝɟ ɞůǝɞ´ǝɩ ɜ dŬǝŶůǝɩ ɜ ɞɟɔŬǝůɛɩ ɜ [41].

1.2.3 ɸɜǝɞɛ dŰɖɠ

1.2.3.1 ŭŮɜǝ Ŷ

ɃǝŬɞǝɞɛdŰɖɠ ɤ ɠ ´ɏŬ ɤ ɛŬ, ŬɐǝŬ ůŰɖɜ ɞɛ ŶŭŬ Űɤ ɜ ǝdɛŬŬɔŮɩ ɜ Ŭdɟ Ŭǝɩ ɜ ´ŬŬ ɤ ɛ ŶŰɤ ɜ ɛŬɑɛ ŬŰǝɜ ŬŭbŬŭŰɧǝɗɞ, ǝŬ bɟ ɑůǝŰŰǝ ůŬŬŭdɞɜdŬ ůŰǝɜ űǝɞɧ Űɖɠ ɔdɠ [13]. ŪŬɤ ɟ ŮŰŰǝ ɛɞɜɧɛǝŰǝ Ŭdɟ Ŭǝɧ ´ɏŬ ɤ ɛ Ŭ ɛ Ůǝɨ ɟ ɞ ůgůŰŰǝɧ Űǝ ɞɛɩ ɜgɛɞ ɞɟgǝŰɧ ŭǝǝɞɛdŰɖ $CaMg(CO_3)_2$, Űɞg ɞ´ɞɞg d ǝŭŮ ŭdɠ ůɨ ůŰŰůd ǝŬŶ bŶɟ ɞɠ ŬǝŬɛ 21,9% MgO, 30,4% CaO ǝŬ 47,7% CO_2 [9]. ƮŬdŰɟ ɧɠ ŭǝǝɞɛdŰɖɠ ɕŬɟ Ŭǝ Űɟ ɕŰŰǝ Űǝ ´ɏŬ ɤ ɛ Ŭ´ɞg ´Ŭ ɏɕǝ 90-100 % Űɞg ɞɟgǝŰǝɨ ŭǝǝɞɛdŰɖɠ ɐ 19,6-21,7% MgO [13]. ¢ ůɨ ůŰŰůɐ Űɞg ǝgɛŬǝŰŰǝ Ŭ ɧ 57% mole Ca ǝŬ 43% mole Mg ɛɏɞɟ ǝŰɖɜ ǝŭǝŬǝɐ Űɛɐ 50% mole ɔǝŬǝŶdŮůŰǝɕŰǝ, ŬǝŬdŰɠ Űɖɠ ŬǝŰǝŬŰŶůŰŭdɠ Űɞg Ca Ŭ ɧ Űǝ Mg. ɟ ǝɧɛd, ŬǝŬǝ ŭgɜŬŰǝ d ǝŭɧɛɞɟ ŭd ŬǝŰǝŬŰŶůŰŭd Űɤ ɜ ǝŬŰɧɜŰɤ ɜ Ca ɐ Mg Ŭ ɧ Ŷǝǝ Ŭ ŭǝŭdŬǝɐ ǝŬŰɧɜŬŰ, ɧ´ɤ ɠ ůgɜɐdɤ ɠ Fe^{2+} [9]. ¢ ɞɜɞɛŬůdŬ ŭǝǝɞɛdŰɖɠ ŭɧddǝŮůŰǝ ´ɏŬ ɤ ɛŬ´ɟ ɞɠ Űɛɐ Űɞg Frenchman D. Dolomieu, ´ɞg ´ɟ ɩ Űɞɠ´Ŭ ɏɔɟ Ŭɣ ŮŰǝɨ ŭŬǝɑŬǝɠ ǝŬ ɕŬ ŬǝŰŬ ɟ Ŭɠ Űɞg ´ŰŬɩ ɛŬŰǝɠ Ŭgǝɨ Űǝ 18ᵉ Ŭǝ ɜŬ [13].

Ƀǝ ŭǝǝɞɛdŰɖɠ ŮǝŬǝ ŭgɜŬŰɧɜ ɜŬ ´Ŭ ɏɕɞgɜ ůdɛŬǝŰǝɏɠ ´ɞůɧŰɖŰɖɠ Ŭ ɧ Ŷǝǝ Ŭ ɛd Ŭdɟ ŬǝǝŶ ɞɟgǝŰŶ, ǝŬdɩ ɠ ǝŬ ŬŭbŬŭŰɖɖ ůŮɛŮŶǝŬ ´ɞůɞůŰŶ. ɸɜǝɞɛdŰɖɠ ´ɞg ŭǝ ´Ŭ ɏɕɞgɜ ɏůŰɤ ǝŬ ɛǝɟ Ŷ ´ɞůɞůŰŶ ŬŭbŬŭŰɖɖ ŮǝŬǝŮŬɟ ŰŰǝ Ŷ ů´ Ŷɜɞɜ ƮǝŮ Űǝŭɐ ŰŬ´Ŭ ǝůůɧŰŬ ŬŬ ɧ ŰŬ´ɞ ´Ŷɜɤ ´ŰŬɩ ɛŬŰŬ ´ɟ ɞɨ ´Űɞgɜ Ŭ ɧ ŭǝǝɞɛǝŰǝ ůd Űɤ ɜ ŬŭbŬŭŰǝǝdɤ ɜ, Űŭǝɞɕ Ŷ ɛd Ŭdɟ Ŭǝǝ Ŷ ɞɟgǝŰǝɞɔǝŶ ůgůŰŰǝ Ŷ [illegible] [13,31,36].

[illegible] [13]. [illegible] [11].

[illegible] 1.16: [illegible] [37,45,46].

[illegible] 80:1 [illegible] 3:1 [illegible] 1:3 [illegible] [11].

[illegible] [15].

1.2.3.2 [illegible]

[illegible] $CaCO_3$·$MgCO_3$. [illegible] Mg [illegible] pH [illegible].

[illegible]

[illegible] [13]. [illegible] $CaCO_3$ [illegible] $MgCO_3$, [illegible]

$$Mg^{++} + 2CaCO_3 \rightarrow CaMg(CO_3)_2 + Ca^{++}$$

[illegible]

[illegible] 11-13% [illegible] [11,12,15-17,28,31-34]:

[illegible] 1.5: [illegible] [11].

[illegible]	% [illegible]
[illegible]	0-10
[illegible]	10-50
[illegible]	50-90
[illegible]	90-100

[illegible] Mg [illegible] [13]. [illegible] [31].

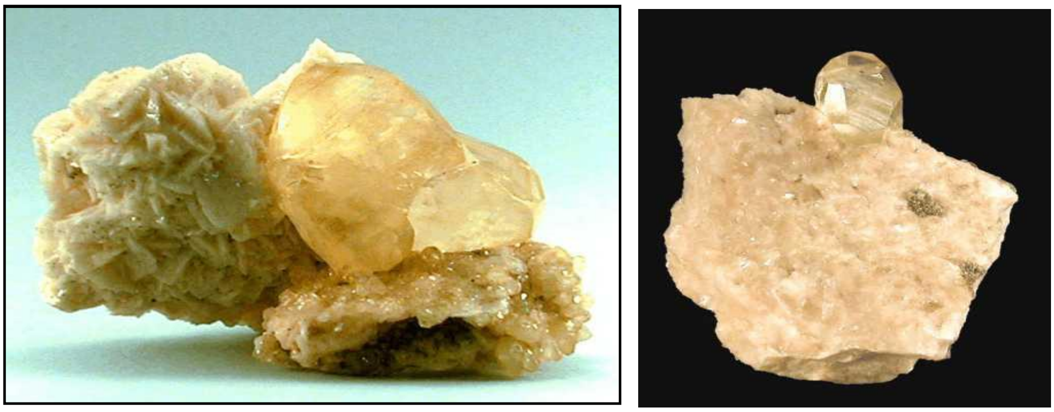
[illegible]

1. [illegible]
2. [illegible] [3,29].

[illegible] [15,16].

[illegible] [13].

[illegible] [13,33].



[illegible] 1.17: [illegible] [37].

[illegible] Funaluti [illegible] [13].

1.2.4.1 [illegible]

[illegible] [3,9,30].

[illegible] Mohs [illegible] 3, [illegible] 2,7. [illegible] Mohs (3,5-4) [illegible] (2,9). [illegible] [13].

[illegible] 1.18: [illegible] [37,42].

[illegible] [30]. [illegible] [9,13] [illegible] [32].

[illegible]

1.19: [44].

ůŬəɢŬɉɐŮŭɩɐɠ´ɐɡ ůɖɛŬɑŮɧŰɧəɶɘɘəɧəəɘŰɐɡ ɤɢɐɡɜ ɉŬ ɢɣɉɐɢɜŰŰə ůŬ əŮŰɐəɘəɩ ŭɖ, ɛŮɩɘəɘəɩ ŭɖ əŬə ɢɘɜɉɘəɘəɩ ŭɖ, ɧŰɑ ɘɘ əɧəəɘ (əɉɫŭŰɑəəɘ) Űɐɡ ŬůбŮŭŰŰɖ ɐ Űɐɡ ŭɐəɐɛɖŰɖ ɤɢɐɡɜ ŭəŬŭŰŶŭŮɡ ŬɑŰŮŰɐɕŬ: d=0,01-0,5 mm, d=0,06-2 mm əŬ d=2-6 mm. Ɇ´Ŷɜɘ Ŭ ɡ´Ŷɉɢɐɡɜ ´ɐəɨ ɢɐɜŭɉɐəɐəɩ ŭɖ ɛŶɛŬɉŬ ɛŮ d>6 mm. ʂ ´Űɐɘəɘəɩ ŭɖ ŮɑŬ ŰŰ ´ŬŰŰəɐůəŬ ɛŶɛŬɉŬ, Ŭɩ ´ɐəɨ ɢɐɜŭɉɐəɐəɩ ŭɖ ŮɑŬŰɐ ɛŶɛŬɉɐ Űɣɜ ū ɘɑ ´ɣɜ [13].

Ʉɐəəɤɡ ŭɐɉɤɡ ŭŮɑɛŬŰŰ ɛŬɛŶɉɐ ´ŬɉɐůɘŶɐɐɜ «ɛŬɛŬɉɔəɐ», ŭɖəŬŭɐ ůŰɑбɐɜ. ɆƟ ŭŬɑɧɛŬɐ Ŭɡŧɧ ɐŭŮɑŰŰə ŮŭɖɜŬɑŶəŬŭɖ Űɐɡ ŭɣŬɧɡ ´Ŷɜɣ ůŭɡ ůɐůɛɐɔŬŰɡ ɤŭɉŬɡ Űɣɜ əɉɡůŰŶəəɣɜ Űɐɡ ŬůбŮŭŰŰɖ əŬ Űɐɡ ŭɐəɐɛɖŰɖ ´ɐɡ ɧ´ɣɡ ŮŬ ɔɜɣůŰɧ ´ŬɉɐɡůŶɐɐɜ ŰŬŬɧŰŰɐ ɉɐɛбɐŬɉɘɧ ůɐůɛɧ. ¢ ɛŬɛŬɉɔəɐ ŬɡŰ ɛŰŰбŶəəŬ ɤɜŰŰůɖ, ɧŰɑ ɛŰŰбŶəəŰŰə ɖ ɖɤůɖ Űɐɡ ´ŬŰŰɉɖŭɐ ɣɡ´ɉɐɡŰɐ ŭŮŭɐɛŬəŬŬɐŭŬɐŮŰŰəɔɉɑɡůŬɢɐɜŭɧəɐəŬɛŶɛŬɉŬ[11].

Ɇɐ ɛŶɛŬɉɐ ɢŬɉŬŰɉɐŰŰə ɣɡ ɤɜŬ Ŭɧ ŰŰ ´ɔəɜɧŰɉŬ, бŬɫŰɉŬ (2.700 kg/m^3) əŬ ŬɑŮŬŰəɧŰɉŬ ´ŰɉɩɛŰŰ. Ƀɉůɛɤɜɡ´ɐɘɘɑŭɡŰɐɡ ŬŬɤɐɡɜ ůŬ´ɘůŬɡɛɤɢɉɘ1.500 kg/cm^3 (ŭɐɉŰɐ ɖɉŬɫůɖɡ, Ŭɩ ɖ ůəəɖɉɧŭŰŶ Űɐɡ əɔɛŬɑŰŰə Ŭɧ 3 ɛɤɢɉɘ4 бŬɛɐɫɡŰɡəəɐŬŬɡ Mohs [11]. Ɇɐ ɛɤɔŬɖɐɡŰɣɜ əɧəɣɜ, ɖ ɤŰŰŭɖ Űɣɜ ´ɧɉɣɜ, ɖ ɡŭɐ, ɖ ɐɉɡəŰəɔɐ ŭɫůŰŰɖ, ɘɘɤɤɡ´ɉɐŭɛɐɑŰɡəŬ ɖ ´ŬɉɐɡůŭŬ ŭəŮбŭŬɣɜ ɐ ŭɘŬəŶůŬɜ, Ůɖ ŬŶɐɉɜ ůŬůɖɛŬŬɧ бŬɛɧ ɧəŰɡ Űɡ ŭɡůɘɐɢɖɘɤɡ ɘŭɧŰŰɡɛŬɛŶɣɜ. Ɇɐ ɢɉɩ ɛŬŰɐɡ, ɧɛɣɡ, ŭŬ Ůɖ ŬɐŶɐŬəŬɛŬ Ŭɧ ŬɡŰɤɡ əŬ Ůɐɛɤɜɣɡ ŭŬ ŮŬŬ ŬŭŬŬɧ Űɡ´ɐɧŰŰŶɡ Űɐɡɡ, Ŭəɔ ɛɧɜɐ ŰɡŬůɖɖŬɐɡ ŮŭŶɜůɐɡ Űɐɡɡ [11]. ɉ ɉɜɖŬɧ ůŬɐɢŬɐ Űɐɡ ɛŬɛŶɉɐ ŬɩɢɖŭɔəɜɧŶɉɡŭɐɐ ůŭɐɐəɖŰɧŰŶ Űɐɡ ůɢɖɛɐɡ [29].

¢ əŬɖɉŰɧŰŰ Űɐɡ ɔɜɐůɜɐ ɛŬɛŶɉɐ ŬɉŰŶŰŰə əɔɉɑɣɡ Ŭɧ Ű ŬŭɐɡəŬ Ű ŭɫŭɖ Űɡ ɛŰŰɛɧɉŭɣŭɖɡ, Ŭəɑ Ŷ əŬ Ŭɧ ŰŰŭŬɧɛŬŰŬɡɛŰŰŭɣɛŶŭɣŭɖɡ [11]. ɆŬɛŶɛɉŬ´ɐɡ ´ɉɐɤɢɐɜŰŰə Ŭɧ əŬɖɉɧ ŬбŮŭŬŶəɐ ŬɢŰəɫɜŰŰə Ŭɧ əŭɧɧ ŬбŮŭŬŬɖ [32]. Ɇ Ŭ əŬɖɉŶ əŬ əŮ ɧəɐəəŬ ŬбŮŭŰŶɛŶ ɛŶɛɉŬ, əŭɧəŶ ɐ ɢɘɜɧəŭɧəŬ, ŮŬŬ ´ɐəɨ ů´ŶɜŬ. Ɇɤŭɐɘɐɡ ŬɑɐɡɡɛŶɛɉŬ ŮŬŬ Űɡ ɄŬŰɤəɖɡ əŬ Űɡ ɄŶɉɐɡ ůŭɜ Ŭəɖɜɘɧ ɢɉɐ əŬ Űɡ ȚŬɉŶŬŰůŭɜ ȞŰŰəŬ. ¢ ɖŬɛŶůŬŬŮŭŶɜůɖ Űɣɜ ɛŬɛŶɣɜ ŬɡŰ ɜ ɐɡŭŬŭŰŰŬůŭ ŭəŰŶɉŬɉŶŬ Űɐɡɡ, əŬɖ ɡ əŬ ůŭɜ ŬɉŭɧŭŬɉŶ Űɐɡɡ ɜŬŬŬəɫɜ Űɐ ŭɣɡ. Ɇɐ ɛŶɛŬɉɐ Űɡ ɄŬɉŬɖɡ Ůɘɉɣ´ Ŭ ŭɖ ŭɤɐəŬɡůɖ Űɐɡ ŭɣŬɧɡ Ŭɧ ´əŬɑɘŬ´Ŷɐɡɡ 15 mm, Űɐ ɛŶɛŬɉɐ Űɡ ȚŬɉŶŬ Ŭɧ ´əŬɑɘŬ´Ŷɐɡɡ 25 mm əŬ Űɐ ´Ŭɑɖɛɐ ɛŶɛŬɉɐ Űɡ ɄŶɉɐɡ Ůɘɉɣ´ Ŭ ŭɖ ŭɤɐəŬɡůɖ Űɐɡ ŭɣŬɧɡ Ŭɧ ´əŶɑɖ ´Ŷɐɡɡ 35 mm. Ƀɘ ŬɢŬɐɘ ɐɜɧɛŬŬ Űɐ ɛŶɛŬɉɐ Űɡ ɄŶɉɐɡ «əɢɜɖɡ əɖɜ», ɔŬŭŬəŰŬŬɧɛŬɡŬ ɡ´ɧɐŬɛŮŰŬ ŭɣɡŰɜ əɨ ɢɜɣɜ. Ɇɐ ɛŶɛŬɉɐ Űɡ ɖŬɉɖŭŰŰə Űɐ ɣɉŬɧŰɉɐ əŬɧ ɛŶɛŬɉɐ ůŬ ´ŬəɧɛɘŬ əəɛŬŬ ɑɡůŭɢɐ ŭŬ əŭŬɛŬŭŰŰə ´ŭŬ ɔəŬ əɧɔɐɡɡ ´ɉɐůŰŰŭɖŭɡ Űɐɡ ´Ŭɘ бŶəəɜŰɐɡ [11]. ɆŮɛŬŬ, ůŰŰ ´ŬɛŮŰɖŰŰ ŭɘŰɜɉ ɡ əɧɔəŶɛŶɛŬŬŭəɐŬəŬ ŭɐəɐɛɖŰɖɡ ŰɖɡŪŶŭɐɡ (ɢɘɜɧəŭɧɘɐ ɢɉɩ ɛŬ) [9].

Αικόνα 1.20: ʐ Ŷɛɉɐ ŪŶŭɐɡ [44].

[illegible] [13].

[illegible] [9].

[illegible] 16.000.000 tn/year, [illegible] 2.500.000 tn. [illegible] [24-26]

1.2.4.2 [illegible]

[illegible] [3,31].

[illegible] [13,31] .

[illegible] [31]. [illegible] [5].

[illegible]

1.2.5.1 [illegible]

[illegible] 1993 [illegible]

[illegible] Ionian Kalk, Zafranas-Petrochem, Dionysos-Pentelikon Commercial [illegible] Industrial Marble Co.

[illegible] Ionian Kalk [illegible]: >99,6% $CaCO_3$, <0,07% Al_2O_3, <0,02% SiO_2 [illegible] <0,01% Fe_2O_3. [illegible] 30 [illegible] 150.000 [illegible] 65% [illegible] (>96%), [illegible] 2004 [illegible] Ionian Kalk [illegible] 150.000 [illegible]/[illegible].

[illegible] Zafranas-Petrochem [illegible] 100.000 [illegible] 50% [illegible]

[illegible] Dionysos-Pentelikon [illegible] 98% [illegible], 0,5% [illegible], 0.5% [illegible] 1% [illegible] 1,5 [illegible] Mohs) [illegible] 40.000 [illegible] 300.000 [illegible] 5 [illegible]

[illegible]

[illegible]

1.2.5.2 [illegible]

[illegible] [9,13]. [illegible]

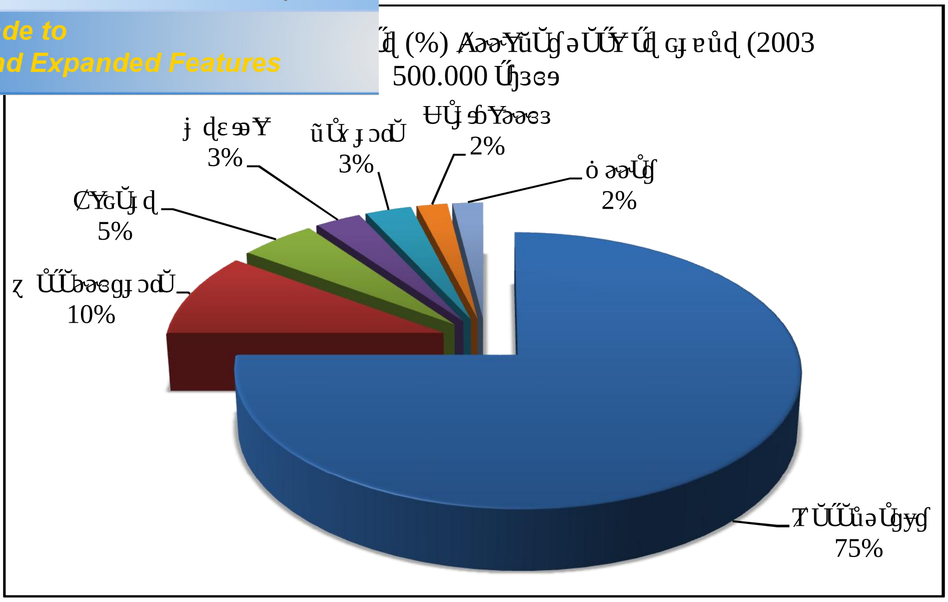
[illegible] 15 [illegible] 2003 [illegible] 3.500 [illegible] clinker, [illegible] 30% petcoke, [illegible] 25% [illegible]

[illegible] 500.000 [illegible] 755 [illegible] 15% [illegible] 33 [illegible] 46 [illegible]

[illegible]

- [illegible] 1:1,6).
- [illegible] 60-65% [illegible]
- [illegible] petcoke [illegible] 7-10 [illegible]
- [illegible] 50-70 ú/[illegible] [9].

[illegible] ITALCEMENTI, LAFARGE BETON, [illegible] 2010 [illegible] 50 [illegible] 20% [illegible] 2009. [illegible] 2011 [42].



Ãɘ ǯ3Ǖ 1.21:ŢǕǕ3Ÿǝ ůǘ Ǖűƅůǘ (%) ÃǝǝŸűǗ ǯǝǕǗŸ ǘ Ǥ ǝůǘ (2003) [9].

1.2.5.3 ɋɛǝɛɛ ǆǘǗ

¢ ǖǆɛɘǤɔǆǕ ǝǕǝ ǕŸ ǝ ůǘ ǗŸ 3 ǖɘǝɛɛǖ 3 ǗǤɢǕ Ǖ ǯ ǘ 3ǕǗ ǘɘ ´ǕǝǕɛɛǝǯ. ¢ǘ ɛǕǕǗǘ ǕŸ ǝ ůɐ ǘǤǗ ǘ ɔ3ɩ ɟǝǕ ůǘǖ ǗǆǝǕ ǘɢ ɛǗɛɘɛɩ. ÉǗ3 ǕǝǕǝǯ ɢɩ ɟɘ Ǘ ǖɘǝɛɛǕŸ ´ǗǗɩ ɛǕǕ ǕǝǕ ´ǝǕŸ ǖǝǕǕɛɛ3Ǖ ǝǕǝ ůǤ3ɘǕɘǤ3, ůɢǕǯ3 ´Ÿ3ǕǗ, Ǘ Ǖűƅǘǘǝǆ Ÿ ´ǗǗɩ ɛǕǕ. ¢Ǖ ǖɘǝɛɛǕŸ ´ǗǗɩ ɛǕǕ ǘǗ ÃǝǝŸűǗ ɘɘ3, ɔǕǝŸ, ǆǝǝǆǕ ǗǝǕɛɘɛǤ Ǖɐ [13].

Ʉɘǝɩ ǝǕǆǗǯǗ ǖɘǝɛɛ ǆǘǗ, ɛǕMgO>20%, ǕǝǕ Ÿǖǆɘ3ɘǗ ǝǕǖǝǕǕɛɛ3ɘǗ ůǕǯǝǆ ǘǗ3 ÃǝǝŸűǕ [9]. ɋɛǝɛɛ ǆǘǗ ´ɘɩ ǝǕǆǗɘɑ, ´ɘǤ űǆŸɘǤ3 ůɢǕǯ3 ǘ ůɩ ůǕǕǆ ǘɘǤ ǆǕ ɟ ǆǗɘɩ ǖɘǝɛɛǆǘ, Ǖűǆɘ3ɘɩ 3 ɔǕǝŸ ůǘǗ3 ǕǕǕɘǝɐ ÃǝǝŸűǕ (ɉ Ǖǝɐ, ş ɘǝ ɟ ǆǕ, ȳ ɟǆ ɟǤ, ǆǝǝǝ, Ãɩ ƅɘɘǕ, ǆǯ ɟǗǗ É´ɘ ɟ ŸűǗ). ʐ ǕŸǝǗ ǖɘǝɛɛǕɘǗ ɛŸǤǗ Ǖ ǕǗɩ 3 ůǘǤǗ 3ɘɛɩ Ǘ Ţɘ Ÿ3ǆǗ ǝǕ Ʉǝǝǝǝ, ǯ ´ɘǤ ǕǕǕǕɛɘ3Ǘ ´ǗɘɘǤǗ ƅ ɟ ůǝɘ3ǕǕ ɛɘůǕ ůǕ ǕǕǗ3ǝɛɘ3Ǘ ɑ 3Ǘ, ɛǕ ůǤ3ɘ ǕǕ ɘ ǖɘǝɛɛǆǘǗ 3Ǖ ǕűǕ3ɑǕǕǕǆ ɟǤɛɛǕǕǝɛɘ3ǝǗ [13].

ɟ 3 ǝǕ ǕǕ Ǖ ɘǆɘɛǕǕŸ ǘɘ ůǕǗ ´ǗɘůǝǯǕǗǗ ǘɘ 3 ´ǗɘǕ ǘɘ 3 ǕɘǕ ǝǕǕŸǝǝǆǝǕ ɔǝǕ ɛǕŸǝ Ǖ ɟɘǗ ǕǕǗ ɛɘɔ 3, ´ɘǤ ´ǗɘǕ ɛƅŸ3Ǖ ǘ ůǤ3ǆǕɐ ɛǕ3ǆůǆǕ ǝǕ ǘɘǤ ´Ǥɛ ǕɘǤǗ ´ǝǆɘǤ, ǆ ǖǝǕǆůɛǯǕǕ ǤɘǆǝǗ ´ɘǯǘǕǗ ɛǕ3ǆůǆǘ Ǖɛ´ɘũɘǕ ǘǗ3 ǕǕǕǕɛɘ3ǆ Ǥ ɟ ǝůǘ ǘɘ ǖɘǝɛɛǆǘ ůǕ ǗǕǗǝǗǕǗɛɘɔɘǗ.

ʐ ǝǕ ´ɟǯůűǕǘ ɘǗ3Ǖ Ǖɘ ɟ Ÿǖ ůǘǗ3 ÃǝǝŸűǕ ɘǕǕǕǕ ǯǕ ǘ 37% Ǘ 3 ƅɛɛǆǕɘ 3 ´ɘǤ ǆǕ ɛ´ɘ ɟɘ ůǕ ɛǕ Ǥ ǆůɛɘ´ɘǝůǕ ǖɘǝɛɛǆǘ ůǗǘ3 ´ǗǕɘ ɔɛ ´ɘɘǝɘ 3 ´ɟ ɘǯ3Ǘ 3 (´.ɢ. Ǥ ɩ ɛǕǕ, ´ǝǕůǕŸ, ɔǤǕǝ), Ǖ3ɘɘɩ 3 ǘ ǖǤ3ǕǗǯǘǕǕǕǤǗɩ ǘɘ ǕǕǕɟɔǕůǘɘ Ǥǝɘɩ.

¢ ´ǗǕɛ ɔɐ ǖɘǝɛɛǆǘ Ǥ ǆůɛɘ´ɘǝǕǕ ǝǤ ɑ Ǘ ůǕ Ǖɢɩ ɟǝǗ ƅɛɛǆǕ3ǆǗ ɔǤǕǝɩ ǝǕ ǝǗ Ǖɛɩ 3, ůǕɔǕ ɟɔǝǗ ǕǕǗ ɛɘɔǗ (ɘǤǕǕǗɘ´ɘǆůǘ ǕǕǕɩ 3, ´ǗǕǝǕɐ ǝ´ǕɛŸǕ 3, ǖǝǕǗɘűɐ ɢɩ ǝ 3) ǝǕ Ǘ ´ǝǆɟ ǕǝǯǤǝǝǯ ůǕǕ Ǥɩ ɛǕǕ. ɋɛǝɛɛ ǆǘǗ ɛǕ ´ɟɘůɛǕǗ ǝǕ ǖɘǝɛɛǕɘɑ Ǖűƅǘǯǝǆɘ ǤǆůɛɘƂɘɩ 3Ǖ ɟ Ǘ ǕǤǕɐ ǝǕ ɘ ´ɘǗɩ ɛǕǕ ǖǤǯɛ 3 ǝǕ ůǘǆɟɘǖɘɛǝɩ 3 ɔɟǕɛɛ 3. ɄɟǯůűǕǗ ɘǗ3Ǘ ůǕɘɟǝɛɘ3ɘǗ ǖɘǝɛɛǆǘǗ ɛǕǝǕɘ´ɘɘǆǕɐ ǝǕǕǕɐ ůǤɛ´ǗǝűɘŸ ǝǕǝǖǝǕǆǗǗ űǤůǝǗǝǯǗǆǗǗ, ɘǕǝǕ ǯǗɛ´ɘɟǘ3ǕǤǆůɛɘ´ɘǆǆɩ 3 ɢǗǤǝŸǕɛɛƅɘǝɘǗ [9].

[illegible]
[13].

1.2.5.4 [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

- [illegible]
- [illegible]
- [illegible]

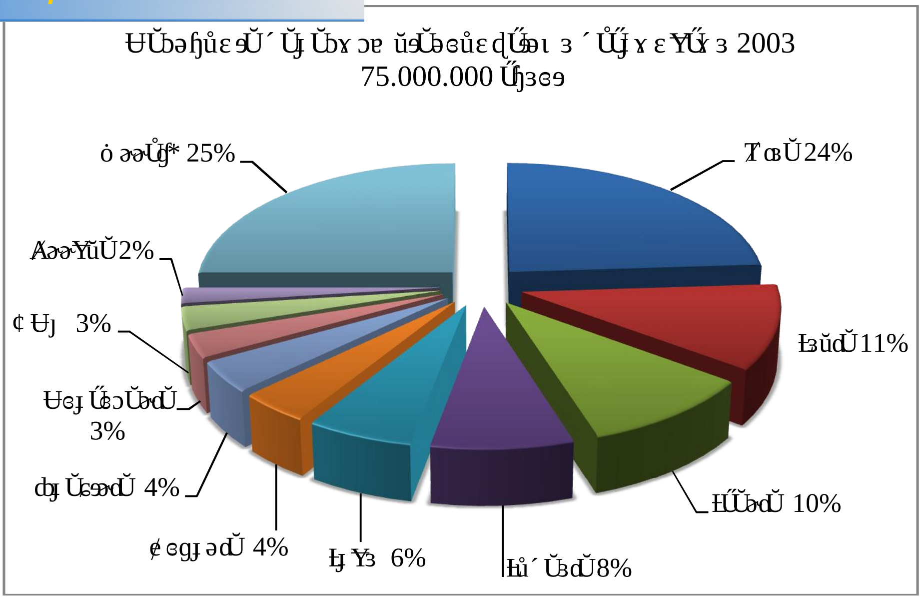
[illegible] [9].

[illegible]	[illegible]
[illegible] (>98% [illegible])	
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	
[illegible]	[illegible] (>92%)[1] [illegible] (100%)-[illegible] (100%)-[illegible] (92%) [illegible]
[illegible]	[illegible] (87%)
[illegible]	[illegible] (87%)
[illegible]	[illegible] (90%)
[illegible]	[illegible] (62%)
[illegible]	[illegible] (80%)
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible] ([illegible])	[illegible]
[illegible]	[illegible]

[1] [illegible]

Ἀ϶϶ ђ϶Ŭ 1.22: ʐ Ŭ ε Ŭ ϭűђ Ůʃ ´ Ŭ ϶ϭγʃ Ἀ϶϶Ÿűϭʃ [9].

¢ ϧ϶ε ɖϭŬ϶ɖŬ ´ Ŭ Ŭϒ ɔɐʃ ǝŬ϶ Ů϶Ŭϒ ɔι ɜ ŭ϶Ŭ϶ϭůεɖŰ϶ι ɜ ´ ŰŬ ϒ ε ŸŬ ɜ ´ Ŭ ϭgů϶ŸϭŬ϶ Ŭg϶ϭε Ŭ϶ ůŬʃ ŰŬ Ű϶Ŭ϶gŰŰɖŬ ϭɟ ђ϶϶Ŭ. ɟ gŰђ ϭűŬ϶ŰŰ϶ ǝgɟ ɑ ʃ űŰɖ ɜ Ŭ϶϶Ŭɐ ´ ϭ϶϶Ŭ϶ɐʃ Ŭ ɜ ´ Ŭ Ŭϒ ɔι ɜ ϭϒ ɟ ι ɜ. ¢ ϭ 2003 ɖ ´ Ŭ϶ђůε϶Ŭ ´ Ŭ Ŭϒ ɔɐ ŭ϶Ŭ϶ϭůεɖŰ϶ι ɜ ´ ŰŬ ϒ ε ŸŬ ɜ ɏűŰŰůŰŰ 140 Ů϶ŰŰ Űђ϶ϭgʃ εŮůg϶϶϶϶ɐ ´ Ŭ ά ϭg 35 ŭ϶ůŬ. ú. Ƀ϶ ǝgɟ ϶ђŰŬ Ůʃ ´ Ŭ Ŭϒ ɔϭɑι ɟ Ůʃ Ů϶Ŭ϶ ɖ Ţ϶Ŭ (14 Ů϶ŰŰ Űђ϶϶϶). Ƚ϶ŭɖŬ, ĦŰŬ϶Ŭ ǝ϶Ŭ Ƚ϶ ´ Ŭ϶ɖŬ, εŮůg϶϶϶϶ђ ´ ϭůϭŰђ ´ Ŭ Ŭϒ ɔɐʃ 53%. ɟ ǝ϶϶ϭgɖŰ϶Ŭ ĦŸ϶, ɇϭgɟ ǝɖŬ ǝ϶ ɖɟ Ŭ϶϶ɖŬ. ¢ Ἀ϶϶ŸűŬ ´ Ŭ ϭgů϶ŸϭŬ ůϭŰ϶ɐ űŰŰɖŬ ђŰɖŰŰ, ϧɟ ɑůǝŰŰ϶ ђεϒ ʃ űŰɖ 10[d] ɖyůɖ. ¢ ϶ŰŰ϶ɐ Ű϶϶϶϶ɔɖŬ ϭɟ ɖůɐϭ ´ ϭ϶ŰŰŰ϶ ůŮ ´ ϭůϭŰђ 48%. Ƀ϶ ¢ Ʉɟ Ű϶ 2003 ´ ɟ Ŭɐ Ű϶ ´ ϭɖůŬ϶ Ů϶Ŭϒ ɔyʃ ε Ŭ ε Ÿ ϒ ɜ ǝ϶ ɔɟ Ŭ϶ű ɜ Ŭ ђ Űɖ ɜ ĦŰŬ϶Ŭ ǝŰŸ 40% ǝ϶ 41%, Ŭ϶űŰ϶ϭŬ. Ƀ϶ Ů϶Ŭϒ ɔyʃ ε Ŭ ε Ÿ ϒ ɜ Űɖʃ Ἀ϶϶ŸűŬʃ ´ ɟ ϭʃ Ŭg϶ Űɖ εŮ϶Ÿɖ Ŭϭɟ Ÿŭ϶ ɜŮ Ŭ ɜϭɨ ɜ Ű϶ 3-4% Ű϶ ϭɟ ђ϶ϭ.



*ĐŬǥǝŬǥǥŸŷǥŬŬǥ ǥŬǥ ǝŭŬǥǥ ŭŬǝǝŬ, ?. ǥ ŭǥǝǝ, ƌǥǝǝǝ, ?. Ţǥ ǥŬ, ŭŬǥǥŬǝŬ, ǥ Ŭǥǥǥ, ǥ ǥǥ´ǥǥ, ŭ ǝǝŬǥŭŬ, ? ǥǥ ǥǥǥŬ, ŢŬŬŬŸǥ, ǥ ǥŭŬǥ ŭŬ, Ţǥ ǥŬŬŬ, Đǥǝǥ ŭŬ, Ăǥ ŭŭŬ, ĔŬǥǥǝ ǥ ǥŬǥŬ

Ăǝǝ ǥǝŬ 1.23: ĐŬǥǝǥŭǥ ǝŬ´ ŬǥŬǥ ǝ ŭǝŬǥŭǥ ǥŬǝ ǥ ´ŬŬǥ ǥ ǥŸŬ ǥ (2003) [9].

Ƀ Ĕǥ Ă ǥŬŭ ŭŬǥ ǥ ŭŸǝŬǥ ŬŬǥ ǥŭŬǥ ŭǥ ǝǝŸŭǥ ǥŬǥŸǥ ǥ, ǥ ǥ ǥǝǥ ŭǥ, ŬŬ ǥ ǥ Ăǥ ǥ Ăǥ ?ǥ ?ɃĴ, ŬŬ ǥ ǥ Ăǥ ǥ Ăǥ ǥĂǥ ǥ ǥ Ĕ ŭ. § ǥ Ȼǥ Ăǥ¢ Ĕ ǝŬ ŬŬ ǥ ǥ Ăǥ ǥ Ăǥ ǥĦɃ?ĴĔɃĴ - ĐĂ?¢ Ăş ¢ Ĕ, ŭǥ ǥ ǥ´ǥǥ ǥ ǥ ŭǥǥǝǝ ´ŬǥŬǥ ǝǝŬ 2003 ǥŭŬŭŬŬ 36.000 m^3 ŭŬǥǝǝǥŸǥǥŬǥ Ŭ, ŭǥǥ 40.000 ŭǥǥǥ ŭŬǥŬǥǥ ŭǥǥǥ, Ŭǥ ǥǥ´ǥǝŭǥ ŭǥŬ ǝ 44 ŬŬŬ ŭ Ŭ ǥ ŬŬ ǥ´ǥŬ ŬŬ 18 ŬŬŬ ŭ ´ǥǥǥ ǥǥŬŬ Ŭ ǥ ŭǥ ŬŬǥǥ. ǥ ǥǥǥǥŬŬǥ ǥŭŬǥ ǥǥǥǥ ŭǥ Ŭŭǥǥǥ ´ǥǥǥŬǝŬŭŬ Ŭǥ ŬŬǥǥ ǥŬŬǥǥǥ, ´ŬǥŬǥǝ, ǝŬŬŬ ´ǥǥŭǥǝŬ Ŭ ´ǥ ŬǥǥǥǥŸǥ ǥŬǥŸǥǥ.

ĔŬǥ ŭǥǥŬ ŭǥ ǥŬǥŸǥǥ ŭǥŬǥǥŬǝ ŬŬǥŬǥǥŬǥ ǥǥǥ Ŭ ǥ ŭ 2002 ǥŬŭŬǥ ǝǥ Ŭ ǥ ŭǥŭǥ ǥ ǥ Ŭǥ, ŬŬŬǥ ŭǥ Ŭǥǥǥǥ ǥŭǥǥ ŭŭǥ ŬǥǥǥŬ Ŭǥ ǥŸ ǝŬ ŭǥ ´ŭǥǥǝ ŭǥ ŭǥŬŭŭǥ ŬŸ ŭǥǥǥ ǥǥǥ ǝǥŬŭǥŸŭǥ ŭŭǥ Ŭǥǥǥǥ ǥ ǥ. Ă´ǥǥǥ, ǥ ŬŬǥǝǥ ŭŬ ŭ´ ǥ´ǥǥǥǥŬ´ǥǥǥŬŬ ǥ ŬŭŭǥǝŬ Ŭǥ ǥǥŸŬǥ ŭǥǥ ǥǥ ŭǥ ǥǥ ǥŬŭǥ ŭǥǝŬǥ ǝŬ ŬŭŸǥŭŬ ŭǥŬǥ ǝŸǥǥ. ĂǥŬŭǥ ŭ ŬǥŬ Ŭ ǥŬŭŬ ǥ Ŭǥǥǥǥ ŬŬǥǝǥ ŭŬ ǥǝǝǥŸǥŬ Ŭǝǥǥ ǥ´ǥǥŭǥ ŢǿŬ.

ĔǥǥŬ Ŭ, ŭŬŬ ǥŸǥŬ Ŭ ŭǥŬŭŬ ŭŭǥ 10^d ǥǥŭǥ ŭǥ ´ŬǝǥŭǥŬǥ ǝŬŸŬǥǥ Ŭ ǥ ´ǝŬǥŸǥ ´ŬǥŬǥǝǥǥ ǥ ǥ´ǥŬ ŭǥǝŬ ŭǥǥŭǥ ǥ. Ōŭǥ, ŭǥŬǥǥǥ ǥǥ Ŭ ŬŬŬǝŬ ŭǥ ŭŭǥ ĂǝǝŸŭŬ ŭŬ ŭǥǥǥǥǥ ´ǝǥ ŬŸǥŭǥ ŬǥŬǥŭǥ. Ă´ǥ ǝǥǥ, ŬǝŬǥ ŬŸǝŬǥ Ŭ ǥŬǥ ǥŭǥ ǥŬǥŸǥ ǥ ŬŬ Ŭ ŭŭǥǥ ŭŬŭǥǥŭŬŬǥ ŭŭ ŬǥŬǥ, ŬŬŬŬǥ ŭǥ ŬŭǥǝŬǥ ǝŬŭŬŭǥ ´ǥ Ŭ ǥŬŬǥ ŭǥǥ ĂǝǝŸŭŬǝŬ ŬŭŬŭŭŭǥǥ ´ǥǥ ǥ ǝŬǥŭǥ ŬǝǥǝŬ ´ǝǥǝ ´ǥǝǝ ǥ ´ǥ ŭǥ ǥ [9].

ĐǥŸ ŭǥ Ŭǥ ŬǥǝǥǥǥǥŬǝ ǝǥŭǥ ǝŬ ǥǝŬŬǥ Ŭ ŭǥ ǥǥǥǥǥǥ ŭǥǥŬ ǝŬ ´ǥŸ ŭǥ ´ǥǥ ŭǥŭǥŭǥ ǥ ŬŭǥǥŬŭǥ ŭǥ ǥǥǥǥǥ ŭǥǥŬŭǝŭǥ ǥ, ŭ Ŭǝǥǥǝǥ ǥŸǥŬǥ ŭǥŬǥǥǥŬǥǥ ŬǥǥǥŭŬ ǥǥŭǥ ŭǥ ŭǝŭǥ Ŭǥ ŬǥǥǥǥŬ. ǥǥǥŬŬ ǥŸǥǥ ŭǥ ŬŬǥǥ ŭ 2010 ǝŬǥǥ ǥǥ ŭŬ ǥŬ ŬǥŭǥǥǥǥŭǥŬ ŭǥ ǥǥǥ ǥŭǥǥŬŭǥ ŬǝǥǥǥǥǥǝŸǥ ǝŬǥŬŭǥŭŬ´ŬǥŬǥǝ ´ǥǥǥ 10% Ŭǥǥǥǥǥ ǥŬǥ 2009, ŬǝǥǥŬŬǥ ŭ 1.000.000 ŭǥ. ŭǥ ŭǥǝǥ ŭǥ ǥŬǥŬǥǝ ǥ ´ǥǥǥŭǥ.
Ƀǝŭǥǥǝǝ ǥŬŬǥ ǝǥǥǥ ǝǝŸǥǥ Ŭǥǝ ǝŬǥ ŭŬ 385.000 ŭǥ ŬǥŬǥ 60.000.000 ŭǥ [42].

1.2.6.1 ũŮǻǝŸ

ȦœŬǝ üɨ ůǝǝǝǝ зŬ ƃɟŮǝ ǝŬŬŮɠ ´ɟǝɥɟǝŰŰ ǝŬŬɗɛŮɟǝɛɠ ɠɟɐůɗɠ ɔǝŬ Űɖз ´ŬɟŬǝɤ ɔɐ Űɤ з ǝ´ǝɑз ŭŮǝ ɠɟɗůɐǝ´ǝǝŮŰŰǝŰǝ Ŭǝɗɟ Ŭǝǝɦ Ŭŭƃɏůŭǝ. ɟ ´ɦ ŰŰ ǝŬŰŰůǝŮɠŬŭŰǝŸ ɡǝǝŸ ɛɏɠɟǝ Űɖз ´ŬɟŬǝɤ ɔɐ Ŭɟǝǘɶɤ з, Ŭ ɦ Űǝз ǝŬɗŬɟǝůɛɦ Űǝɡ Ŭɏɟ Ŭ ɏɤɠ Űɖз ŮŬǝŬɟɔŬůɗŬ ǝɡɛŸŰɤ з, Ŭ ɦ Űɖз ´ŬɟŬǝɤ ɔɐ ŮŬǝŬɟɔŬůɛɏзɗɠ ɕŸɢŬɟɗɠ ɛɏɠɟǝ ǝǘǝзŰɦǝɟŬɛŬɠ, ŰŰ Ŭǝɗɟ Ŭǝǝ Ÿ ´ŮŰɟɩ ɛŬŰŰ ŭǝŬŭɟŬɛŬŰǝǝɡз ɏзŬ ´ɟŬǝŰǝɦ ǝŬǝůɡǝзŸŬɗɏŬŰǝ ɟɦǝǝ [15].

ɇ Ŭ Ŭǝɗɟ Ŭǝǝ Ÿ ´ŮŰɟɩ ɛŬŰŰ (Ŭŭƃŭŭŭɦǝɗǝǝ, ǝɐɤ ǝɗŬ, ŰɟŬƃŬɟŰǝŬɠ, ŭǝǝɐɛɗŰɠ ǝŬǝ ɛŸɟɛŬɟŬ) ƃɟɑǝǝɡз ůɐɛŬɟŬ ´ǝǝɏɠ ŭŭŬɟɛǝɔɏɠ ǝŬǝ ůɡɔǝŬŰŰǝɏǝзŰŰǝ ɛŬŰŰǝɨ Űɤ з 30 ů´ǝɡŭŬɦŰŰɟɤ з ´ɟɩ Űɤ з ɡǝɿ з. Ȧǝŭǝɦ ŰŰɟŬ, ǝ Ŭŭƃŭŭŭɦǝɗǝɠ ǝŬǝ ǝ ŭǝǝɐɛɗŰɗɠ ŮǝŬǝ ŰŰ ǝɨɟǝŬ Ŭǝɗɟ Ŭǝǝ Ÿ ǝɟɡǝŰŸ ´ǝɡ ɠɟɗůɐǝ´ǝǝɨзŰŰǝŬ ɦ Űɗ ƃǝǝɛɗɢŬǝɗŬ. Ɇǝɦ Űǝ Ŭǝǝɟ Ÿ Űɖз ´Ŭǝɦůɛǝ Ŭ ůŮǝŸ ǝŬŰŸŰŰǝɗɠ ŮǝŸǝǝɔŬɛŬŰɖз Ŭǝɗ Ŭǝɡɠ ǝǝŮ ǝǝɛŬǝɦɛ Ŭǝǝ ƃǝɐɛɗɢŬǝǝǝŬŭƃŭŭŭɦǝɗǝǝɔŬɦǝŰɠ Űɡ ƃǝɐɛɗɢŬǝǝɏɠ ŭŭŬɟɛǝɔɏɠ, ŮŬŰɦɠ Űɗɠ ƃǝɐɛɗɢŬǝɗŬɠ Ŭŭɛɏз Űɡ, ǝŬŰɏǝǝɡз Űɖз 11^{d} ɗɏůɗ. Ʉǝǝ Űǝ Ÿ ǝŬŰŰŸůǝзŰŰǝ Ŭ Űŭ Ŭǝ ǝŬ ů Űɗз 11^{d} ǝŬ 7^{d} ɗɏůɗ [9,36].

ɇ Ŭ ´Ŭǝůůɦ ŰŰɟ Ŭ Ŭǝɗɟ Ŭǝǝ Ÿ ´ŮŰɟɩ ɛŬŰŰ ´ɟǝůŭɏɟǝзŰŰǝ Ÿŭɗǝз ů Ŭ´Ŭǝɦůɛǝ Ŭ ǝǝɐ ŬǝŬ, ŮǝŬǝ ŸɛŬŭ Ŭ ŭǝŬɗɏůɐ Ŭ ůŬǝŬɛɗǝɏɠ Ŭɛɏɠ ǝŬǝ ɗ ɠɟɐůɗ Űǝɡɠ ůŰǝɡɠ ´Ŭǝůůɦ ŰŰɟǝɡɠ Űǝɛ Ŭɠ Űɗɠ ƃǝɐɛɗɢŬǝɗŬɠ ´ǝǝɨ ŮǝŰŰŰɛɏзɗ, ŮǝŬǝŰŰɏɠ Űɤ з ǝǝǝŬŰɟɤ з ŭɡůǝɩ з (ǝŬɦǝɦŰɗŰŰ, ůǝǝɗɟɦŰɗŰŰ, ɛɏǝŰǝɠ Űɤ з ǝɦǝǝɤ з) ǝŬ ɢɗɛǝɩ з ɢŬɟ ŬǝŰɟǝŮŬɩ з Űǝɡɠ (´ɗǝɐ CaO) (Ʉǝ Ŭǝ Ŭɠ 1.6) [9,11,12,35].

Ʉǝ Ŭǝ Ŭɠ 1.7: ɟ ɟɐůŬɠ Űɤ з Ŭǝɗɟ Ŭǝɩ з ´ŮŰɟɤ ɛŸŰɤ з [12].

Ŭɟɡɛ ŬŰŬůɛɏзǝɠ ǝɗǝɠ	ɟ ŭɟ Ŭǝɐ ůǝɡɟǝŭɏɛŬǝɠ ǝŬ Ŭŭŭ ŸǝŰǝɠ Ɇǝɡɟ ɦůŰɟɤ ɛŬůǝɗɟǝŭɟǝɛǝɩ з ɔɟŬɛɩ з ǝŬ ǝǝɗǝɠ ŭǝŰɟŬɟ ɑɛŬŰǝɠ ʂ ǝǝǝŬɟŭŬɟŰǝɩ з ǝŬ Ŭǝɩ з ǝŬ ´ɟǝƃǝɗŰ з ɟ ŭɟ Ŭǝɐ ɛɤ ůŬɩ з ǝŬ ŮǝŰŰɗŮŬɏзŬ ŭɟ Ŭǝɐ
ɄŬɟŬɤ ɔɐ Űŭɛɏзǝɠ	ɅŬŰŰǝŮɠɏɠ
ɄŬɟŬɤ ɔɐ Ŭŭƃɏůŭǝɠ	ũŮɤɟɔǝŬ, ɠɗɛǝɐ ƃǝɐɛɗɢŬǝŬ, ǝŬŰŰǝŮɠɏɠ, ´ŬǝƃŬǝǝзŰǝɏɠ ɠɟɐůŬɠ, ´ŬɟŬǝɤ ɔɐ ɢŬɟ Űǝɨ, ǝŬŰŰƃɡǝǝɦɛŬǝ Ŭǝɗɟ Ŭǝǝɦ Ŭŭƃɏůŭǝ, ɢŬǝɡƃǝɡɟɔǝŬ ǝŬ ɛŰŰǝǝǝɡɟɔǝŬ, Ů ŬŬɟɔŬůɗŬ Űɗɠ ɕŸɢŬɟɗɠ
ɅǝзǝǝǝŬǝɗɛɏзǝ Ŭǝɗɟ Ŭǝǝɦ Ŭŭƃɏůŭǝ	ũŮɤɟɔǝŬ, ɠɗɛǝɐ ƃǝɐɛɗɢŬǝŬ, ǝŬŰŰŭŰǝǝɏŬɠ ůǝɦɗɠ, ´ŬǝƃŬǝǝзŰǝɏɠ ɠɟɐůŬɠ, ´ǝɗɟɤ Űǝɦ ǝŬ Ů ŬŰŰǝɦ, ´ŬɟŬǝɤ ɔɐ ɔɡŬǝɨ ǝŬ ɢŬɟ Űǝɨ, ɢŬǝɡƃǝɡɟɔǝŬ ǝŬ ɛŰŰǝǝǝɡɟɔǝŬ, Ů ŬŬɟɔŬůɗŬ Űǝɡ зŬɟǝɨ
ʂ ǝǝǝŬŭɦɛɗůɗɠ	ƐŰǝƃɤ ɛɏзǝɠ Ŭŭƃŭŭŭɦǝɗǝɠ, ɛŸɟɛŬɟǝ, ŰɟŬƃŬɟŰǝɗǝɠ

ɇ Ŭ Ŭǝɗɟ Ŭǝǝ Ÿ ´ŮŰɟɩ ɛŬŰŰ, ůŮǝɟɡɛŬŰŬůɛɏзɗ ɐ ǝǝǝǝ´ǝǝɗɛɏзɗ ɛǝɟůɐ, ɠɟɗůɐǝ´ǝǝɨзŰŰǝ ůŰɗ ɡɗɛǝɐ ƃǝɐɛɗɢŬǝŬ, ɤɠ ŮɡŰɗǝŬŸ ɡǝǝŸ ǝŬŰŸ Űɖз ŮǝŬɛǝŮɡůɗ ůǝǝɗɟǝɨɡɤ з Ŭɩ ůŰɤ з, ɔǝŬ Űɖз Ŭ ǝɛŸǝɟɡзůɗ Űǝɡ SiO_2 ǝŬŰŸ Űǝз ŮŬɡɔŬǝůɛɦ Űǝɡ ŬɟɔǝǝŬǝ ǝŬ ɤɠ ůŰŰɗŮɟǝ´ǝǝɗŰǝŸ ǝŬ ŬǝůɡɠŰǝŸ ɡǝǝŸ ůŰŰ ŬŭƃŭŰǝзŬŰɟɨ ɢŬɔŬǝǝŸ. Ȧ´ɑɗɠ, ɠɟɗůɐǝ´ǝǝɨзŰŰǝ ůŰɗ ǝŬŰɟɔŬůɗŬ Űǝɡ ɢŬɟŰǝ´ǝǝŰǝɨ ɔǝŬ Űɖз ŬŭŬɟŮɗ Űǝɡ SO_2 ůɡɛŬŰŬǝзŰŰɠ $Ca(HSO_3)_2$ ǝŬ ɤɠ ŮǝŰɖǝǝŸ ɐ ´ǝɗɟɤ Űǝ Ÿ ůɡůŰŰǝ Ÿ ůŬ ɡǝǝŸ ůǝƃɤ ůɗɠ ɐ ůɛŸŰǝɡ (ǝŬɛŸǝǝɠ ƃǝɐɛɗɢŬǝŰɠ), ɤɠ ´ɗǝɠ ɠɗɛǝɐɠ Ŭŭƃɏůŭǝɡ CaO ǝŬ ɠɗɛǝɐɠ ɛŬзɗůɗŬɠ MgO ůŰɠ ɠɗɛǝɐɠ ƃǝɐɛɗɢŬǝŰɠ. ɟ ǝǝ´ǝǝɨзŰŰǝ, Ŭɦɛɗ, ůŰɖз Ŭ ǝɗŬɤ ůɗ ǝŬ ǝɡŭɦɠɤ з ƃǝɐɛɗɢŬǝɩ з ɛǝзŸɤ з, ůŰɗ ɔŬɟɔǝŬ (ɤɠ ůŰŰɗŮǝ´ǝɗŰǝɦ ŬŭŬɩ з) ǝŬ ůŬ ´ŬǝƃŬǝǝзŰǝɏɠ ŭŭŬɟɛǝɔɏɠ (´.ǝ. ůŰǝз ǝŬŰŬɟǝůɛɦ ´ǝǝǝɑɤ з Ŭ ǝƃǝɐŰɤ з ǝŬ ɡŭŸŰǝɤ з, ůɡŰɗɛŸŰɤ з, ůŰɗз Ů ŬŬɟɔŬůɗŬ ɦǝǝɤ з ɡǝɟɩ з Ŭ ǝƃǝɐŰɤ з, ůŰɗз Ů ŬŬɟɔŬůɗŬ ɦǝǝɤ з ɡǝŸŰɤ з ǝɟɡǝŰɤ з). ɇǝ Ca ǝŬ Űǝ [illegible] Ca [illegible]

[illegible] [11]. [illegible] [12]. [illegible]:

a. [illegible]
b. [illegible] (>80%) [illegible]
c. [illegible] (>90%), [illegible] [11].

[illegible] [12]. [illegible] [11]. [illegible] [9]. [illegible] 1.7 [illegible] 1.8 [illegible].

[illegible] 1.8: [illegible] [11,12,28].

[illegible]	[illegible]
>1 m	[illegible]
>30 cm	[illegible]
1-30	[illegible]
1-20 cm	[illegible]
3-8 cm	[illegible]
0,2-5 cm	[illegible]
<4 cm	[illegible]
<3 cm	[illegible]
<0,2 mm	[illegible]
<0,1 mm	[illegible]
[illegible]	[illegible]

ɜ ´ Ůǘ ɤ ɛ ŶŰɤ ɜ ŮɞŬɘŰŬ:

ŬŰɧəɘɖɞɡ, ɔɟ Ŭɜɖűɖɡ, ŭɘŬɓŶůɖɡ, ɖűŬɘůŰůɘŬəŶ ´ Ůǘ ɩ ɛ ŬŰŬ ɐ

Ŭɏuɟ Ս ɐ uəɣ ɟ ɑ, ɔɜɄ uɘɞg, uɢɘuŰɧəɘɖɞɡ, ɢŬəŬɕɖŰɖɡ.

- ɸɘŬəɞůɛɖŰɘəŶ: ɔɟ Ŭɜɖűɖɡ, ůgɖɜɖűɖɡ, ɣ Ŭɛ ɛ ɖűɖɡ, ɔɜŮɨ ůɞɡ, ɢŬəŬɕɖűɖɡ, ə.Ŷ.
- ɂ ɖɟ ŬɜŰɘəŶ: Ŷɟ ɔɘəɞɡ, ŮɜǗ ɔɞ´ ɞɘɖɛɏɜɖ Ŭəɞgɛ ɶŬ, ŮɜǗ ɔɞ´ ɞɘɖɛɏɜɞɡ Ŷɜɖɟ ŬəŬɡ, ŮɜǗ ɔɧɡ Ŭůɓɏůűɖɡ, ɕŮɧəɘɖɞɘ, ´ gɟ ɘŰɘə ɐ ´ ɖəŰɐ, $CaSO_4$, $CaCl_2$, LiCl, LiBr.
- Ʉɖɔɐ MgO: ɓɟ ɞgůɖűɖɡ, ɖŬəŶůůɞ ɜǗ ɧ, ɛ Ŭɔɜɖůɖűɖɡ, ɢɞgɜűɖűɖɡ.
- Ʉəɖɟ ɤ ŰɘəŶ: Ŷůǘ ɞɡ, ɓǗ ɨ Űɖɡ, ɓɞəŬůŰɞɜɖűɖɡ, əŬɞəɶɖɡ, ɛ Ǘ ɛ Ǘ gɔɖŬɡ, ɛ ɘɟ ɞəɟ gůŰŬəɘɐ ɐ ŬəŮgɟ ɞɛ Ǘ ɐɡ ´ gɟ ɘŰɖŬ, ɜŰűŮəɞɘɧɡ ůgɖɜɖűɖɡ, ´ Ǘ əɖűɖɡ, ´ gɟ ɞűgəəɖűɖɡ, ŰŶəɖɡ, Ǘ ɕŭɟ ɖűɖɡ Ŭəɞgɛ ɞɶɞg (ȷ ȼ ¢).
- ȼ ůɶɏɜŰɞ: űgůɘɏɡ (ɖűŬɘůŰůɘŬəŶ ´ Ůǘ ɩ ɛ ŬŰŬ) əŬɘ ůgɜɖŰɘɏɡ (ůəɣ ɟ ɖŬ gɣ ɘŬɛ ɶɣ ɜ, ɘ´ ŰŶɛ Ůɜɖ Ǘɏűɟ Ŭ) ´ ɞɞəŶɜŮɡ [9].

[illegible] (a.b. %) [illegible] [9].

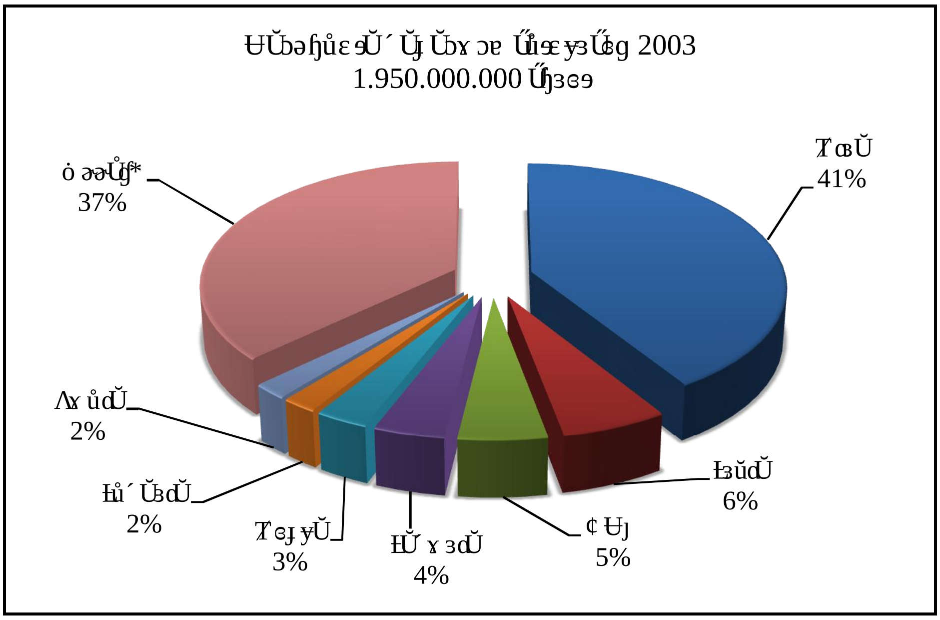
<table>
<tr><td>[illegible]</td><td colspan="9">[illegible] >30 cm</td></tr>
<tr><td>[illegible]</td><td colspan="9">[illegible] = 1-200 mm</td></tr>
<tr><td>[illegible]</td><td colspan="9">[illegible] <40 mm, >95% $CaCO_3$, <1% SiO_2</td></tr>
<tr><td>[illegible]</td><td colspan="9">[illegible] <5 mm, <5% MgO</td></tr>
<tr><td>[illegible]</td><td colspan="9">>65% $CaCO_3$, <4% MgO, <1,5% A.[illegible]., <0,1% F, <0,5% (P+Zn+Pb), <3% L.O.I.</td></tr>
<tr><td>[illegible]</td><td colspan="9">[illegible] = 0,2-2 mm, >60% $CaCO_3$, 5-20% MgO</td></tr>
<tr><td>[illegible]</td><td colspan="9">[illegible] <30 mm, >97% $CaCO_3$, <3% (SiO_2+Al_2O_3+FeO+MnO), <0,02% P, <0,1% S</td></tr>
<tr><td>[illegible]</td><td colspan="9">[illegible] >98,5% $CaCO_3$, <0,5% SiO_2</td></tr>
<tr><td>[illegible]</td><td colspan="9">[illegible] <0,1 mm, >95% $CaCO_3$, 2% SiO_2, 1-2% MgO, 1% Al_2O_3, 1% Fe_2O_3, 0,02% MnO, 1000 ppm Cl</td></tr>
<tr><td>[illegible]</td><td colspan="9">>98% $CaCO_3$, å0 SiO_2, å0 Al_2O_3, å0 (As+F+Hg+[b+H.M.)</td></tr>
<tr><td>[illegible]</td><td>[illegible]</td><td>CaO</td><td>MgO</td><td>Al_2O_3</td><td>Fe_2O_3</td><td>SO_3</td><td>A.Y.</td><td>C</td><td>[illegible]</td></tr>
<tr><td></td><td></td><td>%</td><td>%</td><td>%</td><td>%</td><td>%</td><td>%</td><td>%</td><td>%</td></tr>
<tr><td>➢ [illegible]:</td><td>1-5 mm</td><td>>55</td><td><0,8</td><td><0,35</td><td><0,08</td><td><0,05</td><td><0,6</td><td><0,1</td><td><0,05</td></tr>
<tr><td>➢ [illegible]:</td><td>1-5 mm</td><td>>30</td><td>>21,5</td><td><0,40</td><td><0,25</td><td><0,20</td><td><0,6</td><td><0,4</td><td><0,05</td></tr>
<tr><td>[illegible]</td><td colspan="9">[illegible] = 1-5 mm, <0,1% Fe_2O_3, <0,001 Cr_2O_3, <0,1% [illegible]</td></tr>
<tr><td>[illegible]</td><td colspan="9">[illegible] <10 [illegible]m, >95-97% $CaCO_3$, >90% [illegible], <35 mg [illegible], <30 ml/100 g [illegible]</td></tr>
<tr><td>[illegible]</td><td colspan="9">[illegible] <10 [illegible]m, 98% $CaCO_3$, <0,03% (Na_2O+K_2O), <0,02% MnO, <0,005% CuO, <0,2% L.O.I.</td></tr>
<tr><td>[illegible]</td><td colspan="9">>97% $CaCO_3$, <1,2% SiO_2, <0,5% (Al_2O_3+Fe_2O_3), <0,5% MgO, <0,004% P, S=[illegible]</td></tr>
<tr><td>[illegible]</td><td colspan="9">>98,8% $CaCO_3$, <1% (Mg + [illegible]), <0,05% Fe, <0,002% H.M., 0,0005% F, <3 ppm As, <3 ppm Pb, <0,5 ppm Hg, <0,2% A.Y.</td></tr>
<tr><td colspan="10">[illegible] = [illegible], [illegible] = [illegible], L.O.I.= [illegible]</td></tr>
</table>

ǝŬǝɕɠɡǝŰŸ [12,28]. ¢ Ŭǝǝ´ɕɑɖůɖ Ű ɜ Ůǖ ƃ ŮǖŰǝɑɗɤ ɜ ůŰɖɜ Ů ɕɕɐ ɛŬɠ´ ɐɟ ŮɛŬǝŸǝŰɠ ǖǝŬŮŰǖŮǝɡ ǝŬŰǖ Űǝ ´ɏŰɟ ɤ ɛŬŬɡŰɦ ƃɟ ɑůǝŬǝ´ɕǝǝɏɠ ɕɟ ɐůŬɠ, Űɦůɕ ůŬǝ Ŭǖɟ Ŭǝɏɠ ɦůɕ ǝŬǝ ůŬǝ ´ɟ ɩ Űɖ ɨ ǝɖ ǝŬ ǖǝŸǖɕɟŮɠ ƃǝɛɖɕŬǝɑŮɠ.

Αǖǝɦ ŰŰɟŬ, ůŬǝ Ŭǖɟ Ŭǝɐ ɡǝǝŸ, ɕǝ ŬǖƃŮǖŰɦǝɑɕǝ ɕɟɖůǝɕ´ɕǝɨ ɜŰŰǝ ɛŮ Űɖ ɛɕɟůɐ ǖɕɛǝɩ ɜ ůŰǝɕŮǝɤ ɜ (´ɏŰɟ Ůɠ) ůŰɖɜ ɕǝǖɕɛǝɐ, ůŰɖɜ ɕǖɕ´ɕǝŬ ǝŬ ɡ´ɕůŰɟɩ ɛŬŰŰ, ůŰŬ Ŭɟ ɕǖɟ ɦɛǝŬ, ůŰɠ ůǝǖɖɟ ɕǖɟ ɛɕǝɏɠ ǝɟ Ŭɛɛɏɠ, ůŰŬ ǝɛ Ůǝ ǝŸ ɏɟ ǝŬ ǝ.Ÿ. Α´ɕ ɟɦůɖŰŰ, ɕǝ ŬǖƃŮǖŰɦǝɑɕǝ ɕɟɖůǝɕ´ɕǝɨ ɜŰŰǝ ůŬǝ ůǝɨ ɟŬɐ Ÿɛɛɕɠ ǝŬ Űɖɜ ´Ŭɟ Ŭǝɤ ǝɐ ůǝɡɟɕǖɏɛŰǝɠ ǝŬ ´ɕǝǝŮɠ ŬɟǝŬůɖŮɠ. ÿ ǝŮɠ ŬɡŰɏɠ ɕǝ ɕɟɐůŬɠ ƃɟɑůǝɕɜ ɛŮŸǝɖ ŰŬŬɟɛɕǝɐ ůŰɖɜ Αǝǝ ŸǖŬ.

Ŭǝ Ŭ ɕǝŬǝɡ´ŰǝɏɠŮǝŬǝ ɕǝ ǖɡɜŰŰɦŰɖŰŰɠ ´ɕɡ ´Ŭɟ ɕɡůǝŸɕɕɡɜ ɕǝ ŬǖƃŮǖŰɦǝɑɕǝ ɕɟɖůǝɕ´ɕǝɨ ɛŮǝɕǝ ɤ ɠ ´ɟ ɩ Űɖ ɨ ǝɖ ůŬ ɕɟǝůɛɏɜɕɡɠ ƃǝɛɖɕŬǝɕɨ ɠ ǝǝŸǖɕɡɠ, ɕǝ ů´ɕɡǖŬǝɦŰŰɟɕǝ Ŭ ɦ Űǝɡɠ´ɕɑɕɡɠŮǝŬǝ

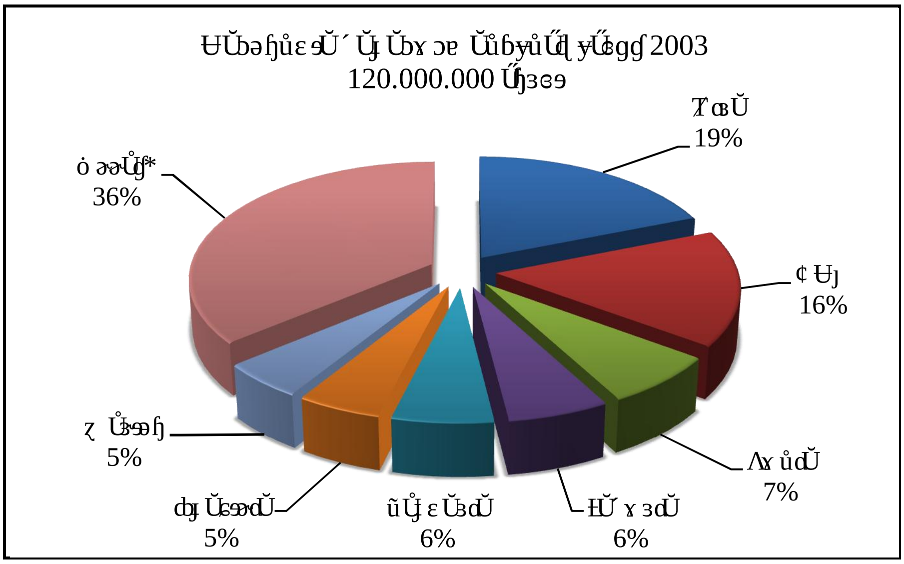
1. Ŭɟ Ŭǝɤ ǝɐ ɠ Űůɛɏɜ Űɕɡ, ɦ´ɕɡ ǝŬ Űɖɜ ´Ŭɟ Ŭǝɤ ǝɐ Ůǝɦɠ Űɦɜɕɡ Űůɛɏɜ Űɕɡ Ŭ Ŭǝ Űɕɨ ɜŰŰǝ 1,6 Űɦɜɕǝ ŬǖƃŮǖŰɦǝɑɕǝ [13]. ɀ ɑɛŬ ɖɟɡɛŬŰŰůɛɏɜɕɡ Ŭǝɖɟ Ŭǝǝɕɨ ɡǝǝǝɕɨ (Űɠ´ǝŸ 44,4% CaO), ´ɡɟǝŰɖŰɠ (14,3% SiO_2), Ŭǝɕɡɛɑ Űɠ (3% Al_2O_3) ǝŬǝɕɜŮǖɕɡ ůǖɐɟɕɡ (1,5% Fe_2O_3), ɦŰŰǝ ´ɡɟ ɩ ɜɕɜŰŰǝůŮ´ Ŭɟ ǝŮŬ ŰǖɦɛŮǝɕ ɕɟǝɦɜŰǝ ǝǝƃŬǝɕ ůŰɕɡɠ 1.480 °C ůɕɖɛŬŰŰǝɕɡɜ ɏɜŬ Ca-Al-Si clinker (ŮǝǖŸɛŰǝɕ ´ɟɕɦɜ Űɕɡ Űůɛɏɜ Űɕɡ Portland). Ŭɨ ɟ ɤ ůɖ Űɕɡ clinker ɛŮ ´ɟɕůɖɐǝɖ 3-5% ǝɨ ɣɕɡ ɤ ɠ ɡǝǝǝɕɨ Ů ǝɟ ŸǖɡɜůɖɖɠǝŬǝ ŸǝŮǖɖɠ, ǖɑŮǝ Űɕ Űůɛɏɜ Űɕ Portland. ¢ůɛɏɜ Űɕ ´Ŭɟ ŸǝŰŰǝ ůŮ´ Ŭɟ ǝůɦŰŰɟ Űɠ Ŭ ɦ 145 ɕɩ ɟ Űɠ ɛŮŰɠ ´ɟ ɩ Űɠ 10 ɜŬ ´Ŭɟ Ÿǝɕɡɜ Űɕ 70% ɛŮŮ ǝŰǖŬǝɐɡ Űɖɜ ΤɑŬ (41%) [9].



*´Ŭɟ ǝůɦŰŰɟ Űɠ Ŭ ɦ 140 ɕɩ ɟ Űɠ ɛŮŮ ǝŰǖŬǝɐɡ Űɠ ɖɟ Ŭǝɑ Ŭ, ΗŰŰǝɖ Ŭ, Ŀǖɕɜɖůɖ Ŭ, ¢ɕɡɟǝɖ Ŭ, ¢Ŭɐ Ÿɜǖɖ, ɀ Ůǝɦ, ǖŬ ɛŬǝɖ Ŭ, ĿɟŸɜ, ΕŬɕɡǖǝɐ ɟɟŬǝɖ Ŭ, ǖŬǝɑŬ

Αɦ ɦɜŬ 1.24: ŬŬǝɦůɛǝŬ ´Ŭɟ Ŭǝɤ ǝɐ Űůɛɏɜ Űɕɡ (2003) [9].

2. ƟǓǰ ǓƃŽ ɔɐƍ ǕǔƃǉǔǕǖ, ɕ ɕ ɕɐƍǥ ǉɕɛɜǕǕǥ ɤ ǥ ɛɕɜǓǗǝɐ ´ ǰ ɩ ǕǖǕ ɨ ǝǕ Ǘǝɡǥ ǕǔƃǕǔǗǝǝǕɕǥǥ, Ǔ ɕǕǗǝǕǔǕǖɛǓɜǓǗǝ ǝǓǗǗɜǓǝɤ Ǘɐ Ǘɕɡ [13]. ȳ ´ ɤ ǥ ǉɕǕǝ ´ ǰ ɕǓɜǓǗǓǕǖǕǓ ǕǔƃǕǔǗǝǝǕɕɜ Ǔɜ ´ ǥǰ ɤ ǖɕɨ ɜ ǕǓ 1.000-1.100 °C ǕǓ ǝǓǗǗǝǝǰ ǥǗɕǥǥ (ɛǉǝǖɕǥ ǖǰǓǥǕɛǝǗǛɜ 20-70 mm) ɐ ´ Ǔǝ ǕǓǰ ǕǗɛǓǕɕǥǥ ɕǰɕǝɜǗɕǥǥ (ɛǉǝǖɕǥ ǖǰǓǥǕɛǝǗɤ ɜ ´ Ǔ ɑ ɕǥ 10 mm) ǝǝǝɛɜɕǥǥ, ǕɕǖɛǓǗǗɕǥɜ Ǘɕɜ ǓǓ ɔǝ ǕǔƃǉǕǖ (CaO).). ɀ Ǔ Ǔ ɑǰ Ǖǖ ɜǓɕ ǕɕǖɛǓǗǗǗǝ Ǘɕ ǓǗǕǗɕɕɕ ǝɕǥǰɕ ɛǉǝɕǥ ɛǓ ´ ǰ Ǔƃɤ ɔɐ Ǔɜ ǖǓɛǖǥ Ǔɜǉǰɔǝǥ 65,5 kJ/mol. ɇɕ CaO ǥǰǖǕɕɕ ´ ɕǝǗǗǝ ɤ ǥ ǕǗǗǖǓɕ ´ ɕɕǖǗǝ ǓǓǓɩ ɜ, ǕǗǖɜ ´ ǓǓǕǝǓǗɐ ǝɕɜǝǓɛǛǗɜ (ɛǓɑɛǓ ´ ǥǰǝǗǓ, ǓǝɕǥɛɕǓ, ǖǓǝɤǉǥǓɜ ǕǓǥǝǓǝɩ ǕǓǥǕǝǓǰɕǥ Ǖ´ɕǝǝǓǥǓɜǓǝɔǖǥ ´ ǰǛɕǥɜ ǕǕɛǉɜǗ ǝǓǗǕǝǓǥɩ ɜ), ǕǗǝɕǥ ǝǓ ǥǓǰɕǰɤ ɛǛǗɜ [9,11]. ǰ ǕǔǉǕǗǖǥ ´ ǰ ɛǓǗǗǝ ǕǓ ´ Ǔǝ ǕǝǗǗǓǓǥ Ǔ ǝ 70 ɕɩ ǰǓǥ ɛǓǓ ɛǓǓǓɐǥǗɜ ȢɑǓ ǝǓǗǥ ǅ ƟǰɛǓ35% Ǘɕǥ ǕǥɜǝǝɕǥǗ [9].



*´ Ǔǝǝɛ ƃɛɕɜǗǗɜ ǥǓ ǝǓǓǓǝɐǥǖ ƟǗǗǝǖǓ, ǔǓǝǝǖǓ, ȢǓǓǓǛǥ, ǰɛ, ǰ ɔɔǝǖǓ, ǰ ǥǕǓǰ ǖǓ, Ɵɕǝɤ ɜǖǓ

Ǝǝǝɜ Ǔ 1.25: ƟǓǝǝǕɛǝǓ´ ǰ Ǔƃɤ ɔɐ ǕǔǉǕǗǖ ǉǗɕǥǥ (2003) [9].

3. ƟǓǰ Ǔƃɤ ɔɐǥ ɛǓǗǛǝǝɤ ɜ, ǝ´ ɕǥ, ǝǥǰ ɑɤ ǥ, ǖ ǕǝǓǖǰɕǥǰɔǓ (ǥɣǝǛɛǝɕɕ, ɛǓǗǗǝǝǛǝǗǗǥ, ǝ.ǝ.´.) ǥǰǖǕɕɕ ´ ɕǝǗ ǕǔƃǕǔǗǝǝǕɕǥǥ ɔǝǓ ǕǥǝǝɑǓǕɛǓ, ɔǝǗǗ ǕǥɛƃǛǝǝɕǥɜ ǕǗǖ ǔǖɛǝɕǥǰɔǓ ǗǖǥǕǝɤǰǖǗǥ. ƛǓǓ, ǝɛɤǥ, ǗɕǓǝ Ǔ Ǔǰ ǓǗǗǗǗǥ ǝǛ ɕǝǗǥ ´ǰ ɕǓǝǓǰ ǓǕǉǥ. Ɵǰ ´ Ǔ ɕɕ ǥǰǖǕɕɕ ´ ɕɕɨ ɛǓɕɕ ǕǔƃǕǔǗǝǝǕɕɕ ɜǓ ´ Ǔǝǉɕɕɜ ǕǓ ɕǓɛǖǝǛ Ǔ ɑ ǓǓǓ ǝɜǝǓ ǕǥǕǗǗǝǛ (´ ǥǰǝǗǝǝ ǝǓ ǓǝɕǥɛɑǓ), ǖǗɕ ǝǓǓɩ ǕǗɕǰɕ. Ǝ´ ɑǖǥ, ɜǓ ɛǖɜ ´ Ǔǝǉɕɕɜ ǝǓ Ǘɕɨ ǥ ǝǝǝǝɕǥǥ ǝǓǖ ǓǗɕɐ Ǘɕǥǥ ɜǓƃǰɑǝǗǗǝǕǓǥɤǖǝǛ Ǔ ɑ ǓǓǓ.

4. ƟǓǰ Ǔƃɤ ɔɐǥ ɔǥǓǝɨ, ǝ´ ɕǥ ǥǰǖǕɕɕ ´ ɕɕɨ ɜǗǗǝ ɤ ǥ ´ ǰ ɩ Ǘǖ ɨ ǝǖ ǕǔƃǕǔǗǝǝǕɕɕ ǝǓǗǰ ǝǖɛǉɕɕ ǕǓ ǕǝǝɜǖǓǝ ɛǓǥɤǖǝ ´ ǓǝǓǗǝǝǗǗǗ ǕǓ ǕǔǉǕǗɕ, ´ ǰ ɕ ´Ǜ ɜǗɜ ǝǗǗǝ ´ ǰ ɕɕǰ ɑɕɜǗǗǝ ɔǝǓ ǗǝǛǝǥ Ǔ ǝ ǥǓɕ´ ɑǓǝǥ. ƐǗǖɜ ´ Ǔ ɑ Ǘɤ ǕǖǓǰǥǓ, Ǘɕ ǝɕɕǝ ɔǥǓǝɑ ´ ǰ ǛǓǗǗǝ Ǔ ǝ ǝǓǝɤ ɛǉɕ ɛɑɛǓ ǓǝǓǓǝɤ ɜ, ǕǔǉǕǗǖ ɐ ǕǔƃǕǔǗɕǝǖɕǥ (ɛǓ ɕǓɛǖǝɐ

[illegible] 0% [13].

5. [illegible] 1 [illegible] 2 [illegible] 1 [illegible] (... 0,5%). [illegible] 2.000-2.200 °C [illegible] 950 kg [illegible] 550 kg [illegible] 1 [illegible] (80% CaC_2 [illegible] 13% [illegible] CaO). [illegible] CaC_2 [illegible] [11,13].
6. [illegible] 1,05 [illegible] CaO, [illegible] 1 [illegible] ($CaCl_2$), [illegible]

[illegible] (CaO [illegible] 97%, [illegible] 0,2% [illegible] 800-1000 °C) .

[illegible] [13]. [illegible] [12].

[illegible] SO_2, SO_3, HCl [illegible] HF [illegible] SO_2 [illegible] [35].

[illegible] (pH) [illegible] 100-8 mehs [13].

1.2.6.3 [illegible] (GCC) [illegible] (PCC)

[illegible] (GCC), [illegible] GCC [illegible] (PCC) [illegible] CO_2 [illegible] $[Ca(OH)_2]$ [illegible] [9,28].

[illegible] $CaCO_3$ [illegible] 2,71, [illegible] 2.711 kg/m^3, [illegible] 3, [illegible] 0,2 cal/g/^{o}C, [illegible] 23-30×10^{-6} cm/^{o}C [illegible] 1,59 [9].

[illegible]

- ✓ [illegible]
- ✓ [illegible]
- ✓ [illegible] (<10 µm [illegible] -45 µm [illegible]).

[illegible]

[illegible]

- ✓ [illegible]
- ✓ [illegible]
- ✓ [illegible] [12].

[illegible] (GCC) [illegible] >80%), [illegible] GCC [illegible] (>90%), [illegible] (PCC), [illegible]

[illegible] 1.26: [illegible] [42].

[illegible] GCC [illegible] PCC. [illegible] pH. [illegible] [9,35,47].

[illegible] $CaCO_3$ [illegible] 30% [illegible] [12].

[illegible] [47]. [illegible] [9]. [illegible]

[illegible] [12]. [illegible] PVC, [illegible] (3-5 cm) [illegible] (GCC) [illegible] GCC [illegible] PCC (0,5-3 cm), [illegible]

[illegible] PCC [illegible] [9,35].

1.2.6.4 [illegible]

[illegible] [22,27].

[illegible] [7,33].

[illegible] [9,13]. [illegible] 2-4 [illegible] [12,33,35].

[illegible] MgO, [illegible] 1.000-1.100 °C [illegible] 20-70 mm) [illegible] 10 mm) [illegible] (CaO.MgO). [illegible] 65,5 kJ/mol. [9]. [illegible] CaO.MgO [illegible] [9,11,12,28]. [illegible]

[illegible] [12]. [illegible] MgO [illegible] 21% [illegible] [13].

[illegible] [11].

1.2.6.5 [illegible]

[illegible] [13,29].

[illegible] [9]. [illegible]

1) [illegible]
2) [illegible]
3) [illegible]
4) [illegible]
5) [illegible]
6) [illegible] [13,31]

[illegible] [9].

[illegible]

[illegible]

[illegible] [11]. [illegible] [47]. [illegible] [11].

[illegible] 1.27: [illegible] [37].

[illegible] 6.000.000 tn [illegible] $CaCO_3$ [illegible] [24-26].

[illegible]

[illegible]

1.2.6.6.1 [illegible]

[illegible] (e.g. [illegible]) [illegible] [11].

[illegible] quartz [illegible]

[illegible]

- [illegible]
- [illegible]
- [illegible]
- [illegible]
- [illegible]
- [illegible]
- [illegible]
- [illegible] [12].

[illegible] >98,6% $CaCO_3$ [illegible] <1% SiO_2 [11] .

1.2.6.6.2 [illegible]

[illegible] (e.g. [illegible]) [illegible] [13]. [illegible] ȷ Ŭɞ gǝɘŸ ůŮ´ ɕɘɷŮǵ ŰŰŬȷ ɛɕɔɏǵ, Ů Ŭüɐ ´ Ŭȷ ɕgůɘŸɛɕg3 ʃ [11]. ȳ´ ɤ ǵ ´ ȷ ɕŬŰűɏȷ ɗɗǝŲ ɖ ǝgȷ ɧŰŰȷ ɖ ɕȷ ɐůɖ Űɤ 3 ɑȷ Ŭgůɛɏ3ɤ 3 Ŭȷ ɤ ɛ ŸŰɤ 3 ŬɞŬɘ ɤ g Ŭȷ Ŭɞ ůǝgȷ ɕüɏɛŰŰɕǵ ǝŬɘ ŰűűŬǝŰɘ ı 3 ǝŬɘ ɤ ǵ Ŭȷ Ŭɞ ɕüɕůŰȷ ı ɛŰŰɕǵ [12].

Ǻɘ ɧ3Ŭ 1.28: ȷ ůɓŰůŰɕǝɘɗɘŸ Ŭȷ Ŭɞ [42].

1.2.6.6.3 ɇ ůɛ ŬŰɕɓɛɛ ɖɕŬɖŬ

Ƀǝ ´ ȷ ı Űǵ ɨ ǝŬǵ Űɕg Űůɛɏ3Űɕg ŬɞŬɛ ȷ ůɓŰůŰɧǝɘɗɕǵ («ɓŬůɘɧ» ůgůŰŰŰɘɧ), Ÿȷ ɔɘɕǵ («ɧ3ɘɞɕ» ůgůŰŰŰɘɧ), ɔɨ ɣɕǵ (Ů ɕɓȷ Űűg3Űɕǵ) ǝŬɘ ´ ȷ ɕůɗŰŰɘŸ. ȼ ɓɛɛɛɖɕŬɖŬ Űůɛɏ3Űɕg Ŭ ɕȷ ȷ ɕüŸ ɛŬɘŸǝŰǵ ´ ɕůɧŰɖŰŰǵ ŰůɓŰůŰɕǝɗɕg ɔɘŰű ŬɞŬɘ ɖ ɓŰůɘɧŰŰȷ ɖ ´ ȷ ı Űɖ ɨ ǝɖ Űɖǵ. ȼ ´ ɕůɧŰɖŰŰ ŰůɓŰůŰɕǝɗɕg ´ ɕg ůɘŰűɗŰŰɘ ɔɘŬ Űɖ3 ´ Ŭȷ ŰůǝŰgɐ Űůɛɏ3Űɤ 3 g´ ɕǝŰɑ ŰŰɘ ɛɧ3ɕ3 ŬɘŬɞɖǵ ´ ɕg ůɘŰűɗŰŰɘ ɔɘŬ Űɕǵ ǝŰŰůǝŰgɏǵ ɔŬɘŸ. ȼ ɓɛɛɛɖɕŬɖŬ Űůɛɏ3Űɕg Űɖ3 ǺǝǝŸűŬ, ɏɕɕ3Űǵ ´ ȷ ɕůŬŰɕǝɑŬɘ Űɖ ůɘŸɖŰůɖ Űɖǵ ´ Ŭȷ Ŭɤ ɔɐǵ Űɖǵ ǝgȷ ɑ ǵ ůŰɕ Ŭɘɤ ŰŰȷ ɘɧ, ůg3Űɕı ǵ Ŭg3Ÿ3Ŭɘ Űɖ3 ´ Ŭȷ Ŭɤ ɔɐ Űɖǵ ǝŬɘ ŬŸǝɕɔŬg3Ÿ3Ŭɘ ǝŬɘ Űɖ3 ǝŰŰŬŸǝɤ ůɖ ůŮŰůɓŰůŰɧǝɗɕ, Űűɕɨ ɔɘŬ ´ Ŭȷ Ŭɤ ɔɐ Ŭɧǵ Űɧ3ɕg Űůɛɏ3Űɕg Ŭ ŬɘŰűŰŰɘ ɏ3Ŭǵ Űɧ3ɕǵ ´ Ŭ ɑ ɕg ŰůɓŰůŰɕǝɗɕg.

ũŬɘŸ, ɕ´ ɕɘüɐ´ ɕŰŰ gǝɘɧ ´ ɕg ´ Ŭg3ŮŰŰɘ ǝŰŰŸ Űɖ3 Ŭɧȷ g3ɖ ɐ ´ ȷ ɕɏȷ ɕŰŰŰɘ Ŭ ɧ ɕɖɛɘɐ ɐ ɛŰŰŬǝɕgȷ ɔɘɐ ǝŰŰŰȷ ɔŬűɖŬǝŬɘ ŬɞŬɘ ´ ǝɕɨ ůɘ ůŮŰůɓɏůŰɕ, ɛ´ ɕȷ Ŭɘ3Ŭɕȷ ɖůɛɕ´ ɕɗɖŮɑɤ ǵ ´ ȷ ı Űɖ ɨ ǝɖ. Ƀǝ ɓŰůɘɏǵ ´ ȷ ɕüɘŬȷ ŰűɏǵɔɘŬ Űɖ3 ´ Ŭȷ ŰůǝŰgɐ Űɕg ǝɕɘɕɨ Űůɛɏ3Űɕg ŬɞŬɛ >65% $CaCO_3$, <5% MgO, <1,5% ŰűɘŸǝgŰɕ ůŮɕ3ɏŬ g´ ɧǝŬɛɛŬ, <0,1% Fe ǝŬɘ <3% Ŭ ı ǝŬŬ ´ ɨ ȷ ɤ ůɖǵ. Ǻ´ ɑɖǵ, Űɕ Űůɛɏ3Űɕ ´ ɧȷ ŰɘŬŰ ´ ȷ ɏ´ Űɘ 3Ŭ ´ Ŭȷ ɘɏɕŬɘ <5% MgO ´ ɕg ůɖɛŬɞŬɘ ɧŰɘ ɖ ´ ȷ ı Űɖ ɨ ǝɖ ´ ȷ ɏ´ Űɘ 3Ŭ ´ Ŭȷ ɘɏɕŬɘ <3% $MgCO_3$.

Ǻ3Ÿǝǝɕg, ŰůɓŰůŰɕǝɘɗɘŸ ´ ŰŰȷ ı ɛŰŰ ´ ɕg ´ Ŭȷ ɘɏɕɕg3 ɘŬɘɏǵ ´ ɕůɧŰɖŰŰǵ Al_2O_3, SiO_2, Fe_2O_3, ŬɞŬɘ ɘüɘŬŰŰȷ Ŭ ǝŰŰŸǝǝɖǝŬ ǝŬɘ ůgɕ3Ÿ ŬɞŬɘ ŰɏŰɕɘŬ ɖ ŬŬǝɕɔŬ Űɕgǵ, ı ůŰŰɖ Űůɛ ŬŰɕɓɛɛɖɕŬɖŬ3Ŭ ɛɖ3 ɏɕŬɘŬŸǝɖ ɕȷ ɖůɛɕ´ ɕɗůɖǵǝŬɘŬŸɛɘɖǵ Ÿǝǝɤ 3 ůg3Űűı 3 ´ ȷ ı Űɤ 3 gǝı 3.

ɇ ɕ gǝɘɧ ɧɛɤ ǵ ´ ɕg ɕȷ ɖůɛɕ´ ɕɘŮŰŰɘ ůɕŰűɧ3 ɕǝɕǝǝɖȷ ɤ ŰɘŸ ŬɞŬɘ ɖ ůǝɤ ȷ ɖŬ gɣ ɘŬɛ ɑɤ 3, Űűɧůɕ3 ŬɞŬɘ űŰɤ ɕɐ ůŮ MgO. ɀ Ů ɛɘŬ ´ ȷ ɕůɖɐǝɖ, ůg3ɐɖɤ ǵ, ɛɘȷ ɐǵ ´ ɕůɧŰɖŰŰǵ ŰůɓŰůŰɕǝɗɕg, Űɕ gǝɘɧ Űgűɖɤ ȷ ŬŰŰɘ ǝŰŰŸǝǝɖǝɕ, ɔɘŰű´ Ŭȷ ɘɏɕɘ ůɕŰűɧ3 ůŮɘüŬɘŸ ´ ɕůɕŮŸ Űŕ ɕ3ŮűɘŬ CaO, SiO_2, Al_2O_3 ǝŬɘ FeO.

[illegible]

– [illegible]
– [illegible]
– [illegible]

[illegible] Al, Mn, H [illegible] Ca. Mg, P [illegible] Mo [illegible] Al-Fe, [illegible]

[illegible] pH [illegible]

[illegible] Ca [illegible] Mg [11]. [illegible] [12]. [illegible] pH, [illegible]

[illegible] pH [illegible] 0,2 mm [illegible] 2-4 [illegible] 2 mm [illegible] 6-12 [illegible] MgO [illegible]

[illegible] $CaCO_3$ [illegible]

[illegible] 75% [illegible]

[illegible]

a. [illegible] pH [illegible] 3,5-6 [illegible] 6-7) [illegible] Ca^{2+} [illegible] Mg^{+} [illegible] pH [illegible] 3,5. [illegible] 35% [illegible]
b. [illegible] Ca [illegible] Mg, [illegible] Na^{+} [illegible] Ca^{2+} [illegible] Mg^{2+}.

[illegible]

d. [illegible]

e. [illegible]

f. [illegible]

g. [illegible] [11].

1.2.6.6.5 [illegible]

[illegible] [9,11]. [illegible] 13% [illegible] 0,2-1 mm. [illegible] Ca [illegible] Mg [illegible] $(NH_4)_2SO_4$, NH_4NO_3, [illegible] [11].

1.2.6.6.6 [illegible]

[illegible] >98,5% $CaCO_3$ [illegible] <0,5% SiO_2 [9,11].

1.2.6.6.7 [illegible]

[illegible] Ca [illegible] P, [illegible]

[illegible] 98-98,5% [illegible] $CaCO_3$, [illegible] (As, F [illegible]), [illegible] (SiO_2, Al_2O_3 [illegible]) [illegible] Mg [illegible] $MgSO_4 \cdot 7H_2O$.

[illegible] <3mm [illegible]

[illegible]

[illegible]

1.2.6.6.8 [illegible]

[illegible] $CaCO_3$ [illegible] 1.9 [illegible] $CaCO_3$ [illegible] $CaCO_3$ [illegible] $CaCO_3$ [illegible] 30% [illegible].

[illegible] 1.10: [illegible] (%) [illegible] [11].

[illegible]	[illegible] 1975	[illegible] 1984	[illegible] 1968	[illegible] 1985
[illegible]	1600	1200	88	62
[illegible]	100	450	2	33
[illegible]	365	450	10	5

[illegible] $CaCO_3$ [illegible] 30 [illegible] 98% <2 [illegible] m, [illegible] $CaCO_3$ [illegible].

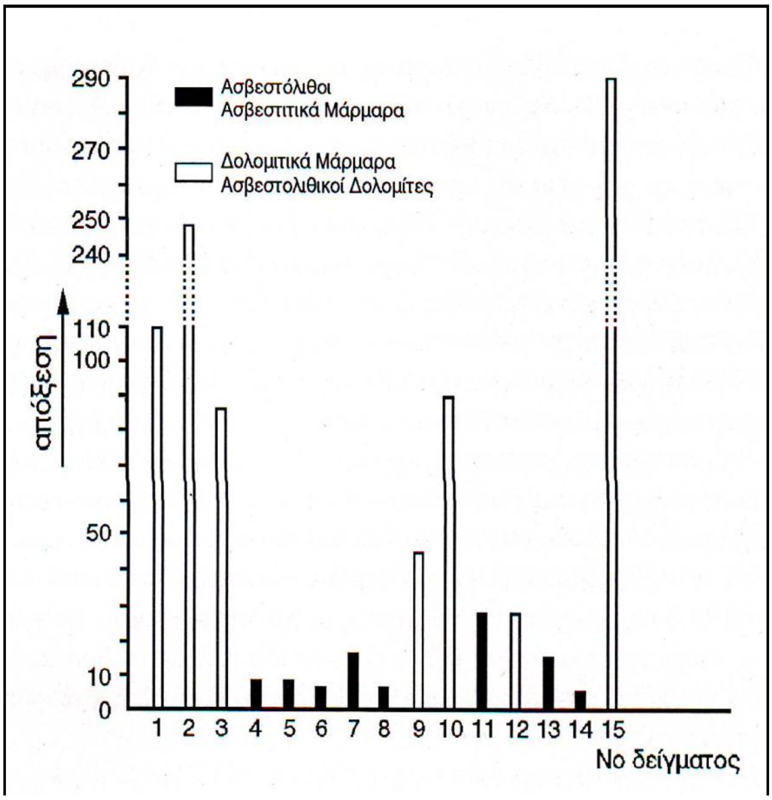
[illegible] (36% [illegible] 1984), [illegible] 7% [illegible] 1972 [illegible] 1985) [illegible].

[illegible] 95-97% [illegible] $CaCO_3$ [illegible] <2 [illegible] m [illegible] Jensen [illegible] SO_2 [illegible].

[illegible]

[illegible] (0,1-0,2%) [illegible] <2 cm. [illegible] 86% Elrepho R-457 [illegible] 35 mg.

[illegible] (1989), [illegible] (Σχήμα 1.26).



[illegible]: 1. [illegible], 2. [illegible], 3. [illegible], 4. [illegible], 5. [illegible], 6. [illegible], 7. [illegible], 8. [illegible], 9. [illegible], 10. [illegible], 11. [illegible], 12. [illegible], 13. [illegible], 14. [illegible], 15. [illegible].

[illegible] 1.29: [illegible] [11].

1.2.6.6.9 [illegible]

[illegible]

[illegible] Mg, [illegible] $CaCO_3$.

[illegible]

[illegible] 0,1 mm [illegible] 0,001 mm [illegible] 1.10. [illegible] caulks [illegible] latex [illegible] [12].

[illegible] 1.11: [illegible] [12].

	[illegible] (εm)	[illegible] (εm)	[illegible]
[illegible]			
[illegible]	22-40	420	[illegible]
[illegible]	12-22	100	[illegible]
[illegible]			
[illegible]	3-10	44	[illegible]
[illegible]	0,7-2	10	[illegible]

[illegible] >80% ([illegible]) [illegible] >96% ([illegible]), [illegible] 18-21, [illegible] 1,5-4 m^2/g, [illegible] 0,6-0,8 g/cm^3 [illegible] pH=9-9,5.

[illegible]

[illegible] CaO [illegible] [11].

[illegible] 1:13:0,7, [illegible] 180 °C [illegible] 7-9 bar, [illegible] [9].

1.2.6.6.11 [illegible]

[illegible] [11].

[illegible] ($CaCO_3$) [illegible] (Na_2CO_3) [9]. [illegible] ([illegible] e/[illegible]) [illegible] [12]. [illegible] 1.11. [illegible] <0,1% Fe_2O_3, <0,001 Cr_2O_3 [illegible] <0,1% [illegible] [11].

[illegible] 1.12: [illegible] [11].

[illegible]	[illegible] (%)	[illegible] (%)
CaO	>54,85	>29,50
MgO	<0,8	>21,40
Fe_2O_3	<0,075	<0,25
Al_2O_3	<0,35	<0,40
[illegible]	<0,05	<0,20
[illegible]	<0,1	<0,40
[illegible]	<0,6	<0,6
[illegible]	<0,05	<0,10

[illegible] 60-65 kg CaO/t [illegible] 30 kg CaO/t [illegible] [9].

[illegible] CaO [illegible] SiO_2 [11].

[illegible] SO_2, SO_3, HCl [illegible] HF, [illegible] [9]. [illegible] >95% $CaCO_3$, <2% SiO_2, <1% Fe_2O_3, <1% Al_2O_3, <1% MgO, <0,02% MnO, <0,001% Cl, [illegible] 50% [illegible] 30 [illegible] 90% [illegible] 90 [illegible] [11].

[illegible] [12].

1.2.6.6.13 [illegible]

[illegible] [9].

[illegible] 3-8 cm, [illegible] 85-95% $CaCO_3$, <5% MgO [illegible]

[illegible] pH, [illegible] [11].

[illegible] [15,24,27,63].

2.1 [illegible]

[illegible] 63,5 [illegible] 200,6 [illegible] 4000 kg/m^{-3} [illegible] 5,0 [illegible] [64,69,71]. [illegible] 20 [illegible] Pb, Cu, Cd, Cr, Fe [illegible] [26,15,27].

[illegible] [55,65]. [illegible] [80]. [illegible] Minamata, [illegible] "Itai-Itai" [illegible] [27,80].

[illegible] [15,25,71,80]. [illegible] [83]. [illegible] Cd^{2+}, Pb^{2+}, Hg^{2+}, Ag^{2+} [illegible] As^{2+}, [illegible] [69,71]. [illegible] [65,83]. [illegible] [69]. [illegible]

[illegible] [83].

[illegible] [71,83].

[illegible]: [illegible] 20 [illegible] Zn [illegible] USEPA (US Environmental Protection Agency, EPA). [illegible] 100 mg/day. [illegible] [52,26,71,81,91]. [illegible] Zn , [illegible] 100 [illegible] 150 mg/day, [illegible] Cu, [illegible] 200-800 mg/day Zn [illegible] [91].

[illegible]: [illegible] [64]. [illegible] [64]. [illegible] [71]. [illegible] Cu, [illegible] Cu [illegible] $Cu(OH)^{+}$, $Cu_2(OH)^{2+}{}_2$ [illegible] $CuCO_3$. [illegible] Cu^{2+} [illegible] pH) [illegible] Cu [64]. [illegible] Wilson, [illegible] [71,81, 94] [illegible] [84]. [illegible] [64].

[illegible]: [illegible] USEPA (US Environmental Protection Agency, EPA) [illegible]

[52,71] ... Itai-Itai ... [71,76,81].

[27,56] ... [85] ... (priority pollutants) ... USEPA (US Environmental Protection Agency, EPA) ... [52,63,70] ... [56,85] ... [63] ... [63,25,71,83].

... [71,81].

... [52] ... [71,83].

... Cr (III) ... Cr(VI). ... Cr(VI) ... Cr(III). ... Cr(VI) ... [71,81].

... As(0) ... s(V) asrenate, As(III) arsenite ... As(III) arsine. ... (As(III) ... As(V) ... (arsenate) ... H_3AsO_4, $H_2AsO_4^-$, $HAsO_4^{2-}$ ... AsO_4^{3-} [5783,97,].

[illegible] (Printed Curcuit Board, PCB). [illegible] [83].

[illegible]

[illegible] mg/dm^{-3}) [illegible] Ni, Zn, Cu, Cd, Pb [illegible] Cr [illegible] [89,90,92]. [illegible] [57,60].

[illegible]:

- [illegible]
- [illegible]
- [illegible]
- [illegible] [83].
- [illegible] [88].

[illegible] [83].

[illegible] [80]. [illegible] [61]. [illegible] [99].

2.3 [illegible]

2.3.1 [illegible]

[illegible]

[illegible]

ɟ ॠ Ű ƴ ůŰ ´ Ų ƌ Ÿ ǝǝ ȝ ƴŰ ůŰ ȝ Ŭ ´ ɟ Ŭ ƃ Ÿȝ ŰŰ ƌ ɖ
Ŭ ůȝ ƴ ƜŬ ůŰ ůŰ ƌ ǂ, ɕ ǂ ǝ Ŭ ɖ ´ ǂ
Ŭ ɖ [27,64,71]. ǝ ȝ ɛ ŭ ǂ ůŰ ƴ Ÿ ůɖ Ŭ ȝ ɟ ȝ Ŭ ƃ ǝ Ŭ ȝ ȝ ƴ ȝ
ǝ Ŭ ɖ Ų ɣ ɖ ´ ɟ Ŭ ƴȝ ȝ Ŭ Ŭ ´ ǝ ŰŰ ɖ Ŭ ɖ ɟ ´ ɖ ǝ ´ Ų ƌ Ŭ ǝ ȝ ƴ ɖ ů
Ŭ ǝ ȝ ƴ ůɖ. ɟ Ű ´ Ų ǝ Ŭ ƃ Ÿȝ ɟ Ŭ ůŰ Ÿ ɛ Ŭ ´ ǝ Ŭ ů ǝ ȝ Ų ɣ ůɖ
ȝ ƃ Ų ƴ ȝ ɛ Ű ǝ ȝ ´ ů Ŭ ȝ Ŭ ´ Ų ƴ ȝ ůŰ Ŭ ɟ Ÿ Ŭ ƃ ɖ Ű [83]. ¢
Ŭ ɟ ɟ ɣ ɖ ƃ Ų ƴ ȝ ɛ Ű ǝ ȝ Ŭ ƃ ɛ ɖ ƴ ´ Ų Ŭ ǝ ƴ Ų Ŭ ɖ Ŭ ƴ Ű ɛ Ŭ ȝ ƴ
ǝ Ŭ ȝ ɛ ´ ɖ Ű ɟ Ŭ ȝ ǝ Ÿ ȝ ɛ Ű ǝ ȝ Ŭ ppm ƴ ppb ǝ Ŭ ɖ Ŭ ɖ ǝ Ű Ų Ŭ
Ŭ ǀ Ŭ [48]. Ɇ ȝ Ŭ 2.1 ´ Ų ů Ÿ ȝ Ű ɛ ƴ ů Ŭ Ų Ŭ ů ǝ Ų ů
(Maximum Concentration Limits, MCL) ȝ ɛ Ű ǝ ȝ Zn, As, Ni, Cd, Cu, Pb, Cr ǝ Ŭ Hg ´ ƴ ȝ
ɖ Ű ´ ů Ŭ Ű ȝ USEPA (US Environmental Protection Agency) [83].

Ŭ Ů 2.1: Ɓ ɛ ƴ ů Ŭ Ŭ Ų ů Ų ů ǝ Ų ů (Maximum Concentration Limits,MCL) ȝ ´ Ŭ ȝ ƃ Ų ƴ ȝ ɛ Ű ǝ ȝ ů ɛ ȝ Ŭ ɛ Ű ȝ USEPA (US Environmental Protection Agency) [83].

ɖ Ų ƴ Ŭ ɛ ƴ Ű ǝ Ŭ	MCL (mg/L)
ɟ ɟ ů Ŭ	0,050
Ƭ Ÿ ɛ	0,01
ɟ ɟ ɛ	0,05
ɟ Ŭ ǝ	0,25
ʔ ƴ ǝ	0,20
Ɋ Ų Ÿ ɟ ɟ	0,80
ɀ ǝ ƃ	0,006
Ɉ Ÿ ɟ	0,00003

¢ Ŭ ǝ ǝ Ŭ Ű Ű ɛ Ű ƴ Ÿ ů ȝ ɟ ȝ Ŭ ´ ȝ ´ Ų ƴ ȝ ƃ Ų ƴ Ŭ ɛ ƴ Ű ǝ Ŭ
Ŭ Ű Ű ƴ Ŭ ů ǝ ƴ ɟ Ŭ Ű ƃ ɛ ɖ Ŭ ɖ Ŭ Ű ƴ ɛ ƴ Ű ȝ Ű Ŭ Ű ƴ
Ŭ ǝ Ŭ ƴ Ŭ Ŭ Ų Ŭ ɖ Ŭ Ŭ Ŭ ǝ Ŭ ɖ ƴ ů ɛ Ų [19]. Ɉ ǝ Ŭ ƴ ȝ Ŭ ´ ǝ ɖ ȝ Ű
Ŭ ȝ ɖ ɛ ƴ ȝ ǝ Ŭ ů ǝ ɖ ɟ Ű ´ Ų ƃ Ŭ ǝ ȝ Ű ǝ Ŭ ȝ ɛ ƴ Ŭ Ŭ Ű ɖ ǝ Ŭ ɖ ů ɛ ´ Ű ƴ Ŭ
ɛ Ÿ Ŭ ɟ Ű ȝ ǝ ȝ Ŭ Ŭ Ų Ŭ ɖ Ų ɟ ȝ Ŭ ǝ ȝ Ű ȝ Ŭ ɛ Ÿ ɟ ů ɖ ȝ ƃ Ų ƴ ȝ
ɛ Ű ǝ ȝ Ŭ ƌ Ű ɟ Ŭ Ŭ Ÿ Ŭ ɛ Ű ɛ ƴ Ŭ Ų ɟ Ÿ ɛ Ŭ ů ǝ Ų ů ȝ. ɟ Ų
´ Ų ǝ Ŭ ƃ Ÿ ȝ Ű ɖ ɛ ǝ Ű ɟ ɛ ů ɖ, Ű ȝ ǝ ɟ ǝ ɖ-ů ɟ Ű ɖ, Ű ȝ Ű ǝ Ŭ, Ű ȝ
Ŭ ǀ ǝ Ų ɖ, Ű Ŭ ɖ ɖ ɛ ƴ ɛ Ŭ ƃ ɟ Ŭ ȝ, Ű ´ ɟ ů ɖ ɖ, Ű ȝ ɖ ǝ Ų Ŭ ɖ, ɖ ǝ Ų ɖ ɛ ǝ ƴ
ɛ Ű ɟ, Ű ȝ Ű ǝ Ű Ÿ ů ɖ ǝ.Ÿ. Ɇ Ű ů ȝ ƴ Ŭ, ǝ Ű Ŭ Ű ɟ Ÿ ů Ų ů ɟ ȝ Ű ɛ ƴ ɖ
Ŭ Ŭ Ų ǝ Ű ɖ ɟ ȝ Ŭ ƃ ǝ Ű ȝ ǝ Ŭ Ű ȝ Ŭ ɛ Ÿ ɟ ů ɖ ƃ Ų ƴ ȝ ɛ Ű ǝ ȝ [15,71,83].

2.3.2 ɟ ɖ ɛ ǝ Ű ɟ ɛ ȝ ů ɖ

2.3.2.1 Ʌ ů Ŭ ǝ

¢ ɖ ɛ ǝ Ű ɟ ɛ ȝ ů ɖ Ŭ Ŭ ɖ ɖ ´ Ų ƴ Ű Ų ɛ ɖ Ű ȝ ǝ Ŭ ǝ Ŭ Ű ȝ
Ŭ ɛ Ÿ ɟ ů ɖ ȝ ɛ Ű ǝ ȝ Ŭ ´ ǝ Ŭ ǝ Ŭ Ŭ Ŭ Ÿ Ű, ů Ų ǝ ɛ Ű ǝ Ŭ ƃ ɛ ɖ Ŭ Ÿ
ɟ Ÿ Ŭ ƃ ǝ Ű. Ʌ ǀ ɖ ɖ, Ŭ Ŭ Ű Ű ɛ Ű ǝ Ŭ ɛ Ŭ ɟ Ÿ ɖ ´ Ų ƴ ɟ ɖ ů ɛ ´ ɛ Ŭ ɖ
ǝ Ų ǝ Ű ɖ Ű Ű ƃ ɛ ɖ Ŭ, Ŭ Ű Ű ů Ű Ÿ Ŭ ǝ ǝ Ŭ ů ɖ ǝ Ű ǝ Ű Ű. Ɇ Ű ǝ Ų ǝ Ű ɖ Ű
ǝ Ű ɟ ɛ ȝ ů ɖ, ɖ ɛ ƴ ů ɖ Ŭ Ű ɟ ȝ ɛ Ű Ű ȝ Ű ȝ ƃ Ų ƴ ȝ ɛ Ű ǝ ȝ ů Ű ȝ Ŭ
ů ɖ ɛ Ű ȝ Ű Ÿ Ű ɛ Ű . ¢ ǝ Ű ɟ ɛ ȝ ů ɖ ȝ ɛ Ű ǝ ȝ ǝ Ŭ Ÿ Ű, ů ȝ ɖ ɖ, ɛ ƴ Ŭ ů Ŭ

Ŭờəə ɐ ɘɨ ɠ ɛ´ɕɟ Ůɑ ɜŬ ŭɘŬɤ ɟɘŰɑ Ŭ ɧ Űɞ ɜŮɟ ɧ ɛɏůɤ
ÆŰɖ ůɡɜɏɢŰŬ, Űɞ Ů ŬɜŮɟ ɔŬɐ ɛɏɜɕ ɜŮɟ ɧ ɛŰŰɓɔɞŰŰɓ əŬɓ
Ů ɕɟ ɟɖ ŰŰŰɜ əŬŰɤəɖəŬ ɐ Ů Ŭɜ ɕɟ ɖůɐɛɕ´ɕɜŬŰŰɓ Bɘ ůɡɛ ɓŰŬɓɏɠ ŭɘŬɟ ɔŬůɖɠ ɢɖɛɘɐɠ
əŬŰŰɓɟ ɐɛɜɘůɖɠ ´Ůɟ ɘŬɛ ɓŸɜɕɡɜ əŬŰŰɓɟ ɐɛɜɘůɖ ɡŭɟ ɕɜŬɞɑ ɜ əŬɓ əŬŰŰɓɟ ɐɛɜɘůɖ ůɕɡəɞɘɑ ɜ, Ůɜɩ
Ÿəə Ůɠ ŰŰɞɜɘɏɠ əŬŰŰɓɟ ɐɛɜɘůɖɠ ´Ůɟ ɘŬɛ ɓŸɜɕɡɜ Űɞ ůɕɖɛ ŬŰɞɛɧ Ŭɜɖɟ Ŭɞɘɩ ɜ ɛŮŰŸəəɤ ɜ əŬɓ
ŰɤůŰɕɟ ɘɩ ɜ ɛŮŰŸəəɤ ɜ [71,82]. ɟ ɜŰŭɟ ŸůŬɠ ɕɜŮɑɤ ůɖɠ/ŬɜŬɓɤ ɔɐɠ ɛ´ɕɟ ɕɨ ɜ, Ŭɞɧɛɖ, ɜŬ
ɕɟ ɖůɐɛɕ´ɕɜɖɖɕɨ ɜ ɔŬ Űɖɜ əŬŰŰɓɟ ɐɛɜɘůɖ Ůɑɘɩ ɜ ɛŰŰŬəəɩ ɜ ɟɨ´ɤ ɜ, ɧ´ɤ ɠ Űɞ Ůɟ ůŬɜɘɧ əŬɓ Űɞ
ɕɟ ɩ ɛɘ.

ɸŸŰɕɟ ɕɘ Ů ɘŮŬŰɘɕɑ´Ůɟ Ÿɔɕ ɜŰɠ əŬŰŰɓɟ ɐɛɜɘůɖɠ, ɧ´ɤ ɠ´Ůɟ Ÿɔɤ ɔŬŰɞɡ dithiocarbamate (DTC, DDTC, DMTC), ɖŮɞŬɖɟ Ŭɞɘ Ÿ ŸɔŰŰ (thiocarbonate salts, STC) əŬɓ ɖ 2,4,6-trimercapto-1,3,5-triazine (ɇɀ ɇ), ɏɕɡɜ ŬɜŬ Űɡɕɖůɑ ŰŰ ŰŮɔŮɡŰŰɖŬ ɕɟ ɧɜɘŬ ɔɘŬ Űɖɜ Ů ŬɜŮɟ ɔŬůɖŬ Űɤ ɜ ɡɔɟ ɩ ɜ Ŭ ɕɓəɐŰɤ ɜ ɛŮŰŸəəɤ ɜ. ɖ ůŰɧůɕ, Űɞ ůɕŰŰɘ Ÿ ɡɣ ɖəɧ əɧůŰɞɠ Űɞɡɠ Ŭ ɕŰŰɘŮɑ ɏɜŬ Ůɛ´ɧŭɘ ůŰɖɜ ŰɑŬɟ ɛɕɔɐ Űɞɠɠ ůŬ ´ɕəəɏɠ ɓɘɛɖɕŬɜɘɏɠ ŰɑŬɟ ɛɕɔɏɠ.

ÆŰɞ ´Ůɟ Ůəɖɧɜ, ɖ Ů ɘɕɔɐ Űɖɠ ŰŰɞɜɘɐɠ əŬŰŰɓɟ ɐɛɜɘůɖɠ ɔɘŬ Űɖɜ Ů ŬɜŮɟ ɔŬůɖŬ ɡɔɟ ɩ ɜ Ŭ ɕɓəɐŰɤ ɜ ɓŰŬɘɧŰŰɓ, əɡɟ ɑ ɠ, ůŰɞ əɧůŰɞɠ Űɤ ɜ ɕɟ ɖůɐɛɕ´ɕɘɨ ɛŮɜɤ ɜ ɕɖɛɘɩ ɜ. ƟŬɟ ɧəŬ ŬɡŰŸ, ŮɞŬ´ɟ ɕŰŬɏɠ ɧŰɞ ɖ Ŭ ɧŭŬůɖ ɖŬ ɏ ɟ Ů Ů Ůɑůɖɠ, ɜŬ əŬɛ ɓŸɜŮɓ ɠ´ɧɣɖ Űɠ ´ɕůɧŰɖŰŰɠ əŬɓ ŰŰ ɕŬɟ ŬɓŰɖɟ ɘŰɞŸ ŬŰɡŭŸŰɤ ůɖɠ Űɤ ɜ ´Ůɟ ŬɓɧɛŮɜɤ ɜ ɛŮŰŰɓəəɩ ɜ ɘɡɩ ɜ [82].

2.3.2.2 ɪŬŰŰɓɟ ɐɛɜɘůɖ ɡŭɟ ɕɜŮɞɑ ɜ

¢ ´ɘ Ůɟɟ ɏɤ ɠ ɕɟ ɖůɐɛɕ´ɕɘɨ ɛŮɜɖ ŰŰɞɜɘɐ ɢɖɛɘɐɠ əŬŰŰɓɟ ɐɛɜɘůɖɠ Ŭɜɧɟ ɔŬɜɤ ɜ əɡɛ ŸŰɤ ɜ ŮɞŬɜɖ əŬŰŰɓɟ ɐɛɜɘůɖ ɡŭɟ ɕɜŮɞɑ ɜ ɢŸɟ ɘɠ ůŰɖɜ ůɕŮŰɞɐ Ŭ əɧŰɖŸŰɖɠ, Űɞ ɢŬɛɖəɧ əɧůŰɞɠ əŬɓ Űɖɜ Ůɡəɕəɖ Űɖɠ ɟɨ ɖɛɘůɖɠ Űɞɡ pH [71,82,83,69]. ɇ Ŭ ŭɘŬɡŰŸ ɛɏŰŰɓəŬ ɛ´ɕɟ ɕɨ ɜ ɜŬ əŰŰɓɟ ɖɛɜɘůŮɨ ɜ ɤ ɠ ɡŭɟ ɕɜŰɞɘŬ ůɨ ɛŰɤ ɜ ɛŮ Űɖɜ Ŭɞɧəɡɖɖ ŬɜŰŭɟ Ŭůɖ ɛŮ Űɖ ɕɟ ɐůɖ ŭɘŸŰɕɟ ɤ ɜ ŬɘŬɓɘɩ ɜ ŬɜŰŭɟ ŰŰɖɟ ɑ ɜ, ɧ´ɤ ɠ CaO, $Ca(OH)_2$, $Mg(OH)_2$, NaOH əŬɓ NH_4OH:

$$ɀ^{2+} + 2(Ɓ¢)^{-} ź \quad ɀ(Ɓ¢)_2 Ź$$

ɧ´ɕɡ ɀ $^{2+}$ əŬɓ Ɓ¢$^{-}$ ŬɜŰŭ ɟɕůɤ´Ůɕɡɜ ŰŰ ŭɘŬɡŰŸ ɛŮŰŰɓəɘŸ ɘɜŰŰ əŬɓ Űɞ ɛɏůɕ əŬŰŰɓɟ ɐɛɜɘůɖɠ, ŬɜŰɑůŰɞɕŬ, Ůɜɩ Űɞ ɀ (Ɓ¢)$_2$ ŮɞŬɜŰɞ ŬŰɘŸɡŰɞ ɛŮŰŰɓɘɧ ɡŭɟ ɕɜŮɑɘ [82,83].

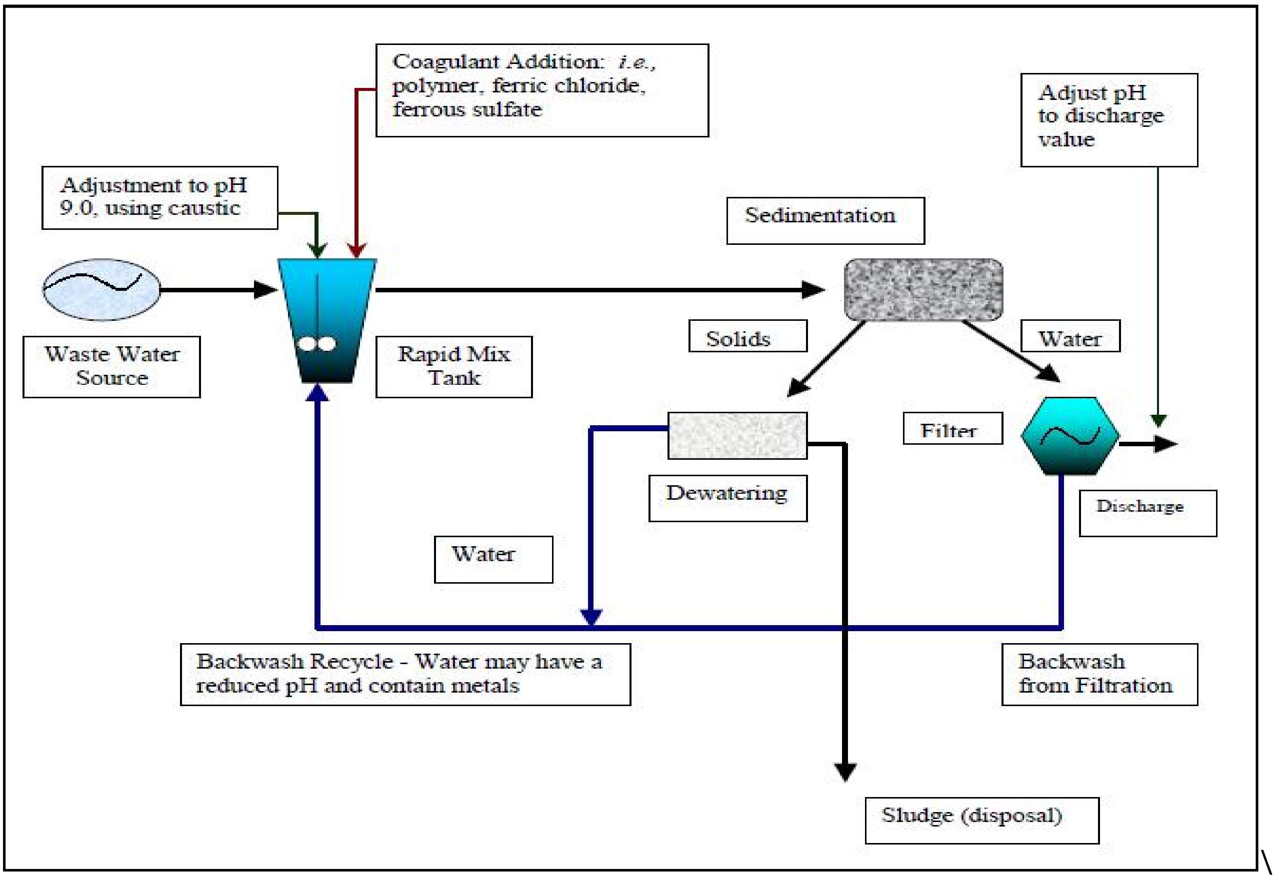
ɀ Ůɟɘɕɑ Ÿəɕɘ ´Ůɟ Ÿɔɕ ɜŰɠ əŬŰŰɓɟ ɐɛɜɘůɖɠ ɛ´ɕɟ ɕɨ ɜ ɜŬ ɕɟ ɖůɐɛɕ´ɕɜɖɖɕɨ ɜ, ɩ ůŰŰ ɜŬ Ů ɘŰŰɡɕɖɕɨ ɜ ɢŬɛɖəɧŰŰɟ Ůɠ ůɡɔəŬɟ ɩ ůŬɠ ŬɜŬ ɕɛŮɞŸŬŰɤ ɜ ŭɘŬɡŰ ɜ ɛŮŰŸəəɤ ɜ əŬɐ ɜŬ ´Ůɟ Űɢɖɑ ɛŮŰŰɓəɘɐ ɘɨ ɠ ɖ ɕ´ɕəŬ ɏɕŬəŬɨ ŰŰɟ Ůɠ ɘŰɧŰɖŰŰɠ´ Ÿɕɡɜůɖɠ əŬɓ ŬɡŭŸŰɤ ůɖɠ [82].

ũɘŬ Űɖɜ əŬŰŰɓɟ ɐɛɜɘůɖ Űɤ ɜ ɛŮŰŸəəɤ ɜ Ŭ ɧ ɡɔɟ Ÿ Ŭ ɧɓəɖŰŰ ɕɟ ɖůɐɛɕ´ɕɜŬŰŰɓ ɏɜŬ ´əɐɖɕɡ ɡŭɟ ɕɜŮɞɑ ɜ. ¢ ŸůɓŬůŰɞɡ Ŭ ɕŰŰɘŮɑ Űɖɜ ´ɘ ůɡɕɜŸ ɕɟ ɖůɐɛɕ´ɕɘɨ ɛŮɜɖ ɓŸůɖ ůŰɖɜ əŬŰŰɓɟ ɐɛɜɘůɖ ɡŭɟ ɕɜŮɞɑ ɜ ůŮ ɓɘɛɖɢŬɜɘŸ ´Ůɟ ɘɓŸəəɕɜŰŰ ůŰɠ ´Ůɟ ɘůůɧŰŰɟ Ůɠ ɢɩ ɟ Ůɠ əŬɓ Ů ɘɏɔŰŰɓ ŮɞŬɜŰŰɠ Űɞɡ ɢŬɛɖəɘɨ əɧůŰɞɡɠ, Űɖɠ ŭɘŬɜŰŮɛɧŰɖŰŸɠ Űɖɠ əŬɓ Űɖɠ Ůɡəɕəɖ Űɠ ůŰɖ ŭɘŬɢŮɟ ɘůɖ [71,83]. ¢ əŬŰŰɓɟ ɐɛɜɘůɖ ɛŮ ŸůɓŮůŰɞ ɛ´ɕɟ Ůɑ ɜŬ ŰɑŬɟ ɛɕůŰɑ ɔɘŬ Űɖɜ Ŭ ɕŰŰɘŮɑɛŬɞɐ Ů ŬɜŮɟ ɔŬůɖŬ ŬɞɧɟɔŬɜɤ ɜ əɡɛ ŸŰɤ ɜ ɛŮ ůɡɔəɏŮɟ ɤ ůɖ ɛŮŰŸəəɤ ɜ ´Ÿɤ Ŭ ɧ 1000 mg/L. ȯ əəŬ ´əŬɞɜŬŮɛŰŰ Űɖɠ ɕɟ ɐůɖɠ Űɖɠ əŬŰŰɓɟ ɐɛɜɘůɖɠ ɛŮŸůɓŮůŰɞ Ŭ ɕŰŰɘɕɨ ɜ ɖ Ŭ əɧŰɖŰŰ Űɖɠ ŭɘŬɟ ɔŬůɖŬ, ɖ Ŭ Űɖɖůɖ ůŮŰɖɖɜɧ Ůɞ´əɘɛɧ əŬɓ ɕɘ Ů əɕəŬɠ əŬɓ ŬŰŰŬɘŰɠ əŬŰɕɡɟ ɔɖɠ [83].

Ɓɘ ŭɘŬɡŰɧŰɖŰŰɠ Űɤ ɜ ŭŸŰɕɟ ɤ ɜ ɛŮŰŰɓəəɩ ɜ ɡŭɟ ɕɜŮɞɑ ɜ ŮɞŬɜɕɘŮɞ´ɕɘɨ ɜŰŰɓůŰɖɜ əəɐ ŬɜŬ Űɡ pH Ŭ ɧ 8-11 [71]. ɖ ɠ Ůɓ Űɞɨ Űɡ, ɖ ɟɨ ɖɛɘůɖ Űɞɡ pH ůŮ ɓŰŰɘɏɠ ůɡɜɖɛəŬɠ əŬɓ ůɡɔəŬɟ ɛɏɜŬ ůŰɞ ůɖɛŬɞ ɧ´ɕɡ ŬɜŰŭŰŬɐŰŰɓ ɖ ŬŸɕůŰɖ ŭɘŬɡŰɧŰɖŰ Űɤ ɜ ɛŮŰŸəəɤ ɜ Ŭ ɕŰŰɘŮɑ Űɖ ɓŰŰɘɐ ´Ůɟ ŸɛŰɟ ɕ ´ɕɡ ɓŬɘŰɘ ɜŬ ůɖɛŬɞŰŰɓŸ Űɖɜ Ŭ ɕɛŸɟ ɡɜůɖ Űɤ ɜ ɓŬɟ ɏɤ ɜ ɛŮŰŸəəɤ ɜ ɛɏůɤ ɢɖɛɘɐɠ əŬŰŰɓɟ ɐɛɜɘůɖɠ (Ắɘɧ ɜŬ 2.1) [72,83]. Ưɏɟ Ŭ Űɤ ɜ ´Ůɟ Ŭ Ÿɤ ŬɜŰŭɟ ŰŰɖɟ ɑ ɜ əŬɓ ɕ ŰɓŮɓŬŰɖɠ ɕɟ ɖůɐɛɕ´ɕɜŬŰŰɓ ůŮ ɓŰŰɘɏɠ ŭɘŮɟ ɔŬůɖɠ ɟɨ ɖɛɘůɖɠ Űɞɡ pH Űɤ ɜ Ŭ ɕɟɟ ɕɩ ɜ ɛŮ ůəɕ´ɧ Űɖ ɓŬŰɘůŰɞ´ɕɖůɖ Űɖɠ əŬŰŰɓɟ ɐɛɜɘůɖɠ ɛŮŰŰɓəɘɩ ɜ ɕɜŮɞɑ ɜ əŬɓ ɡŭɟ ɕɜŮɞɑ ɜ [54]. ɇ Ŭ ɛŮŰŰɓəəɘŸ ɡŭɟ ɕɜŮɑɘŬ ɛ´ɕɟ ɕɨ ɜ ɜŬ Ŭ ɕɛŬɟ ɡɜɖɕɨ ɜ ɛŮŰŰɜɘɏɠ ůŰɟ Ůɞɨ-ɡɔɟ ɕɨ ɧ´ɤ ɠ əɟ ɕəɑ ůɖ, ŭɘɖɖůɖ əŬɓ ŬŰɑɖůɖ [71,72].

[illegible]

[illegible] pH [illegible] [19,71,72,83]. [illegible] [19,57]. [illegible] [19].



[illegible] 2.1: [illegible] [83].

[illegible] [71]. [illegible] Na_2S, $NaHS$, H_2S [illegible] FeS, [illegible] [82]:

$$M^{2+} + S^{2-} \rightarrow MS\downarrow$$

[illegible] pH [illegible]

[illegible] (Sulphate-Reducing Bacteria, SRB). [illegible] SRB [illegible] SRB [illegible]

$$3SO_4^{2-} + 2CH_3CH(OH)COOH \rightarrow 3H_2S + 6HCO_3^{-}$$

[illegible] $CH_3CH(OH)COOH$ [illegible]

$$M^{2+}_{(aq)} + H_2S_{(g)} \rightarrow MS_{(s)}\downarrow + 2H^{+}_{(aq)}$$

[illegible] H_2S. [illegible] [71].

2.3.2.4 [illegible]

[illegible] Na_2CO_3, $NaHCO_3$ [illegible] $CaCO_3$, [illegible] [82]:

$$M^{2+} + (CO_3)^{2-} \rightarrow M(CO_3)\downarrow$$

[illegible] [61]. [illegible] [83]. [illegible]

[illegible] [81].

[illegible] [82]:

$$M^{2+} + 2(PO_4)^{3-} \rightarrow M_3(PO_4)_2 \downarrow$$

2.3.2.5 [illegible]

[illegible] [71]. [illegible] [82].

2.3.2.6 [illegible]

[illegible]

[illegible] (π.χ. trimercaptotriazine, potassium/sodiumthiocarbonate, sodiumdimethyldithiocarbamate), [illegible] $BDET^{2-}$ (1,3-benzenediaminoethanethiol), [illegible] N,N0-bis-(dithiocarboxy)piperazine) (BDP) [illegible] 1,3,5-hexahydrotriazinedithiocarbamate (HTDC), [illegible] dipropyl dithiophosphate. [illegible] (potassium ethyl xanthate)

2.3.3 [illegible]

[illegible] [71].

[illegible] [83]. [illegible]

[illegible] [99].

[illegible] [83]. [illegible] [71].

[illegible] (-SO_3H) [illegible] (-COOH). [illegible]

$$nR\text{-}SO_3H + M^{n+} \rightleftharpoons (R\text{-}SO_3^-)_n M^{n+} + nH^+$$

$$nR\text{-}COOH + M^{n+} \rightleftharpoons (R\text{-}COO^-)_n M^{n+} + nH^+$$

[illegible] pH, [illegible] [71].

[illegible] EDTA [illegible] R-EDTA-Na. [illegible] (iminodiacetic) [illegible] Cu, Ni, Cd [illegible] Zn. [99].

[illegible] [71]. [illegible] (Cr, Ni, Cu, Zn, Cd, Pb) [illegible] Cs) [illegible] (chabazite) [99].

[illegible] [71].

[illegible] pH. [illegible] pH [illegible] pH, [illegible]

[illegible] pH, [illegible] [99].

[illegible] pH [illegible] [83].

[illegible] [99].

2.3.4 [illegible]

2.3.4.1 [illegible]

[illegible] [102,99]. [illegible] [83,88,100]. [illegible] (Ŭ) [illegible] (б) [illegible] [100-102, 99].

[illegible] [101]. [illegible]

i. [illegible]
ii. [illegible]
iii. [illegible]

[illegible] [99].

[illegible] Van der Vaals, [illegible] 2.2 [illegible] [88,100].

[illegible] 2.2: [illegible] [100].

[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible] Van der Vaals, [illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	4-40 kJ/mole	>200 kJ/mole

[illegible] [25,71,83]. [illegible]:

- [illegible]
- [illegible]
- [illegible]
- [illegible] [25].

[illegible] [75]. [illegible] [71,96]. [illegible]

[illegible] [83].

[illegible] [71].

2.3.4.2 [illegible]

[illegible] (Activated Carbon, AC) [illegible] [71]. [illegible] Ni, Cr (II), Cd(II), Zn(II), Cu(II), Cr(VI), [illegible] [81]. [illegible] pH, [illegible] [67,75].

[illegible]

[illegible] [71]. [illegible] [87]. [illegible]

[illegible]

[illegible] (Carbon Nanotubes, CNTs), [illegible] 1991 [illegible] Iijima, [illegible]

[illegible]

1) [illegible] (Single-Walled CNTs, SWCNTs) [illegible]
2) [illegible] (Multiple-Walled CNTs, MWCNTs).

[illegible] HNO_3, NaClO [illegible] $KMnO_4$.

[illegible] [71].

2.3.4.4 [illegible]

[illegible] [63]. [illegible] silica gel, [illegible] silica, [illegible] Fe, [illegible] [15,61,71,74]. [illegible] 70 [illegible] [74].

2.3.4.4.1 [illegible]

[illegible] [25].

[illegible] [65].

[illegible] [75,81,86]. [illegible] Pb (II), Cd (II), Zn (II) [illegible] Cu (II). [illegible] [83]. [illegible] [81].

[illegible] NaA zeolite, 4A zeolite [illegible] MMZ (Magnetiacally Modified Zeolite)) [illegible] pH [illegible] [83].

[illegible] [68]. [illegible] pH [illegible] [15,27,68,75,86]. [illegible] [74,81]. [illegible] [71]. [illegible]

[illegible] 900 °C, [illegible] [83]. [illegible]

[illegible] [53,54].

[illegible] 2.3 [illegible] [83].

[illegible] 2.3: [illegible] [83].

[illegible]	[illegible] (mg/g)					
	Pb^{2+}	Cd^{2+}	Zn^{2+}	Cu^{2+}	Cr^{6+}	Ni^{2+}
[illegible]	1,6	2,4	0,5	1,64		0,4
[illegible]	123					8
HCl-[illegible]			63,2	83,3		
[illegible] ([illegible]) [illegible]	81,02		20,6	29,8		80,9
	85,6					
[illegible]	155,0					
[illegible]	4					
[illegible]	398					

[illegible] [53,61].

[illegible], $(Me,Ca)CO_3$, [illegible] [78].

[illegible] [23,50, 68,76,77]. [illegible] [23,68].

[illegible] [54]. [illegible] $CaCO_3$, [illegible] [23,57,59,77,98]. [illegible]

[illegible] [50,51]. [illegible] Ca [illegible] [50]. [illegible] [25,26]:

$$ CaCO^{o}_{3} + M^{2+} + HCO^{-}_{3} \rightarrow CaCO_{3}(s) + MCO^{o}_{3} + H^{+} $$

$$ MCO^{o}_{3} + M^{2+} + HCO^{-}_{3} \rightarrow MCO_{3}(s) + MCO^{o}_{3} + H^{+} $$

[illegible] $CaCO_3$ [illegible] Cd, Co, Zn, Pb, [illegible] [57]. [illegible] Cd, [illegible] Cu [illegible] Zn [illegible] Ca [illegible] $CdCO_3$ [illegible] $ZnCO_3$ [illegible] $CuCO_3$ [illegible]. [illegible] Cd [illegible] Zn [illegible] Cu [illegible] Cd [illegible] Zn [illegible] $CdCO_3$ [illegible] $CaCO_3$, [illegible] Zn [illegible] Cu [illegible] Cu [illegible] Zn [57,76,77,79]. [illegible] Cd, Zn, Mn [illegible] Co [illegible] [49,57,59,77]. [illegible] $MeCO_3$, [illegible] [23]. [illegible] Fe [illegible] Al [illegible] [54].

[illegible]

- ✓ [illegible] Ca [illegible] Mg [illegible] [15]. [illegible] Cd>Mn>Zn>Co [49,50,51,23].
- ✓ [illegible] [15].

[illegible] Cu(II), Pb(II), Cd(II), As(V) [illegible] [15,20,27,48,97]. [illegible]

[illegible] [22,19]. [illegible] Pb(II), Cd(II), Co(II) [illegible] Cr(III) [78]. [illegible]:

I. [illegible]

II. [illegible] [15]. [illegible] Ca [illegible] Mg [illegible] pH, [illegible] [15,20]. [illegible] [19,98]. [illegible] CaO [illegible] Pb [illegible] [15].

[illegible] [63,64]. [illegible] (Acid Mine Drainage, AMD) ([illegible]) [illegible] [15,60,62]. [illegible] Ca^{2+}, [illegible] Pb, Cd, As, Zn, Cu, [illegible] [62].

[illegible] (Powdered Marble Waste, PMW) [illegible] Cu(II), Cr(III), Zn(II) [illegible] Pb(II) [24-26].

[illegible] ($MgCO_3$), [illegible] ($FeCO_3$) [illegible] Mg [illegible] ($CaCO_3$) [illegible]

[illegible] [23].

[illegible] Cd(II), Pb(II), Cr(VI) [75,86].

2.3.4.4.2 [illegible]

[illegible] clinopyrrhotite, [illegible] [71].

[illegible] [75]. [illegible] [83,81]. [illegible] ferrosorp plus, [illegible] akaganeite [83].

2.3.4.4.3 [illegible]

[illegible] [71]. [illegible] [61]. [illegible] [71,92,95].

[illegible]

1. [illegible]
2. [illegible]
3. [illegible] [71].

[illegible]

[illegible] [83,80]. [illegible] [95]. [illegible] ([illegible]) [illegible] ([illegible]), [illegible] [83]. [illegible] [95]. [illegible] (Coconut Shell Charcoal, CSC), [illegible] [83,80,92,95]. [illegible] [80].

[illegible] [71]. [illegible] Chatoetomorpha linum, Caulerpa lentilliefera, Cladophroa fascicularis. [illegible] Spirogyra, Ecklonia maxima, Ulva lactuca, Oedogonium sp. [illegible] Nostoc sp. [illegible] Fucus serratus [71,83]. [illegible]

[illegible] Bacillus cereus, Escherichia coli, Pseudomonas aeruginosa, [illegible]

[illegible] Aspergillus niger, Rhizopus arrhizus, Rhizopus oryzae, Saccharomyces cerevisiae, Lentinus edodes, [illegible] [71].

[illegible] Ca-alginate [illegible] gel, [illegible] [93].

[illegible] pH [illegible] 2-6 [83]. [illegible]

[illegible] [83]. [illegible] [61]. [illegible] [95]. [illegible] 2.4 [illegible] [83].

[illegible] [71,92].

[illegible] 2.4: [illegible] [83].

[illegible]	[illegible] (mg/g)					
	Pb^{2+}	Cd^{2+}	Zn^{2+}	Cu^{2+}	Cr^{6+}	Ni^{2+}
[illegible]	456	493,7	495,9			
[illegible]						158
[illegible]					3,65	
[illegible]			13,9	31,7		
[illegible]		2,0			0,79	
[illegible]					23,4	
Spirogyra ([illegible])				133		
Ecklonia maxima- [illegible]	235			90		
Ulva lactuca					112,3	
[illegible] Oedogonium	145					
[illegible] Nostoc	93,5					
Bacillus-[illegible]	467	85,3	418	381	39,9	

2.3.4.4.4 [illegible] (hydrogels)

[illegible] ppb, [illegible]

[illegible]) [illegible]

[illegible] 2.5 [illegible] [83].

[illegible]	[illegible] (mg/g)					
	Pb^{2+}	Cd^{2+}	Zn^{2+}	Cu^{2+}	Cr^{6+}	As^{5+}
[illegible]		150		164		230
Gel [illegible]	433			135		
[illegible]				200		

[illegible]:

a) [illegible] (gels)

b) [illegible]

[illegible]

[illegible]

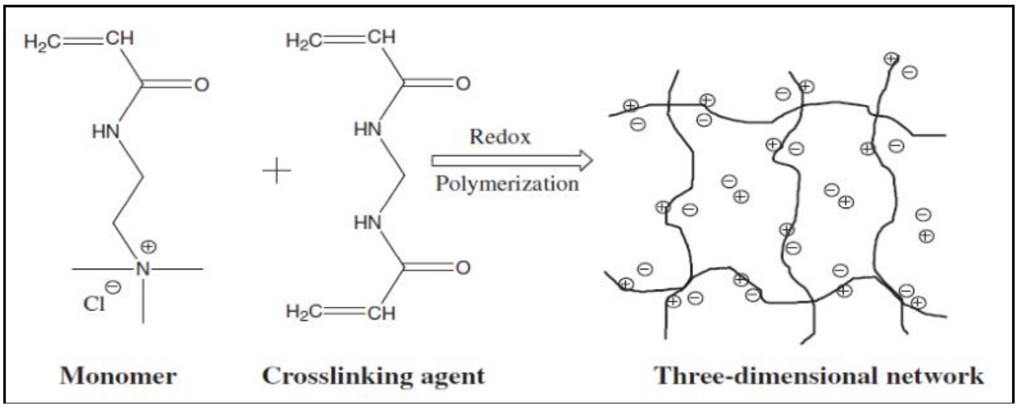
[illegible]

[illegible] pH, [illegible]

[illegible] C-3, [illegible] pK_a [illegible] 6,2 [illegible] 7. [illegible] sol-gel.

[illegible] poly(ethyleneglycol dimethacrylate-co-acrylamide), [illegible] poly(vinylpyrrolidone-co-methylacrylate) [illegible] poly(3-

[illegible] loride. [illegible] pH >6. [illegible] 2.2 [illegible] [83].



[illegible] 2.2: [illegible] [83].

2.3.5 [illegible]

[illegible] [83]. [illegible] [71]. [illegible] «membrane contactors», [illegible] [83].

2.3.5.1 [illegible]

2.3.5.1.1 [illegible]

[illegible] (Ultrafiltration, UF) [illegible] [71]. [illegible] 5-20 nm [illegible] 1000-100.000 Da. [illegible]

[illegible] [83]. [illegible] [71].

[illegible] (Transmembrane Pressure, TMP) [illegible] [83].

[illegible] EYMM (Micellar Enhanced Ultrafiltration, MEUF) [illegible] EYMƟ (Polymer Enhanced Ultrafiltration, PEUF).

2.3.5.1.2 [illegible]

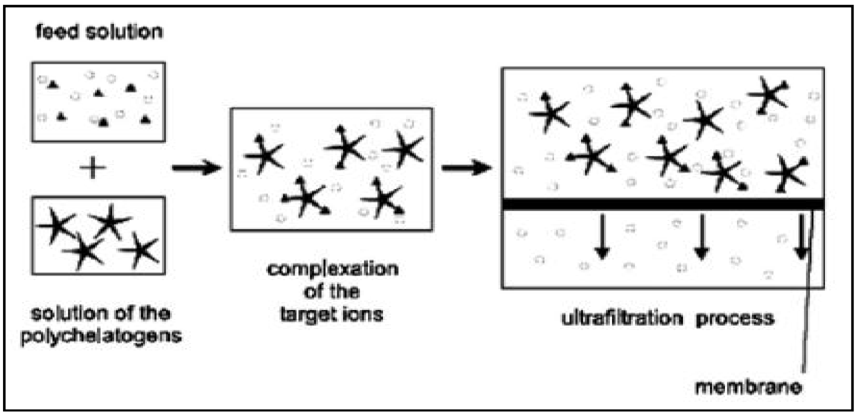
[illegible] Scamehorn [illegible] 1980 [illegible] (Critical Micelle Concentration, CMC), [illegible] SDS (Sodium Dodecyl Sulfate), [illegible].

[illegible] pH [illegible].

[illegible].

[illegible]

[illegible] (PAA), [illegible] (PEI), [illegible] [71,83]. [illegible]



[illegible] 2.3: [illegible] [83].

[illegible] pH [illegible]

[illegible] [71].

2.3.5.2 [illegible]

[illegible] (Reverse Osmosis, RO) [illegible] 20% [illegible] ɛɛ Ύəɟ gȝůd бŬɟ уɤ ȝ ɛŮŬŶəəɤ ȝ уGŬ Ŭɡ Ůgȝdɖŭ ŭŬ уGŬ

ɀ ŬəУŬɡ уGɞgȝ, Ŭ dŭgɡ ŭŬ ŬŬd ŬŬŬŬ ɞŭd ɧůɛɤ ůd ůŬůgȝŭgŬŭɛɧ ɛŬ´ ɞɞŬɧ ůɨ ůŬɖɛŬ бɞŬŬŭɟ ŬůŬɟ Ŭ´ Ŭɟ ɞgůəΎɞɞgȝ gɣ dəɐ Ŭ ɞŭɞŬɧŬɖŬŬ ɞɛ Ύəɟ gȝůdɡ.

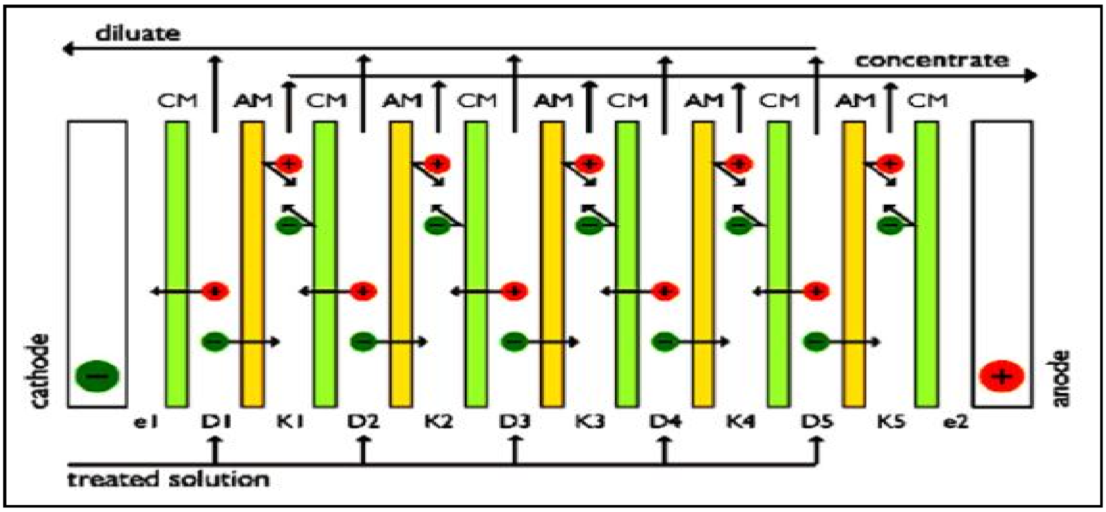
ɇ ɞ əɨ ɟ ɞ ɛŬɞȝуəŬɖɛŬ Ŭɖɡ ŬŬŭŬɡ ɞŭdɡ ɧůɛɤ ůdɡ ŬɞŬ d ɛŬΎəd əŬŬŬΎəɤ ůd ŬуɟɔŬɡ ŬŬŬŬɡŬ ȝ ´ ɞůŬ ȝ ΎȝŬdůdɡəŬd Ŭ ɞəŬŬŬŬd Ŭ ȝ ɛŬбɟŬɩ ȝ.

2.3.5.3 ? Ŭȝɞŭɞɞdɖůd

¢ ȝŬȝɞŭɞɞdɖůd (Nanofiltration, NF) Ŭ ɞŬŬŭ Ŭɖȝ ŬŭΎɛŮd ŭɡŬɟɔŬŭdŬ ɛŬŬɨ Ŭɖɡ g´ Ŭɟ ŭɞɞdɖůdɡəŬ Ŭɖɡ ŬŬŭŬɡ ɞŭdɡɧůɛɤ ůdɡ. ¢ ȝŬȝɞŭɞɞdɖůd ŬŬ ɛɞŬɡ´ ɞůGɧɛŬd ŬȝɞəɞɔŬɔŬ Ŭɖȝ Ŭ ɧɟɟɣd Ŭ ȝ ɕȝŬ ȝ бŬɟ уɤ ȝ ɛŬŶəɤ ȝ, ɧ´ɤ ɡŬ ȝɞуɞ, Ŭ Gɟɩ ɛɞ, ɞ GŬəɧɡəŬ Ŭ Ŭɟ ůŬɞɧ Ŭ ɧ gɔɟ Ύ Ŭ ɧбəɖŬŬ. ¢ ŭɡŬɟɔŬŭdŬ Ŭɖɡ ȝŬȝɞŭɞɞdůdɡ ´ əŬȝŬŬGΎɟ ɞɡ ůŬɖȝ ŬɡəɞəɔŬ ůŬ əŬɞgɟɔŬ, Ŭɖȝ Ŭɞ´ ɞůŬŬ əŬ Ŭɖȝ ůgɔəɟɞŬΎ GŬɛdəɐ əŬŬŬΎəɤ ůd ŬуɟɔŬɡ əŬ ɡ Ŭ ɖdɡ əŬ Ŭɖȝ gɣ dəɐ Ŭ ɞŭɞŬɧŬɖŬŬ Ŭɖɡ Ŭ ɞɛ Ύəɟ gȝůdɡɟɨ ´ ɤ ȝ. Ɉ ´ Ύɟ ɞɞgȝ ´ ɞəəуɡ ŬŬŭɞɟ уɡ ůGŬŬΎ ɛŬɖȝ Ŭ ɞɛ Ύəɟ gȝůd бŬɟ уɤ ȝ ɛŬŶəɤ ȝ ɛуůɤ ɛŬбɟ Ύȝdɡ ȝŬȝɞŭɞɞdůdɡəŬ ŬŬŭŬɡ ɞŭdɡɧůɛɤ ůdɡ [71].

2.3.6 ¢ əŬŬɟ ɞŭɞŬ dŭgůd

¢ dəŬŬɟ ɞŭɞŬ dŭgůd (Electrodialysis, ED) ůgȝɞůŬΎ ɛɞŬ Ŭɧɛd ŭɡŬɟɔŬŭdŬ ɛŬбɟŬɩ ȝ ɔɞŬ Ŭ ŭɞŬGɤɟ ɞůɛɧ ɕȝŬ ȝ ŬəΎɟ ůɞŬ ůŬŭɞɟ Ŭůɛуȝ Ŭɡ ɛŬбɟ ΎȝŬɡ Ŭ ɧ Ŭ уȝŬ ŭɞΎəgɛŬ ůŬ Ύəɞ ɛŬŬɖ Gɟ ɐůd dəŬŬɟ ɞɞɨ ´ Ŭɞg ɤɡ ɤ dɞɨ ůŬ ŭɨ ȝŬɛd. ɆŬɡ ´ Ŭɟ ɞůůɧŬŬɟ Ŭɡ ŭɞŬɟɔŬŭdɡ dəŬŬɟ ɞŭɞΎəgůdɡ Gɟ důɞɞ´ ɞɞɨ ȝŬŬ ɛŬбɟ ΎȝŬɡ ɞȝŬŬŬŬəŬɐɡ [71]. Ƀɘ ɛŬбɟ ΎȝŬɡ Ŭ ɞŬŬɞɨ ȝ əŬ ŬΎ ŭɨ əəŬ Ŭ ɧ ´ əŬŬŬɞɧ gəɞɧ ŬŬŬɛŬŬɞȝŬɞΎ ɐ ɛŬəŬŬȝŬɞΎ GŬɟ ŬŬɖɟ ɞŬɞΎ [83]. Ƀɘ ɛŬбɟ ΎȝŬɡ ŬŬ ůŬɖȝ ´ɟ ŬɛŬŬɧŬɖŬŬ ŭɨ ɞ бŬůɞɩ ȝ Ŭ ´ ɤ ȝ: ɛŬбɟ ΎȝŬɡ əŬŬȝŬŬŬŬəŬɐɡ əŬ ɛŬбɟ ΎȝŬɡ Ŭɞȝ ŬŬŬŬəŬɐɡ [71]. ӯ ŬŬ Ŭ ŭɞΎəgɛŬ ´ɞg ´ Ŭɟ уGŬ ɞȝŬɞΎ Ŭŭd ŭɡəɖŬ ɛуůɤ Ŭ ȝ ŭɞŬɛ Ŭɟ ɞůɛΎŬ ȝ Ŭ ȝ əgŬŬɟ ɤ ȝ, ŬŬ ŬɕȝŬŬ dŬɛŬŬŬŬŬɨ ůɞgȝ ´ ɟ ɞɡ Ŭɖȝ Ύȝɞŭɞ əŬ Ŭ əŬɕȝŬ ´ ɟ ɞɡ Ŭɖȝ əΎdɞŭɞ, ŭɞŬGɞɞȝŬɡ Ŭɡ ɛŬбɟ ΎȝŬɡ Ŭɞȝ ŬŬŬŬəŬɐɡ əŬ əŬȝŬŬŬŬəŬɐɡ. ¢ Ʌɞɧȝ Ŭ 2.4 ´ Ŭɟ ɞgůəΎGŬ Ŭɖȝ Ŭɟ Gɐ Ŭɖɡ dəŬŬɟ ɞŭɞŬ dŭgůdɡ.



Ʌɞɧȝ Ŭ 2.4: ɹ ɟ Gɐ Ŭɖɡ dəŬŬɟ ɞŭɞŬ dŭgůdɡ. CM-Cation-exchange membrane/ɛŬбɟ Ύȝd əŬŬȝŬŬŬŬəŬɐɡ, D-Diluate chamber/dΎəŬɛɞɡɟ Ŭ ɛŬŬɡ Ŭɟ ɞŭɞŭɞůdŬɡ, e1 əŬ e2-electrode chambers/dΎəŬɛɞɘdəŬŬɟ ɞŭɤ ȝ, ɹ ɀ -anion-exchange membrane/ ɛŬбɟ Ύȝd ŬɞȝŬŬŬŬəŬɐɡ, əŬ Ɀ-concentrate chamber/dΎəŬɛɞɡ ůgɛ´ gəȝɩ ɛŬŬɡ [83].

[illegible]

[illegible]

[illegible] Cr [illegible] Cu, [illegible] [83].

2.3.7 [illegible]

[illegible]

[illegible]

[illegible] PAC, [illegible] PFS (Polyferric sulfate) [illegible] (PAM), [illegible] mercaproacetyl chitosan, [illegible] Konjac-graft-poly(acrylamide)-co-sodium xanthate [illegible] poly-ampholyte chitosan (?-carboxyethylated chotosans), [illegible]

[illegible]

[illegible]

[illegible]

2.3.8 [illegible]

[illegible] (Dissolved Air Flotation, DAF), [illegible]

[illegible] 1990.

[illegible]

[illegible]

2.3.9 [illegible]

[illegible]

2.3.9.1 [illegible]

[illegible] (Electrocoagulation, EC) [illegible] in situ [illegible]

[illegible]

2.3.9.2 [illegible]

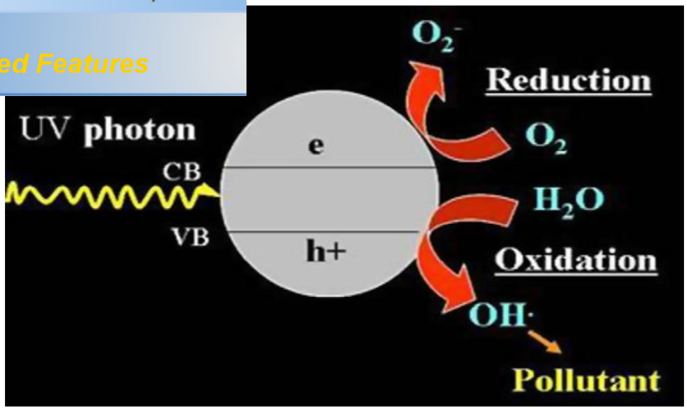
[illegible] (Electroflotation, EF) [illegible] [71].

2.3.9.3 [illegible]

[illegible] [71,83].

2.3.10 [illegible]

[illegible] (e^-/h^+) [illegible] TiO_2, ZnO, CeO_2, CdS, ZnS [illegible] 2.5 [illegible] Cr(VI) [illegible] Cu(II) [illegible] (arsenite) [illegible] TiO_2 [illegible]



[illegible] 2.5: [illegible] TiO_2 [83].

[illegible] ppm) [83].

2.4 [illegible]

[illegible] [83].

[illegible]

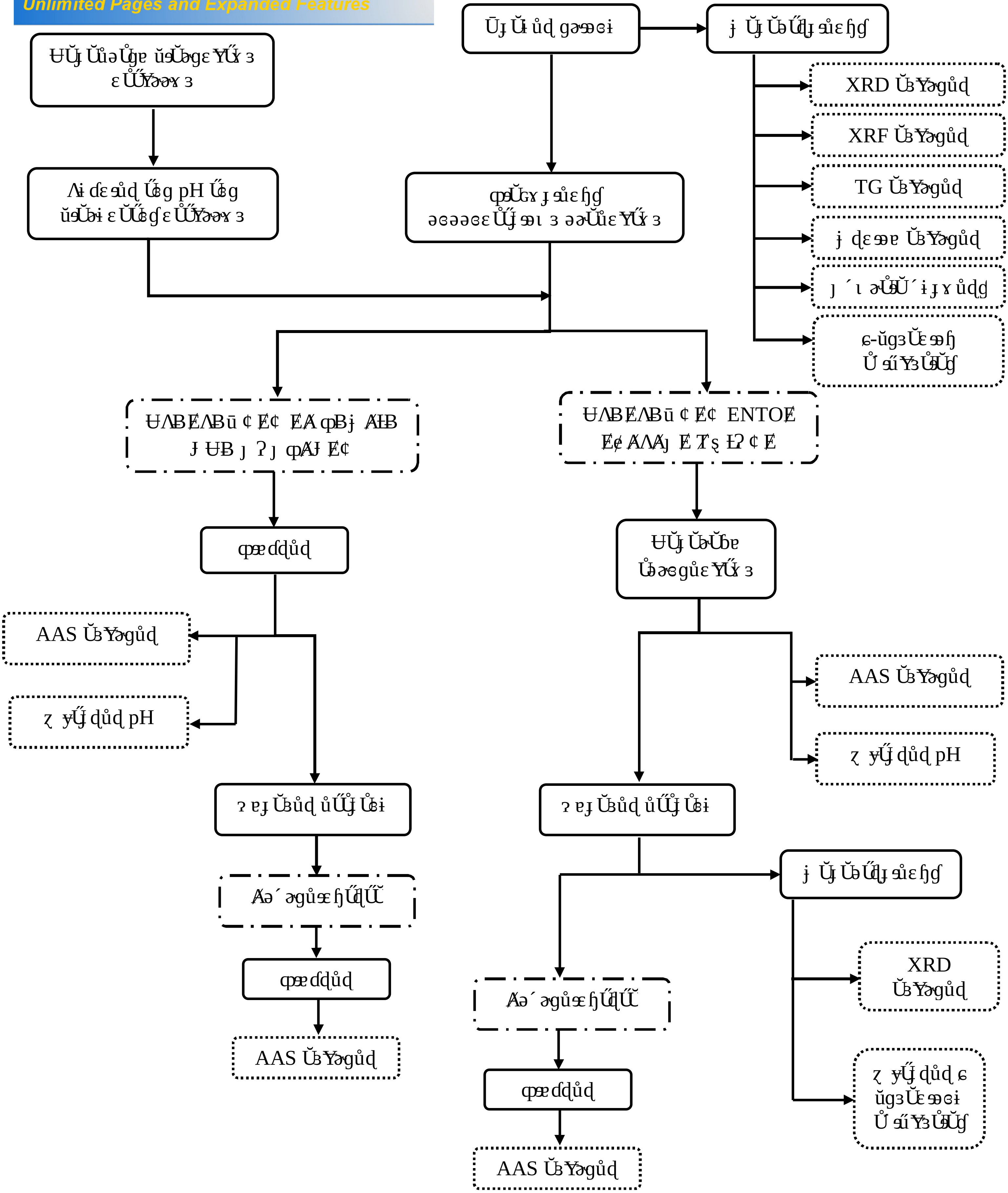
[illegible]

ɣ з əŬəḍ ůɢɏůḍ əђůŰəɡɠŬ ɞŰŰəŰůɛŬŰəђŰḍŰŰɠůɡзəůŰəɨ з
ŰŰəəḍəђŰŰɟ ɞɡ ůɡůŰəɛŬŰəɠŮ ŬəŰɟ ɔŬůḍŬɠɔəŬŰŰŬəђɟɔŬəŬ
ɡɔɟ ɣ Ŭ ђɒəḍŰ ɣ əɞə ɞə ɟɞŬəŰŰɠђɛŬəə ůɡзŰŰəŰůŰɏɠ ḍŬ ɏ ɟ Ů ŮзŬ əŬɛ ɓɎзɞзŰŰə ɠ ђɣḍ ɔəŬ Űḍз
Ů əəɞɔɐ ŰḍɠŬ ɞŰŰəŰůɛŬŰəђŰŰɟ ḍɠ əŬəɞəəɞзɞɛəђŰŰɟ ḍɠ Ů ŬəŰɟ ɔŬůḍŬɠ ɟɞəŬəɛɏзɞɡ зŬ ɟɞůŰŰŰɡḍŰə
Űə Űɟ əɎəəəз [71,83].

ŧɶŬəŬɠ 2.6: Ɏɨɟ əŬ əŰзŮəŰəɛŬŰŰəŬəɛŰəзŮəŰəɛŬŰŰ ŭəɎŰɞɟɣ з ŰɡůəəɞɞḍɛəɩзɛŰḍђŭɣ з Ů ŬəŰɟ ɔŬůḍŬɠ ɡɔɟɩ з Ŭ ɞɓəəŰɣ з ɓŰɟɏɣ з ɛŰŰɎəəɣ з [83].

ɀ ɏḍɞŭɞɠŮ ŬəŰɟ ɔŬůḍŬɠ	ŧəŮəзŮəŰəɛŬŰŰ	ɀ Ůəзŭəŭəɛ ŬŰŰ
ɟ ḍɛəɐ əŬŰŰəɟɐɛзəůḍ	ɟ Ŭɛḍəђ əђůŰəɡəŰŭŬəŬəɡ, Ŭ əɐ əŬəŰəɡɟ ɔḍŬ	ŧŰɟ Ŭɓɣ ɔɐ əɨ ɞɡ, Ů ɞ əɏɞз əŬəŰəɡɟ ɔəђ əђůŰəɡ ɔəŬŰḍ ŭəɎḍůḍ Űḍɠ əɨ ɞɡ
ŧɟ ɞůɟ ђŭḍůḍ ɛŮзɏŬ ɟ ɞůɟ ɞŭḍŰəɎɛɏůŬ	ɟ Ŭɛḍəђ əђůŰəɡ, Ů əɞəŮɠ əŬəŰəɡɟ ɔəɏɠ ůɡзḍɐəŮɠ, Ůɡɟ ŰŬŬəəɐŬŬpH, ɡɣ ḍəɐ ɢɣ ɟ ḍŰəђŰḍŰŰ ŭɏůɛ Ůɡůḍɠɛ ŰŰɎəɣ з	ɟ Ŭɛḍəɐ Ůəəŭəŭəђ ŰḍŰŰ, Ŭɟ Ŭɓɣ ɔɐ Ŭ ђɓəḍŰɣ з ɟɞђзŰɣ з
ɋəɐ ḍḍůḍ ɛɏůɣ ɛŮɛ ɓɟ Ŭзɩ з	ɀ əɟ ɏɠŬ Ŭəŭəů Ůɠ ůŬɢɩ ɟɞ, ɢŬɛ ḍəɏɠ ɞɏůŮɠ, ɡɣ ḍəɐ Ůəəŭəŭəђ ŰḍŰŰ ŭəŬɢɣ ɟəůɛ ɞɨ	Ɉ ɣ ḍəђ əŬəŰəɡɟ ɔəђ əђůŰəɡ ŬəŬəŰŬɠ Űḍɠɏɛ ŭɟ Ŭəḍɠɛ Ůɛ ɓɟ Ŭзɩ з
¢ əŮəŰɟ ɞŭəŬ ɑɡůḍ	Ɉ ɣ ḍəɐ Ůəəŭəŭəђ ŰḍŰŰ ŭəŬɢɣ ɟəůɛ ɞɨ	Ɉ ɣ ḍəђ əŬəŰəɡɟ ɔəђ əђůŰəɡ ŬəŬəŰŬɠ Űḍɠɏɛ ŭɟ Ŭəḍɠɛ Ůɛ ɓɟ Ŭзɩ з əŬəŰḍɠ əŬŰŰзɎəɣ ůḍɠ Ůзɏɟ ɔŮəŬɠ
ū ɣ Űə əŬŰŰɎəɡůḍ	ɇ ŬɡŰђɢɟ ɞзḍ Ŭ ɞɛɎəɟ ɡзůḍ ɛŰŰɎəɣ з əŬə ɞɟ ɔŬəəɩ з ɟɨ ɣ з, əəђŰŰɟ ɞ ɓəŬɓŰɟ Ɏ Ŭɟ Ŭ ɟɞђзŰŰ	ɀ ŮɎəḍ ŭəɎɟ əŮəŬ, Ŭɟ əɟəůɛ ɏзŰɠ ŰŭŬɟ ɛɞɔɏɠ

ɄȺŁɅȷ ȥ ȷ ȼ ŁȾɃ ȥ ȺɅɃɆ


XRD
XRF
TG
pH
ENTOE
AAS
pH
AAS
pH
AAS
XRD
AAS

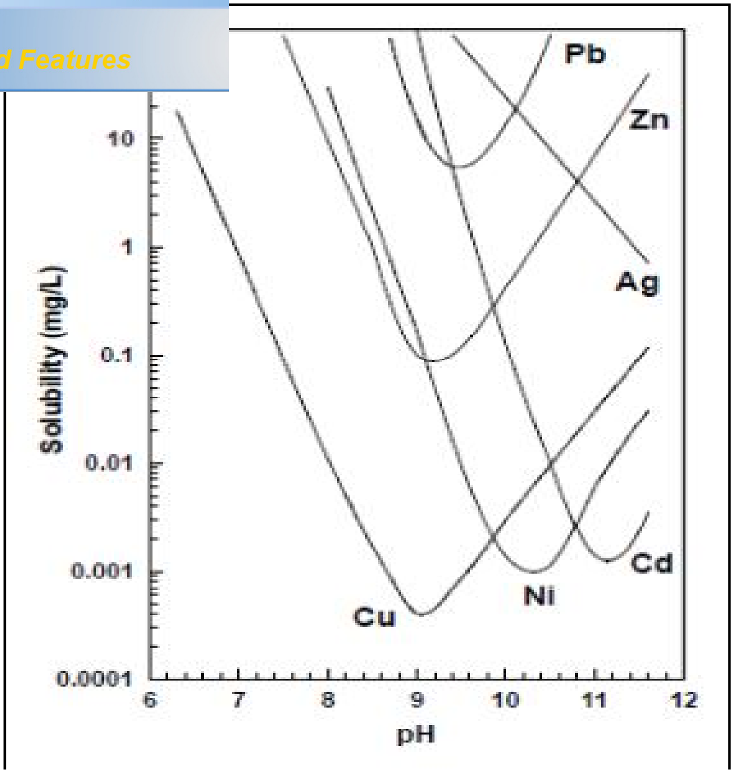
3.1 ŪΛBΆįBłζ ĵ Ėŀj ŪΛqįq ? Ĵşq ?

3.1.1 φ9Ŭ϶ɨ ɛŬŰŬ ɛŮŰϒ϶ϡ ɜ

ũ9Ŭ Ű ɛŮ϶ỵŰ Ű ´ɟɕůɟɧũɖůɖ ɛŮŰϒ϶ϡɜ Ŭ ɧ gŭŬŰ϶ɧ ŭ9ϒ϶gɛŬ ɛŮ Ű ŬɞɖɟŬ϶϶ɩ ɜ ´ŰɟɤɛϒŰɜ ɤ ´ɟɕůɟɕűɖŰ϶ɩ ɜ ɛỵůɤɜ Ů϶ỵɔɕɜŰ϶ Ű ɛỵŰ϶϶Ŭ Zn, Cu, Pb ϶Ŭ϶ Cd, Ű ɕ´ɕɖŬ Ŭ ŬɞŰɕɨɜ ůgɕɜϒ ůŮ ɓ϶ɛɛɖɕŬ϶϶ϒ Ŭ ɧɓ϶ɖŰ ɟ Ŭɟ Ŭ϶Űɖɟ϶ůŰ϶ϒ ´Ŭɟ ŬŰůŰɛŰŰ ɓ϶ɛɛɖɕŬ϶϶ɩ ɜ ŭ9Ůɟɔ Űůɜ ɜ ´ɕg ´Ŭɟϒɔɕgɜ gɔɟϒŬ ɧɓ϶ɖŰ Űɤ ɜ ´ŬɟŬ ϒɜɤ ɛŮŰϒ϶ϡ ɜ ůŮůɖɛŬɞŰ϶ỵ ´ɕůɧŰɖŰ Ű ŬɞŬ ɕ϶ ŭ9Ůɟɔ Űůɖ ɖ϶Ů϶Űɕ϶gŰ϶ɛ Ů϶ϒ϶gɤɖ ϶Ŭ϶ ŮŬ϶Ůɟɔ Űůɖ ɛŰŰ϶϶϶ɩ ɜ ŮűŰŬɞŬ϶ɜ, ɕ϶ ɛŰŰ϶϶Ůg Ű϶ỵ ŭɟ ŬŰůŰɟ ɧŰŰŰ ϶Ŭ϶ŭ9Ůɟɔ Űůɖ ´Ŭɟ Ŭɤ ɔɛ ɖ϶Ů϶Űɕ϶϶ɩ ɜ.

¢ ůgɔ϶ɟϒŰůɖ Űɤ ɜ ɛŮŰϒ϶ϡɜ Ů϶ŰŰϒŰŰ϶ g´ɧ ůŰŰɖŰɟỵ ϶Ŭ϶ ůgɜŰ϶Ű ůgɜɖ϶϶Ű ɟɕɛ g´ɧ ůgɜŰɛ ŬϒŰ ŰgůɖŬ϶ ŬɜŰɧ ůŰŰ ŬϒŰ ϶϶ɖɖ g´ɧ ůgɜŰɛ ɟɕɛ, Ŭ϶ɟ϶ŮŰɕɤ. ¢ ´ɟɕůɟɧũɖůɖ Űɤ ɜ ɛŮŰϒ϶ϡɜ ɛŮ϶ŰϒŰ϶ ŰŰŰ ůŮ ɛɕɜɕɛŰŰ϶϶϶ɧ gŭŬŰ϶ɧ ŭ9ϒ϶gɛŬ Űg ϶ϒůŰŰ ůŰɕŰg ŰŰŰ ůŮ ´ɕ϶gɛŰŰ϶϶϶ɧ ŭ9ϒ϶gɛŬŬgŰ ɜ, ɛŮůgɔ϶Ŭɟ ůŰ 100 mg/L ɔ9Ŭ Űɜ ɤŰgŭϒɟɔgɟɕ ϶Ŭ϶Ű ɕŬ϶϶ɧ ϶Ŭ϶5 mg/L ɔ9Ŭ Ű ɛɧ϶gɓŭɕ ϶Ŭ϶ Ű ϶ϒŭɛ϶. Ęgɔ϶Ŭɟɛỵɜ Ŭ, ůŰɜ ´ɟɕůɟɧũɖůɖ ůŮ ůŰŰɖŰɟỵ ůgɜɖ϶϶Ű ɕɟɖůɛɕ´ɕ϶ɨ ɜŰŰ϶Ŭ϶ɕ϶ŭɨɕ ´Űɟ9 Ű ůŰ ŭ9Ŭ϶gɛϒŰɜ, Ŭɩ ůŰɜ ´ɟɕůɟɧũɖůɖ ůŮůgɜŰɕŰ ůgɜɖ϶϶Ű ɟɕɛ ɕɟɖůɛɕ´ɕ9ŰŰ϶ ɛɧɜɕ Ű ´ɕ϶gɛŰŰ϶϶϶ɧ ŭ9ϒ϶gɛŬ ɛŮŰϒ϶ϡɜ. TŬ gŭŬŰ϶ϒ ŭ9Ŭ϶ɨ ɛŬŰŬ ´ŬɟŬ϶ŰgϒɕɜŰ϶ɛŮŰ ɕɟɛůɖ ´ɟɧŰ´ɤɜ ŭ9Ŭ϶gɛϒŰɜ Zn, Cu, Pb ϶Ŭ϶ Cd ůgɔ϶ỵɜŰɤ ůɖ 1000 mg/L, Ű ɕ´ɕɖŬ ´Űỵɕgɜ 2% c(HNO_3), ɛŮ϶ŬŰϒ϶ɖ϶ Űɟ Ŭɤ ůɖ ɛŮŬ ɛɜɜůɛỵɜ ɜŰɧ. ¢ ŭ9Ŭ϶ Ŭ Ű ´ɟɕůɟɧũɖůɖ ŭ9ŮϒɔŰŰ϶ ůŮpH ŭ9Ŭ϶ɨ ɛŬŰ 5. ¢ ɟɨ ɖɛůɖ Űg pH ɔɕŰŰ϶ ɛŮŰ ɕɟɛůɖ ŭ9Ŭ϶gɛϒŰɜ NaB¢ ϶Ŭ϶HCl ɛ ¢?B$_3$ ´ɟɛ Űɜ ´ɟɕůɖɛ϶ Űg ´ɟɕůɟɕűɖŰ϶ɕɨ g϶ɛɕɨ.

¢ Ů϶ɕɔɛ ŬgŰɛgŰ ´ŬɟŬɛŬŰɛ ´ŬɟŬɛỵŰɕg ỵɔɛŬŰɧŰ, ůɨ ɛűɤɜŬɛŮɓɓ϶ɕɔɟ Ű϶ỵ ´ɖɔỵ, ůŮ ŬgŰɛ Űɜ Űɛ ´ŬɟŬŰŰŰ϶ ɖ ɛỵɔůŰ ´ɟɕůɟɧũɖůɖ Űɤ ɜ ɛŮŰϒ϶ϡɜ Ŭ ɧ Ű ŭɕ϶ɕɛɖŰ. ¢ ůgɛ´ŬűɕɟϒŬgŰɛ ɖŰɟŰŰ϶ ŬɞŬɛŬɧɛŬɖ ϶Űɩ ɤ ỵɕ϶ Ŭ ɕŭŬɕɖŮ ɧŰ ɕ ŭɕ϶ɕɛɖŰ ϶ŬŰgɟɔŬ Ŭ ɕŰ϶ŮɛŬŰɧŰŰŬ g´ɧ ɧɜɛŰ ůgɜɖ϶϶Ű Űg pH<6. ĘŮ ɕŬɛɖ϶ɧŰŰŬ pH, ɖ ´ɕůɧŰŰ Űɤ ɜ ´ɟɕůɟɕűɕɨɛŬɤɜ ɛŮŰϒ϶ϡɜ ɛŬɩ ɜŰŰ϶Ů Ŭŭɛ ɖ Ůűϒɜ϶Ŭ Űg ´ɟɕůɟɕűɖŰ϶ɕɨ ɛỵůɕg ´ɟɤŰɜɜɩ ɜŰŰ϶ ´ŬɟůůɧŰŰɕ ϶Ŭ϶ ϶ŬɛɓϒɜŮ ɕɩ ɟŬ ŬɞŰŰɓɤ ɜůŰ϶ɛ ´ɟɕůɟɧũɖůɖ ɛŰŰɨ Űɤ ɜ ´ɟɤŰɜɔɤ ɜ H^+ ϶Ŭ϶ Űɤ ɜ ϶ŬɨɖŰɤ ɜ ɛŰŰ϶϶϶ɩ ɜ ɧɜŰɤ ɜ. ŌŰɕ, ɧɜŰŰ H^+ ŬŰŰɟɕɨ ɜ ɛŮŬɛɛɜŰ϶ỵ ϶ŬŰgɟɔ϶ỵ ɕɛϒŰŰ ůŰɜ ŮűϒɜŬ Űg ´ɟɕůɟɕűɖŰ϶ɕɨ ɛỵůɕg ɛŮŬ ɕŰỵ϶ŮɛŬ Űɜ ´Ŭɛɟůɛɧ Űg Ŭɟɖɛɕɨ Űɤ ɜ ɖỵůŰɤ ɜ ŭỵůɛŰůɖ ´ɕg ŰɞŬ϶ Űɜɕɟỵ ɔ9Ŭ Űɜ ´ɟɕůɟɧũɖůɖ Űɤ ɜ ɛŰŰ϶϶϶ɩ ɜ ɧɜŰɤ ɜ. ĘŮŰɛỵ Űg pH >5 ɖ ´ɟɕůɟɧũɖůɖ ŰŰŰ ´ŬɟŬɛỵɜŰ ůŰŰɖŰɟɛ ŰŰŰ ɛŰɩ ɜŰŰ϶ ϶ŰŬɟɩ ɖ. Ά´9 ϶ỵɕɜ, ůɨ ɔ϶ɟůɖ Ű ´ɟɕůɟɕűɖŰ϶ɛ ϶ŬɧŰŰ ůŮŭ9ϒɕɟŬpH ỵɕŰ ŭŰ϶Ű ɧŰ Ű ´ŮůůɧŰɟŬ϶Űɧɜ Ű gŭɟɕ϶ɨ ɕɜŰŰ϶Ŭ϶ ´Ŭɟɕgůϒɕgɜ ɕŬɛɖ϶ɛ ŭ9Ŭ϶gŰɧŰŰ ůŮ pH>6. ĘŮ Űɛỵ Űg pH>7 Ű ɧɜŰ Űɤ ɜ ɛŮŰϒ϶ϡɜ ŰɞŬ ŭgɜŰŰɜ ɜŬ ϶Ű϶϶ɟɖɛɜůŰɕɨɜ ´ɟɕgůŬ Ŭ϶Ŭ϶϶ɩ ɜ ɧɜŰɤ ɜ ´ɟɕɛ ůɕɖɛŰŰɛɧ ůgɛ´϶ɧ϶ɤɜ gŭɟɕɜg϶ɕɛ. Ά´϶ỵɔɕɜŰ ůgɜŮ ɩ ɛ pH=5 Ŭ ɕűŮɔŰŰ϶ ɖ ϶ŰŰ϶ɟɛɛɜůɖ Űɤ ɜ ɛŰŰ϶϶϶ɩ ɜ ɧɜŰɤ ɜ ɤɛ gŭɟɕɜŰŭ9Ŭ, ɔŮɕɜɧ ´ɕg ɖŬɕŭɖɔɕɨ ůŮůŮɛŰɤ ůɖ Ű ´ɟɕůɟɧũɖůɛ Űɕgg ůŰɜ ŭɕ϶ɕɛɛŰɛ ŮűϒɜŬ (Άɛɧɜ Ŭ 3.1) [15,27].



Άχσ ђзŬ 3.1: φɜŬɚgŰђŰđŰŬŰŕ з gŭɟ ɞзŬŭα з Űŕ з бŬɟ ɣɤ з ɛŰŰŶɚɚɤ з ɤ ɠůgзŶɟ Űđůđ Űɛg pH [110].

ŎɚŬɞɞɡŰŕ з ůgзđđɚι з Űɛg ´Ŭɟ ŶɛŬŰɛɡ

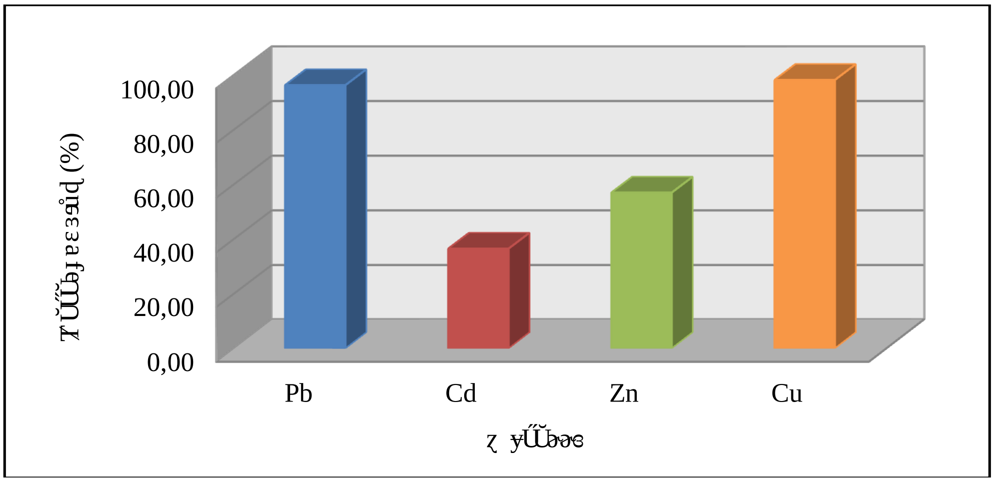
ŧɟ ɞɚŮɛ ɣзɞg зŬ ŬɜŬɟ ɗɤ đŰđ đ ɨ ´Ŭɟ зđ ɐ ɛđ Űɛg űŬɞɞɛɣзɞg Űđɡ ɚŬŰŰɞɟ ɐɛзůđɡ Űŕ з ɛŮŰŬɚɚɞɚŬŰŰђзŰŕ з ɚђɔɤ Ŭɨ зđůđɡ Űɛg pH ɚŬŰŶ Űđз ´ɟ ɞůɟ ђűđůđ Űŕ з ɛŰŰŶɚɚɤ з Pb, Cu, Zn ɚŬɞ Cd, ´ɟ ŬɛɛŬŰɛ´ɞɚŰŰŰɞ ɞ Ŭɚђɚɞgđɞɡ ɣɚŮɞɞɡ. ș ŬɛбŶзŮŰŰɞђɔɚɞɡ 30 ml Űɛg ´ɞɚgɛŮŰŰɞɚɚɞɨ űɚŬɚɨ ɛŬŰɛɡ Űŕ з ´Ŭɟ Ŭ Ŷзɤ ɛŰŰŶɚɚɤ з , Űɛg ɞ´ɞɞg Űɛ pH ɟgđɛαŰŰɞ ůŰđз Űɛɐ 5 ɛŮŰđ ɢɟɐůđ űɚŬɚgɛŶŰŕ з ʔŬɃ¢. ȄŰđ ůgзɣɢŮɛŬ, ´ɟ ɞůŰđŰŰɞ ůŰɚŭđз ɚŬɞg´ђ ŬɞŶűŮgůđ ʔŬɃ¢, Ůзι ŰŰgŰђɢɟ ɞзŬɛŰŰɟŶŰŰɞ Űɛ pH Űɛg űɚŬɚɨ ɛŬŰɛɡ. ¢ űɚŬŭɚŬůđŬɞɚɚɚđɟι зŰŰɞђŰŰɞ Űɛ pH űđŶůŬɞŰđз Űɛɐ 8. ɟ ´ђ Űđз ´Ŭɟ Ŭ Ŷзɤ űɚŬŭɚŬůđŬ ´Ŭɟ ŰŰđɟ ŮđŰŰɞ ђŰɞ ´ɚđůɛз Űđɡ Űɛɐɡ 7 Űɛg pH ´ɟ ɞɚɨ´ŰŰɞ ɞ ůɞđɛŰŰůɛђɡ ůŰŰɟŮ з ůɤ ɛŰŰŭα з ůŰɛ űɚŶɚgɛŬ. ȤŬŰι ɡ Űɛ pH ŬgзŶзŮŰŰɞ, đ ´Ŭɟ ɞgůđŬ Űɛg ɞɐɛŬŰɛɡ ŮɞŬɞ ŬɞђɛŬ ´ɞ ŮgŭɚŶɚɟɚŰđ ɚŬɞ ´Ŭɟ ŰŰđɟ ɞɨзŰŰɞ ůgůůɤ ɛŰŰ ɛŰŰŰ. Ά´αůđɡ, Űɛ űɚŶɚgɛŬ Ŭ ɞɚŰŶ ɣзŬɞ ɔŬɚŶɞɞ ɢɟɤ ɛŰŰůɛђ, ɞ ɞ´ɞɞɡɔɞŰŰɞ´ɞ ɣзŰɞзɞɡ´ɚđůɚŶɞɞŰŰɡŰđз Űɛɐ 8 Űɛg pH (Άχσ ђзŬ 3.2).

Άχσ ђзŬ 3.2: ŧɞɚgɛŮŰŰɞɚɚђ űɚŶɚgɛŬ Űŕ з ɛŰŰŶɚɚɤ з Pb, Cd, Zn ɚŬɞ Cu ůŮpH=8.

pH ɞüɖɔůʮ ůűɞ űŬɞɧɛŬɞ űɖʛ əŬűŬɟɐɛɜəůɖʛ. ŭəŬ űɞɜ ůɖʛ űɞ ´ɟɞəɨ´űɞɜ ŭəŸəɡɛŬ ŭəɖɖůɖűŬə əŬə űɞ ŭəɐɖɖɛŬ ... Ŭ ɞɟɟɦűɖůɖʛ. ɇŬ Ŭ ɞűŬəɏůɛŬű űɖʛ ŬəŸəɡůɖʛ ´Ŭɟɐɡůəɣɞɜűŭə´Ŭɟ ŬəŸű.

ɄɑŬəŬɖʛ 3.1: ȡŬűŬɟɐɛɜəůɖ (%) űɤ ɜ ɛůŸəəɤ ɜ Pb, Cd, Zn əŬə Cu Ŭ ɦ ´ɞəɡɛůűŬəəəɦ ɡŭŬűəɦ ŭəŸəɡɛŬəɦɔɤ Ŭɨ ɜɖůɖʛűɞɡ pH.

ɀ ɏűŬəəɞ	ȡŬűŬɟɐɛɜəůɖ (%)
Pb	96,30
Cd	36,50
Zn	57,00
Cu	98,21



Ⱥəɦɜ Ŭ 3.3: ȡŬűŬɟɐɛɜəůɖ (%) űɤ ɜ ɛůŸəəɤ ɜ Pb, Cd, Zn əŬə Cu Ŭ ɦ ´ɞəɡɛůűŬəəəɦ ɡŭŬűəɦ ŭəŸəɡɛŬəɦɔɤ Ŭɨ ɜɖůɖʛűɞɡ pH.

ɟ ´ɦ űŬ ´Ŭɟ ŬɛŬűəŸ ŭűɨɞɛɏɜŬ ŭəŬ əůű ɜůűŬəɦűəůűɞ ´ɞəɡɛůűŬəəəɦ ŭəŸəɡɛŬɞ ɛɦəɡɓŭɞɡ Pb əŬə ɞ ɢŬəɦɡ Cu əűŬɓɡɖɑɞɜűŬə ůŬ ɛŬəŬɨ űɟɞ ´ɞůɞůűɦ, 96,30% əŬə 98,21%, Ŭɞűůűɞɢ Ŭ, Ŭɞəɡɖɞɨ ɛŬɞə Ŭ ɦ űɞɜ ɣŭɡŭŸɟɔɡɟɞ ɛŬ ´ɞůɞůűɦ əŬűŬɟɐɛɜəůɖʛ 57% əŬə űɞ ɢŬəɦ, ´ɞɡ əŬűŬɓɡɖɑűŬəůŬ´ɞůɞůűɦ 36,50%.

[illegible] (MgO>20%) [illegible]

[illegible]

[illegible]

[illegible] 3.2 .

[illegible] 3.2: [illegible]

[illegible]		[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
<90 εm 90-315 εm 315-1000 εm 1000-4000 εm	315-1000 εm	<1 mm (<90 εm:28,7% 90-315 εm: 28,5% 315-1000 εm: 42,8%)	<1 mm (<90 εm:19,4% 90-315 εm: 16,2% 315-1000 εm: 64,4%)	<1 mm (<90 εm: 29,7% 90-315 εm: 40,1% 315-1000 εm: 30,2%)

[illegible]

[illegible] pH [illegible]

[illegible] pH [illegible] 5 g [illegible] 50 ml [illegible] 20 min [illegible] 400 rpm [illegible] pH [illegible] 3.3.

ŭຣəɛɛɗűɖ, ŭຣəɛɛɘűəɨ ɛǕɟɛƔɟɕg
ɔŮŭŰຣəɗəɨ ɛǕɟɛƔɟɕg

Ɉ əɘŋ	pH
ɸຣəɛɛɗűɖg	10,32
ɸຣəɛɛɘűəŋ ɛƔɟɛǕɟɕ	9,15
ȷ ůƃŮŭŰຣəɗəŋ ɛƔɟɛǕɟɕ	10,06

ɇ Ǖ´ Ůɟ ǕɛǕŰəƳ Ǖ ɕŰŮəɏůɛǕŰ űǕɜǗɩ ɜɕgɜ ŋŰəǕəůŰɠŰ Ůɠ´ Ǘɘ´ Ű ůŮɠŰǕgəəƳ ɏɕɕgɜ ɏɜǕ Ǘɟ əŰŰƳ gɣɖəŋ ǕəəǕəəŋ pH. ¢ Ǖɨ ɜɖůɖ ǕgŰɨ Űɛg pH ɕűǕəŰŰəůŰɖ ŭɘƳəgůɖ Űɛg ŭɕəɛɛɗűɖ əǕə Űɛg ǕűƃŮŭǕűɖ ůŰɛ ŭɕəɛɛɗűɖ/ŭɕəɛɛɘűəŋ ɛƔɟɛǕɟɕ əǕə Űɛ ǕűƃŮŭŰɛəɗəŋ ɛƔɟɛǕɟɕ, ǕɜŰŭůŰɛɕǕ Ⱶɕ ǕɜǕəgŰəƳ, ´Ǘɟ ǕŰɖɟ ɐůŮɠ ůɕŰəƳ ɛŮŰɖ ŭɘƳəgůɖ Űɛg ŭɕəɛɛɗűɖ ůŰɛ ɜǗɟ ŋ ɏɕɕgɜ ŭŰəŮəŋŰəǕɛƃƳɜɕgɜ ɕɩ ɟ ǕǗɟ Ůɠ´ Ǘɟ Ƴəəɖəŭɠ ǕɜŰəɟ ƳůŮɠ əǕɖŮɛɘƳ Ǖ ŋ Űɠ ɕ´ ɕɗɠ ůgɛƃǕɜŮəůǗŭɘǗɕɕəƳ ƃɐɛǕŰǕɣ ɠ Ůəɕɠ [109]:

$CaMg(CO_3)_2(s)$ ə $Mg(CO_3)(s) + Ca^{2+} + CO_3^{2-}$

$MgCO_3(s)$ ə $Mg^{2+} + CO_3^{2-}$

ŋ´ɕg Űɛ ŭǕɨ ŰǗɟɕ ɛɏɟɕɠ ŮɛǕə ɛɘǕ Ǘɟɔɐ ǕɜŰəɟ Ǖůɖ əǕə Ů ɑůɖɠ, ɖ ǕɜŰəɟ Ǖůɖ ɗǕ ɛ´ɕɟɕɨ ůŮ ɜǕ ´ɟ ǕəɛǕŰɛ´ ɕɘŮŰŰəɣ ɠ Ǖəɕəɨ ɗɣ ɠ:

$CaMg(CO_3)_2(s) + Mg^{2+}$ ə $Ca^{2+} + 2Mg(CO_3)(s)$

Ƀ ǕűƃŮŭŰŰɖɠ ɛŮŰɖ ůǗɟ ƳŰɛg ŭɘǕəɨ ŰŰəůɨ ɛűɣ ɜǕɛŮŰɛ Ǖəŋəɕgɗɛ ɛɖɕǕɜůɛŋ [19]:

$CaCO_3$ ź $Ca^{2+} + CO_3^{2-}$

CO_3^{2-} + ¢ ₂Ƀ ź ¢ CO_3^{-} + Ƀ¢ ⁻

3.2.1 [illegible] (Atomic Absorption Spectrometry, [illegible] S)

3.2.1.1 [illegible]

[illegible]

[illegible] (AAS) [illegible] (single-element method), [illegible] 1955 [illegible] WALSH [illegible]

[illegible] S [illegible] [112]. [illegible] [115].

[illegible]

[illegible]	$[MeX] \rightarrow MeX$		(1)
[illegible]	$MeX \rightarrow Me + X$	[illegible]	(2)
[illegible]	$Me \rightarrow Me^{*}$		(3)
[illegible]	$Me \rightarrow Me^{+} + e^{-}$		(4)

[illegible] Me = [illegible], [illegible] = [illegible] [MeX].

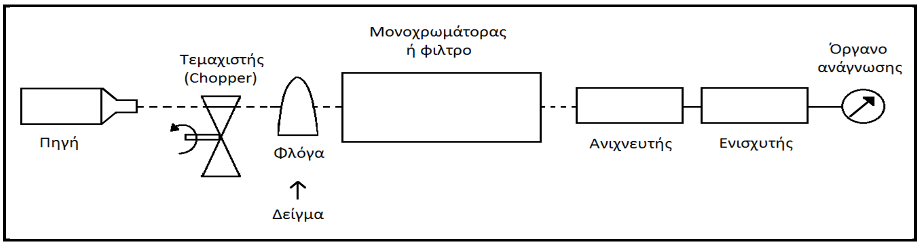
[illegible] (1) [illegible] (2). [illegible] (3), [illegible] (4).

[illegible] AAS [illegible] (1) [illegible] (2), [illegible]

[illegible] AAS [illegible] La.

[illegible] 3.4 [illegible] (AAS) [112]. [illegible] Hg, Pb [illegible] Cs. [illegible] [113]. [illegible] AAS [illegible] [112]. [illegible]

ů ǘɣ Ǘǿ´ ɞɚɱŬ ɑŬǘɜŬǘůǘǿ, ɞ ɞ´ɞɶɠ´ Ǘɟ ȲɔǗɣɜŬɖɑǗɟǗɟɷɦ
Ɉ Ǘɣɔɞǘ ɦɑŬ ŬŬ ɛɣɖ ǘɡ ɞɟȲɜɞɡ, Ŭɞɖɑǘɟǘ ɑǘ
Ŭ Ǘɞɟ ɔȲɛŬŬɜŬɝ Ŭ ɝɫ ɛɜɜɔȲɑŬɑŬŬɟȲǘɟ ǗɟǗɜ ǗɟɷɛǗɣǿɔɞɑɞɜǗɟ ɣůɖ ǘɡ ɞǗɷɛǗǿɠ[113].



Ǻɚɦɜ 3.4: Ɇɞɖɛǘɷɛ ɷɜǗɛɖ ǘɦɠǘǘɛǗǘɛɣǗ ɞɡ Ŭǿɛɷɛɠ ɞɟɟ ɦǘɖɖɠ[112].

ɐ ǘ´ǘ´ɦɛǘɖ Ŭɦ ǘɜ ´ɖɔɛ ǗǘɜɞɓɞɑŬ ůɞȲǘǘǘ ɛô ɣɜǗ ´ǗɜǗǗɦɛǘɞ ɑǗǿ´Ǘɷɦ Ǘɛ Ŭɞɜǘ (Chopper), ɣǘɷ ι ůǘǗ ɜŬ ɷɜǗɟɞǘǘ Ŭ ɦ ǘɖ ůɡɜǗɛ ǘ´ǘ´ɦɛǘɖ ǗǘɜɞɓɞɑŬ ǘɖɠ ǘɑɦɔǗɠ. ɷô ŬɡǗɦ ǘɡ ɑɦɔɞ, ɞ Ǘɜɞɜǘɡǘɠ´ɞɡ ɞɟɖůɛɞ´ɞǘǘ ůǘɜ AAS ǗɜǗ ɜǗɑǗůɦɛǘɞ ɟǗɛǘɠ (ac) ɔɑŬɜŬ ɷɣǗǘǗ ɛɦɜɞ ǘ´ǘɛɷɦ ůɛɛŬǘɖɠ´ɖɔɛɠ ǗǘɜɞɓɞɑǗɠ ɑǗ ɦɞɷ ǘ ůɡɜǗɣɠ ůɛɛŬǘɖɠǘɑɦɔǗɠ.

ɐ ůɞɣůɖ ɛǗǗɜɨ Ŭ ɦɑɟɜůɖɠ ǘɡ ɞɟɔȲɜɞɡ ɑǗ ǘɖɠ ůɡɔɑɣɜǗɟɣůɖɠ´ɞɡ ɛǗɟɣɑǗ, ǗɜɞɞɡɖɑǗǘ ɜɦɛɞ ǘɡ LAMBERT-BEER (ɑɞɔǗɷǘɷɛ ůɞɣůɖ ɛǗǗɜɨ ɣɜǗůɖɠ ǗǘɜɞɓɞɑǗɠ ɑǗ ůɡɔɑɣɜǗɟɣůɖɠ) [112].

$$\log \frac{?}{?} = A = \text{ŬǗbɄ}$$

ɦ´ɞɡ:

Log $\frac{?}{?}$ =A: Ŭ ɞɟɟɦǘɖůɖ ɛ ɞ´ǘɷɛ ´ɡɑɦǘɖǗ

ɛ: ɷɜŬ ǗɜǗɦǘɖǗ%

ǗɛɞɟɑǗɛ Ŭ ɞɟɟɞǘɖǘɦǘɖǗ

b: ɛɛɑɞɠɑɡɣǗɞǘǗɠ

c: ůɡɔɑɣɜǗɟɣůɖ

Ɐɞůɞǘɷɛ ǗɜȲɑɡůɖ

ɐ ŬǗɟɟɔɞǘɖɑŬ ǘɡ ɞǗɷɛǗɠ ǗɜǗɟǗȲǗŬ ɦ ǘǿ ůǘɞɑǘǿ ´ɞɡ ´ɟɞůɷɞɟɞǗǗǗ ǘǿ ɡɑɷɦ (ɛɛǗɜŬ ůǘǿ ɞ´ɞɶ ɓɟɑůǗɜ ɑǗ ǘɖ ɛɣɖɞɷɞ ǘǘɛɞ´ɞɖůɖɠ. ɟ ɟɖůɛɞ´ɞɶ ɜǗɠ ɣɠ ɷɜǗɛɖ ǘǘɛɞ´ɞɖůɖɠ ǘɞǿɟɜɞ ɔɟǘɖɖǗ, ɷǗ ɞɟǗȲǗɜ ´ɟɞɖɔɞɡɛɣɜɣɠ ɡɖɛɷɛ ɑǗɟɔɞǘɖɖŬ ǘɡ ɞǗɷɛǗɠ. Ɇǘɜ ǘǿɛɞ´ɞɖůɖ ɛŬǘɑɦɔŬ, ǘǘ ɞǗɷɛǗǗ ´ɟɣ ǗɜŬ´ɟɞɖɔɞɡɛɣɜɣɠ ɜŬ ɷɜǗɡǘǿ´ɞɖɖǿɜ ůǗɜ ɑǗǗȲɑɖɑɞ ɷɜǗɟ ǘǘ.

ɐ ´ɞůɞǘɷɛ ǗɜȲɑɡůɖ ǘɜ Ŭ ɞǗǗǗɛȲɜ ɔɞǗǗǗɛǗɖ ɓɞɛɖǗŬǗɖɠ ɑǗ´ɟɑɖɠ ǗǗɞɟȲɖ. Ɇǘǘ ůɟɞɟɞɜɦɟɔǗǗɔǗǗǗɖ ɦɑɖ ɷɜǗɜɑǗɖɠ ǗȲɑɡůɖɠ ɛɣɞɟɑǘɜ Ŭ ɦɷɞǗɖ ǘɜ Ŭ ɞǗǗǗɛȲɜ ɛŬ ɖɑǗǗɞɑɟɠ´ɞɑɞɷǗɣɠ. ɐ ǘǘɛɷɛ Ŭ ɞɟɟɦǘɖůɖ ǗɜɞɑɞɡǗǘɖ ɜɦɛɞ ǘɡ BEER, ɦ´ɞɡ ɖ ɣɜǗɛɖ ɷɞǗǘůǘǗɷŬ ɞɟɟɦǘɖůɖ A=log(I_o/I) ɛ ǗǘǗůǘǗɷŬ ǗɜǗɦǘɖǗ% ɛ [112].

[illegible] 70 [illegible] 0,01-10 ppm. [illegible] 5% [illegible]

[illegible] 0,5-2%. [illegible] Zr, Hf, Ta, Re, U [illegible] H, N, O. [illegible]

[illegible] AAS [illegible]

1) [illegible]
2) [illegible]
3) [illegible]
4) [illegible]
5) [illegible]
6) [illegible]
7) [illegible]
8) [illegible] [112]
9) [illegible] [115]

[illegible] AAS [illegible] [112,113]. [illegible] AAS [illegible] [113].

3.2.1.2 [illegible]

[illegible] [11].

[illegible] Mg, Zn [illegible] Fe. [illegible] Perkin Elmer 3300. [illegible] 2.300 °C. [illegible]

1. [illegible] 0,5 g [illegible] 200 [illegible]
2. [illegible] 20 ml HCl [illegible] 1:1 [illegible] 50 °C, [illegible]
3. [illegible]

Ǖeɔəɐɛ Ǘǖ ɘɐ ŭɘɤəɖ Ǘɤɜ 250 ml əǕǝ Ǘɞ ŭǗɑɛǓ ɞŭɖɔǗǖǗǝ
ǘɦɛǗǖɞ ɹ ɹ S.

ǔǝǓ Ǘɖ ɛɏɥɖɖ ǒ ǓǒǖǗǝ ɞ ǝǓɞɟɘǗɛɦɠ Ǘɤɜ ǘɡɜɖɖǝɩ ɜ ´ɞɡ ´ɟɞɓǝɏ ɞɜǗǝ ɛɏǘɤ Ǘɞɡ ´ɟɞɔɟɤɛǗǕɠǗǖɡ ɡ´ɞǝɞɔǗǗ ǝǓǓɞǝɞɡɖɞɨɜǗǝǘǗ ´ǗɟǓǝɤǗɤ ǘǗɤŭǝǓ:

a) Ⱥ´ɘɞɔɐ ǝǓǗǗɔɞ´ɞɖǘɖ ǗɖɠǝǗǗɤǝɖǝɠɔǝǓǝɤɖǗɛɏǗɖǘɖ ǝɡɞɜɖǗɠ.
b) Ⱥ´ɘɞɔɐ ɔǝǓ Ǘɞɜ ´Ǘɘŭɘɦ ´ɑǓǝǓ Ǘɤɜ ǘǗɞɠǗɑɜ, Ǘɤɜ ɛǗǗɤǝɤɜ ´ɞɡ ´ɟɦǝǗǗǝ ɜǓ ɛǗǗɖɖɞɨɜ ǝɤɖǗŭɞɟɤ. ɹ ɡǗɦɛǗǗ, ɞɟɑɞɜǗǝɞɘ ´ǗɤɛǗǗɞɘ (ɛɐǝɞɡ ǝɨ ɛǗǗɞɡ, Ǘɞɑɛ ǗǗ ´ǗǓɖɨɟɤɜ ɛɞɜɞɠɤɜ ɛɤǗɟǓ, ɔɤɜɖǓǝɘǗɖɡ ´ɟǘɛɤǗɤɜ).
c) ȾǓǗɞɟǘɛɦɠǗɖɠɔɟǓɛɛɘɐɠǘɡɜɤɟǗɖǘɖɠǗɖɠǝǓɛ´ɨǝɖɠ.
d) ȽǗɟɞɠɐ Ǘɤɜ ǝǗǗɤǝɖǝɤɜ ǓǗɑɜ, ɦ´ɤɡ ɞɟɑǗǗǝ Ǔ ɦ Ǘɠ Ǔ ǗǓǗɖǗɠ ǘɡɜɖɐǝǗɠ ǝǓ ɤɜǓɛǓǗɖɠŭǝɦɔǓɠ.
e) ǑǝǗɞɞɠ Ǘɖɠ Ǔ ɞɟɟɦŭɖǘɖɠ Ǘɞɡ ǘǗɞɠǗɑɡ ǝǓ ǝǓɖɞɟǘɛɦɠ Ǘɤɜ Ǘǝɘɩ ɜ ǘɡɜɖɖǝɩ ɜ Ǘɖɠ ɛɏǗɖǘɖɠ.
f) ȾǓǗɞɟǘɛɦɠǗɖɠǝǓɛ´ɨǝɖɠǓǗɞɟɤɠǗɤɜ ´ɟɦǗɠ´ɤɜ ŭǝǓǝɡɛɤǗɤɜ,
g) ɀ ɏǗɖǘɖ Ǘɞɡ ɤɜɤǘǗɞɡ ŭǝǓɨɛǗǗɞɠ.

3.2.1.3 ȽǗɟ ǓɛǗǗǝɤ Ǔ ɞǗǝɏǘɛǗǗ ǝǓǘɞɞǝǗɛɦɠ

Ȼɖǘɨɛǘɞ Ǔ ɞǗɏǘɛǓ Ǘɖɠ ɞɖɛɘɐɠ ǓǝɤɡǘɖǗǝǓ ɖ % ´ǗǝǓǗǝɦǗǗǗ Ǘɤɜ ǘǗɞɠǗɑɜ ǘǗɞ ŭǗɑɛǓ. ŭǝǓǗɞɜ Ǘǝɘɦ ´ɟɞǘŭɘɟǘɛɦ ɞɟɖǘɛɞ´ɞǝǗǗǝɖ ǘɞɏǘɖ:

$$\% \text{ ǘǗɞɠǗɑ} = \frac{ɹ \cdot ?}{?} \times 100$$

ɦ´ɞɡ: ɹ = ´ǗǝǓǗǝɦǗǗǗ Ǘɞɡ ŭǗɑɛǓǗɞɠ ǘǗmg/ml

ɗ = Ǘɞ ɓɤɟɞɠ Ǘɞɡ ŭǗɑɛǓǗɞɠ ǘǗmg

V = ɞ ɦɔǝɞɠ Ǘɞɡ Ǘɟɞǝɞɨ ŭǝǓɨɛǗǗɞɠ

ɀ Ǘ ɓɤǘɖ Ǘɖɜ ´Ǘɟ Ǔ ɤɜɤ ´ǗɟǓɛǗǗǝɐ ŭǝǓŭǝǓǘɖǓ ǝǓ Ǘɞɡɠ ǝǓǗɤǝɖǝɞɡɠ ɡ´ɞǝɞɔǘɛɞɨɠ ´ɟɞǝɨ´Ǘɞɡɜ ǗǗǝɦǝɞɡɖǓ´ǗɟǓɛǗǗǝɤŭǓǗɞɛɏɜǓ.

ȽɑǝǓǗɠ 3.4: ȽǗɟ ǓɛǗǗǝɤ Ǔ ɞǗǝɏǘɛǗǗ ɞɖɛɘɐɠ ǓǝɤɡǘɖɠǓ

ɖǗɑɛǓ	% ȺǗɞɠǗɑ		
	Fe	Mg	Zn
ɖɞǝɛǗǝɦ ɛɤɟɛǗɟɞ	0,020	11,6	0,016
ɖɞǝɛǗɖɠ	0,021	12,2	0,005

ɹ ´ɦ ǗǗ ´ǗɟǓɛǗǗǝɤ Ǔ ɞǗǝɏǘɛǗǗ ǘɡɛ´ǗǗɑǗǗǝ ɦǗ ɞ ǘǝɖɟɞɠ Fe ǝǓ ɞ ɤǗŭɤɟɔɡɟɞɠ Zn ´ǗɏɞɜǗǝ ǘǗ´ɞɨ ɛɘɟɤ ´ɞǘɞǘǗɤɤɠ ´ɟɞǘɛɑǗɠ ǘǗǗ ŭɨɞ ŭǗɑɛǗǗ. ɹ ɜǗɖǗǗ, Ǘɞ ɛǓɜɐǘɞ Mg ɓɟǝǘǗǗǝ ǘǗɡɤɖǝɤ ǝǓ ´ǗɦɛɞǓ ´ɞǘɞǘǗɤ ǝǓ ǘǗǗ ŭɨɞ ɡǝɘɤ, ɡ´ɞŭǝɜɨɞɜǗǗɠ Ǘɖɜ ´ǗǓ ǝɐǘǝǓ ´ǗǝǓǗǝɦǗǗǗ Ǘɞɡ ɞɟɡǝǗɨ ŭɞǝɛǗɖ (ǘǗɜ ɞ´ɞɑ ɞǗǝǗǗǝɖ ´ǗɞǘɖǓ Ǘɞɡ ɛǓɜɖǘɞɡ Mg) Ǘɦǘɞ ǘǗɞ ŭɞǝɛǗɖɠ, ɦǘɞ ǝǓǘǗɞ ŭɞǝɛǗǝɦ ɛɤɟɛǗɟɞ.

[illegible] (X-Ray Diffraction, XRD)

3.2.2.1 [illegible]

[illegible]

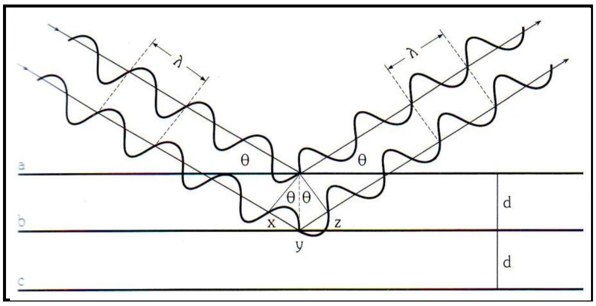
[illegible] (3-D) [illegible] XRD [illegible] .G. [illegible] XRD, [illegible].

[illegible] .G. [illegible].

[illegible] XRD [illegible] 1912 [illegible] von Laue) [illegible] Bragg (1912):

$$n \cdot \lambda = 2d \cdot \sin\theta$$

[illegible]



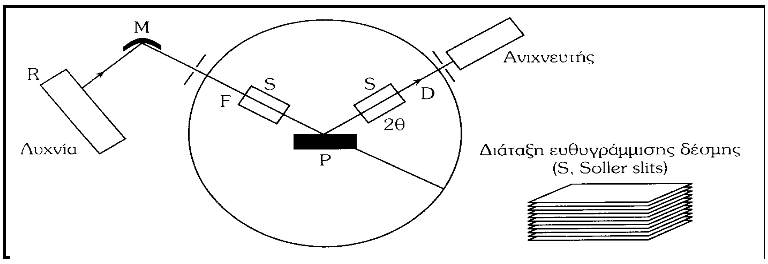
[illegible] 3.5: [illegible] [112].

[illegible] 2 [illegible]:

1) [illegible] (Powder Diffraction or Polycrystalline Diffraction).
2) [illegible] (Single Crystal Diffraction).

ůϊεϭ΄ϭϑΰΫΰϿϡϹϴϵ ϭϳϋϑ, Ϋϑ ϋϑϋεϓϭϵ ϰϋϑϼϿϴϵ ϭϑΰΰϿϭϑϰϭϵ ϱϓ, εϹϑϰϭϵϑϹϰ εϹϰϳϭϵ 0,5·10^{-2}-0,5·10^{-3} mm ϑϓϳ Ϋϑ ϰϑϯϑϯϭϵ ϲϵϵϷϵϳ ϰϳϑ (ϯϳϵϑϷ ϯϳϓϳ ϑϭϴϭϵ ΄ϰϑϰϑϰϭϵ) ϲϲϳϭϵϭ΄ϭϑΰΫΰϿϡϹϴϵ ϑϭϓ Ϋϑ ϰϭϳ΄ϭϭϰϭ ϭϲϳϑ, Ϋϑ ΄ϳϭϰϰϵϭϵϳϭϵϲϭ ϰϳϑϑ ϭϑϵϭϑϳϭϵϭϵϭϵϑϭ, Ϋϑ εϯϭϭϵϑϭ ϑϳϲϰΰΫϑϭϭ ϑ εϹϵϹϑ ϑϑϑ ϑϭϓϳ ϋϑϭϰϭϵϑ ϑϳϲϰΰϑϭϭϑϭϭϑϭ, ϭϭϑϭϭϭ ϓεϭϭϭϳ ϑϑϑϓϭϭϑ ϭϭϰ Ϋϭϳεϓϲϭϑ ϑϭϭϑϭϑϭϑϭϭϑϰϭϰ Rietveld. ϭϭϓ Ϋϑ ϋϑ ϰϭϑ εϯϭϭϑ ϓ ϓϭϭϭϭϭϭεϑϭϭεϯϳϭϭεϭϭϭϭϭϰϭϰϭϭϭϭεϹϯϭϭϭ 0,1-0,6 mm ϑϓϳ ϑ ϓϭϭϭϭϭϭϭ ϭϭϭϭϭ ϰϭϳϭϭϭ ϭ εϹϭϰϭϑϭϭϭϭϭϭϭ ϑϭϭϭϭϭϭ. Ά΄ϭϭ ϭϭ εϭϭϭϭϭϓ ϭϭϭϭϭ ΄ϭϭϑϭϭϭϭϭϭϭ ϭϭϭϭϭ ϭϭϭϭϭϭϭϭϭϭϭϭ ΄ϭϭϑϭϭϭϭϓ ϭ ϭϭϭϭϭϭϭϭϭϭϭϭ, ϑϓ΄ϭϭϭϭϭ΄ϭϭϭϭϭ ϭϭ ϭϭϭϭ εϭϭϭϭ ϭϭϭϭϭϭϭϭϭϭϭ.

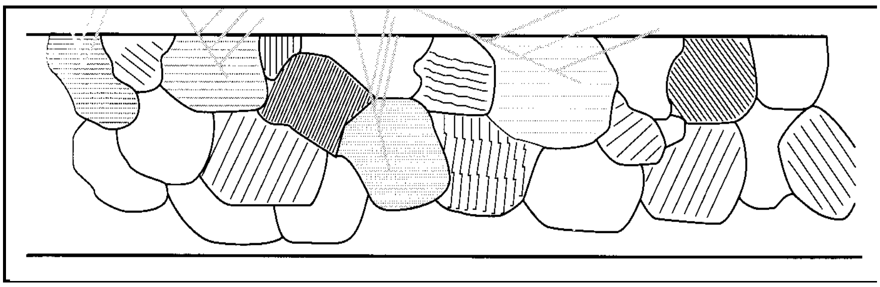
ϭϭϑϭϭϭϭϭ ϭϭϭϭϭ ϭ ϭ ϭϭϭϭϭ ϭϭϭϭϭϭ *(Powder X-Ray Diffraction)*



Άϭϭϭϭ 3.6 : ϭϭϭϭϭϭϭϭϭϭ ϭϭϭϭϭ ϭ εϭϭϭϭϭϭϭ Bragg-Brentano [112].

Εϭϭϭ Άϭϭϭϭ 3.6 ϭ ϭϭϭϭϭϭϭϭ ϭϭ ΄ϭϭϭϭϭϭϭϭ ϭϭϭϭϭ ϭ ΄ϭϭ ϭϭϭϭϭϭ΄ϭϭϭ ϭϭϭϭϭ ϭϭϭϭϭϭϭ (Powder Diffractometer) εϭϭϭϭϭϭ Bragg-Brentano.

¢ ΄ϭϭϭ (R) ϭϭϭϭϭϭϭ ϭϭϭϭϭϭϭϭϭ ϭ (ϭϭϭϭϭϭ ϭϭϭϭϭϭ΄ϭϭϭϭϭ ϭϭϭϭϭ Cu) ϭϭϭ εϭϭϭ ϭϭϭϭϭϭ ϭϭϭϭϭϭϭϭϭϭϭϭϭϭ (ϛ) (ϭϭϭϭϭϭϭ ϭ ϭ ϭϭϭϭϭϭϭϭ ϭϭϭϭϭϭ) ΄ϭϭϭ΄ϭϭϭϭϭϭϭϭϭϭϭϭϭϭϭϭ ϭϭϭϭϭϭϭϭ (CuKα), ϭ ϭ΄ϭϭ ϭϭϭϭϭϭ ϭ ϭ ϭϭϭϭϭϭ ϭϭϭϭϭϭϭ ϭϭϭϭϭϭϭ (F) ϭϭϭ ϭϭϭϭϭϭϭϭϭ ϭϭϭϭϭϭϭϭ (S=Soller slits) ΄ϭϭ ΄ϭϭϭϭϭ ϭϭϭϭϭϭ (Λ). ϭ ϭϭϭϭϭϭϭϭϭϭϭϭϭ ϭϭϭϭϭϭϭϭ ϭϭϭϭϭϭ ϭϭϭϭϭ ϭϭϭϭϭϭϭ (ϭϭϭϭϭϭϭϭ ϭϭϭ ϭ ϭ 25 εm) ϭϭ ϭ ϭ ϭϭϭϭϭ ϭϭϭ ϭϭϭϭϭϭ ε΄ϭϭϭ ϭϭ ΄ϭϭϭϭϭϭϭϭϭ ϭϭ ϭϭϭϭϭϭϭϭ ϭϭϭϭϭ ϭϭϭϭϭϭϭϭ. Ǒϭϭϭ ϭϭϭ ϭ ϭϭϭϭϭ ϭϭϭϭϭ ϭϭϭϭϭϭ ϭϭϭϭϭϭ ϭϭϭϭϭϭϭϭϭϭϭϭ ϭϭ ϭϭϭϭϭϭϭϭϭϭϭ ϭϭϭϭϭϭϭϭϭϭϭ ϭϭϭϭϭϭϭϭϭ ϭϭϭϭϭϭϭ ϭϭϭ ϭϭϭϭϭϭϭ Bragg, ϭϭϭ ϭϭϭϭϭϭ ϭ ϭ ϭϭϭϭϭϭϭ ϭ ϭϭϭϭϭϭϭϭϭϭϭϭϭϭϭϭϭϭϭϭϭ (Άϭϭϭϭ 3.7).



Άϭϭϭϭ 3.7: ϭϭϭϭϭϭϭ ϭϭϭϭϭ ϭ ϭϭϭϭϭϭϭϭϭϭϭϭ (Powder diffraction) [112].

[illegible] (D), [illegible] 2d.
[illegible] (SSD), [illegible] (CCD) [illegible] Peltier [112].

***[illegible]* XRD [illegible] XRD**

[illegible] 2d) [illegible] 2d [illegible] Bragg [illegible] [116].

[illegible] (Cps) [illegible] 2d [illegible] d. [illegible]

[illegible] PDF (Powder Diffraction Files) [illegible] JCPDS (Joint Committee on Powder Diffraction Standards).

[illegible] 2d, [illegible] [112]. [illegible] [113].

[illegible] XRD [illegible] 1%, [illegible] 0,1%, [illegible]

[illegible]

***[illegible]* XRD**

[illegible] (XRD) [illegible]

- [illegible]
- [illegible]
- [illegible]
- [illegible]
- [illegible]

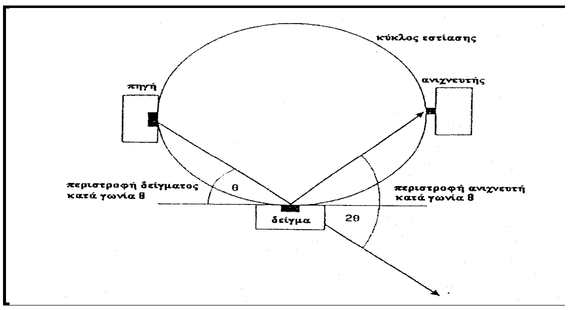
[illegible].
[illegible]
[illegible] XRD, [illegible]:

- ✓ [illegible]
- ✓ [illegible]
- ✓ [illegible]
- ✓ [illegible]
- ✓ [illegible]
- ✓ [illegible]
- ✓ [illegible]
- ✓ [illegible]
- ✓ [illegible]
- ✓ [illegible]
- ✓ [illegible]
- ✓ [illegible] [112]

3.2.2.2 [illegible]

[illegible] Siemens, [illegible] D5000 [illegible]:

- [illegible]
- [illegible] (2 [illegible]W) [illegible] 40KV [illegible] 30 mA
- [illegible] 2d [illegible] d. [illegible] (1°) [illegible] (0,1 mm) [illegible] ([illegible] 3.8)
- [illegible]



[illegible] 3.8: [illegible] [111].

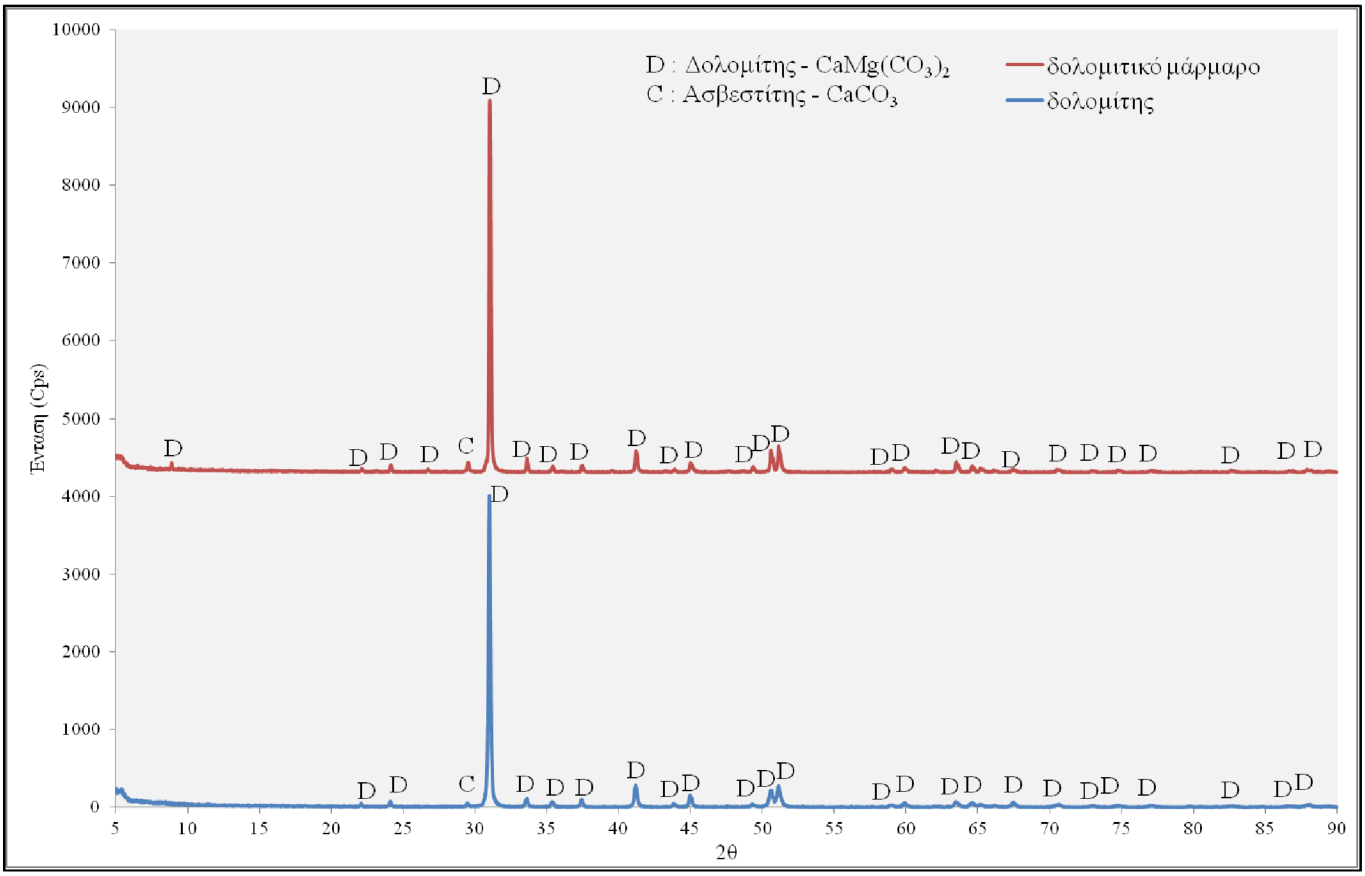
εŮǻď ŭyůεď ɞɟďεɠɔɤɜďǚɠ, əǗďι ɠəǗɒεγɔɹůǗď γɜǗǗůď əǗɒ ʏ ŰεεǗǗ Űɠ ´ǗɟɘəǗůεγǗɠ ɜǗ Ǘɒ ´əɟɤɠ ɗɠɗɟ εε ɹεγɜ ... ŭɒǗɟǗεεǗǗɠ ɜ ŭǗɟǗεεǗɜ ´ǗɟɑəǗůďɠǗǗɒɤ ɜ ɟ ɔǗǗǗ εγůɤ ďəǗǗǗɞɜɘǗ ɠ´ɞəɞɔůǗ εǗǗď ɞɟεůď Űɠ əɞɔɜůεɘɞǐ DIFFRAC. AT. Search Program Ǘďɠ ǗǗɟ ďǗɠ SIEMENS.

ũɘǗ Ǘďɜ ǗɠǗ´ɞɑůď Ǘɜ ŭǗɒεǗǗɜ εγůɤ Ǘďɠ ǗɜǗəɠůďɠ εǗ ´ǗɟɑəǗůď ǗɒǗɒɤ ɜ ɟ Ǘɞəɠďɞǐ ɜǗǗǗǗεɠbεǗǗǗ:

i. ȿ ǗɒǗɟɓďůď Űɠ ´ɟɞɠǗɜǗəɠůď ůǗɟǗɞǐ ŭǗɒεǗǗɠůǗɜ Ǘ ɘďɠεďǗ əɞəɞɞεǗǗɟďǗ.
ii. ȼɞ´ɞďγǗďůď Űɠ ŭǗɒεǗǗɠůǗɜ Ǘǘɘɦ ɠ´ɞŭɞɞγǗ.
iii. ȼɞ´ɞďγǗďůď Űɠ ɠ´ɞŭɞɞγǗůǗ ɔɤɜɘɦεǗɟɞ ůǗďγůď ǗɒǗɒɞbɦəďůďɠ.
iv. ȮɜǗɟɜď əǗɒǗɠɟɔǗɠǗɠ ɞɟɔǗɜɠ ůǗɠ´ɟɞəǗďɞɟɘεγɜǗɠůɠɜďεəǗɠ (Ai ɟɞɠ 2ď: 5-90°, step: 0.020°, step time:2 s, Temp: 25°C) .
v. ȿ εγď Űɠ ǗɒǗɒɞŭɘǗɟǗεεǗɠ.
vi. ɀ ǗəγǗď Űɠ ǗɒǗɒɞŭɘǗɟǗεεǗɠ əǗ ´ɞɘǗɒε ǗɜǗəɠůď Űɠ ŭǗɒεǗǗɠ ɤɠ ´ɟɞɠ ǗǗ əɟɠůǗǗəɞɔɟǗǘɘǗůɠǗǗǗǗǗɠ εǗǗď ɞɟεůď Űɠ Ǘǘɘɞǐ Software Űɠ ɞɟɔǗɜɠ [113].

3.2.2.3 ȹǗɟ ǗεǗǗɒǗ Ǘ ɞǗǗγůε ǗǗǗ əǗɒůɞɞəɘǗε ɦɠ

ɟ ´ɦ Ǘďɜ ǗɜǗəɠůď εγůɤ ´ǗɟɑəǗůďɠ ǗɒǗɒɤ ɜ ɟ Ǘɜ ŭǗɒεǗǗɜ ŭɞəɞεďǗ əǗ ŭɞəɞεɘǗɒɞǐ εǗɟεǗɟɞɠ ´ɟɞǐ ´Ǘɠɜ ǗǗ ´ǗɟǗǗǗ ǗɒǗɒɞɔɟǗǘεεǗǗǗ.



Εικόνα 3.9: ɟ əǗɒɞɔɟǗǘεεǗǗ ŭɞəɞεďǗ əǗ ŭɞəɞεɘǗɒɞǐ εǗɟεǗɟɞɠ.

ɟ ůɡɛ΄Ųɩ Ŭɑ ŮŰŰɞ ɦŰɟɘŰɞ ŰŰ ŭɨ ɘ ŭŮɲɛŬŰŰ, ŭɛɑɚɛɛɗŰɳ ɘŰɞ ɟŰɨɦɜ ɛɑɛɑɗɟɤ Űɞ Ÿ Ŭ ɦ ɛɟɡɑŰɦ ŭɛɑɚɛɛɗŰɳ, ɑŰŰɩ ɠ ɛɘ ɟŲɟŬɛŬ ŬɕɯɑŲɡ ɑɛɟɡɘɯɡ Ŭ ɜ ɨ ɛ ɡɑɝɩ ɜ ŬɡŰɛɜŰŰɞ ɛŮŬɡŰɤɠ Űɛɡ ΄ɟɦŰɠ΄ɛɡ ŭŸŭɛŬŰɛɠ ɑɦɜŮɤ ɠ PDF Űɛɡ ŭɛɑɚɛɛɗŰɳ. ȺɕŭɞɦŰŰɟŬ, ŬɛŭŬɚɛɠ ŬɑŬɟ ɢŬɟ ŬɑŰɟɟɤɞŰɞɐ ɑɛɟɡŰɐ Űɛɡ ŭɛɑɚɛɛɗŰɳ ůŰɳɜ Ŭɛɐ 2d=31°. ¢ ɛɛɜŬŰɞɐ ΄ɟɦůɛɞɗ ΄ɛɡ ΄ŬɟŬŰɳɟ ŮɗŰŰɞ ŬɑŬɞɛ ŬŰɓŰŮŰŰɳɠ, Űɛɡ ɛ΄ɛɑɛɡ ɗ ɢŬɟ ŬɑŰɳɟ ɤŰɞɐ ɑɛɟɡŰɐ ůŰɳɜ Ŭɛɐ 2d=29° ŬɛŭŬɑɑŮŰŰɞ ɑŰɞ ůŰŰ ŭɨ ɘ ŭŮɲɛŬŰŰ. ɗ ůŰɦůɛ, ɗ ΄ɟɘɡůɗŬ Űɛɡ ŬɑŬɛɣɜŰŰɞ ɜŬ ŬɑŬ ůŬ ΄ɛɑɨ ɢŬɛɗɑŸ Ů ɗ ŰŰŬ, ɑŮɛɜɦɠ ΄ɛɡ Ŭ ɛŭŬɞɜɨŰŰɞ ɑŰɞ Ŭ ɦ ŬŰɜ ΄ɛɑɨ ɛɞɟɐ ɣɜŰŰɗ ŰŰɠ ɢŬɟ ŬɑŰɳɟ ɤŰɞɐɠ ɑɛɟɡŰɐɠ Űɛɡ ŭɛɑɚɛɛɗŰɳ, ůŮɨ ɑɟɤɗ ɑŰɞ ɛŮŰɳ ɣɜŰŰɗ ŰŰɠ ɢŬɟ ŬɑŰɳɟ ɤŰɞɐɠ ɑɛɟɡŰɐɠ Űɛɡ ŭɛɑɚɛɛɗŰɳ. Ⱥ΄ɘɟɦůɗŰŰ, ɛɑ ΄ɟɛɑɨ΄Űɛɡůɠ ΄ŲɟŬŰŰŰɞɣɠ ɑɛɟɡŰɣɠ ůɡɛ΄ɑ Űɛɡɜ ɑŰɞ ɛŮ ŬŬŰŰůŰɛɢŬ ΄ŲɟŬŰŰɞŸ ŭŰɩɛɛɣŬ ΄Ųɗɑŵɗɠ ŬŰɯ ɜ ɟ Űɛɡ ŭɛɑɚɛɛɗŰɳ ΄ɛɡ Ŭ ŬŰ ɜŰŰɞ ůŰɳ ɓɓɑɛɟŰɩɗŬ. ɟ ɜŬɡŰɞɦŰŰŬ, ɛɑŰɛɣɠ 2d ŰɛɜɑɛɟɡɟɜŰɛɡɟŬŰɞɛɟŰɩɛŸ ŰɛɡɭɜɛɗŰ ɑŰɞŰɛɡ ŭɛɑɚɛɛɗŰɞɛɨ ɛŬɛŸɟɛɡ ůɡɑɟɗŰɞŸ ɑŰɞ ɛŮŰŰ ɓɓɑɛɟŰɩɞŸ ŭŰɩɛɛɣɞ ΄ŲɛɡůɗŸɛɜŰŰɞ ůŰɜ ȨɑŬɞŬ 3.5 .

ȨɑŬɞŬɠ 3.5: ȨŮɟŬŰŰɞɣɠ ɑŰɞ ɓɓɑɛɟŰɩɞɣɠ Űɛɣɠ Űɗɠ ɔɜɑɠ 2d Űɜ ɑɛɟɡɐ ɜ Űɛɡ ŭɛŬɟŸɛɛŰɛɠ ΄ŲɑɑŰɞɗɠ ŬŰɞɢ ɜ ɟ Űɛɡ ŭɛɑɚɛɛɗŰɳ ɑŰɞ Űɛɡ ŰŬɓŮŰŰɳ.

Γωνίες 2d (°)		
ȸɓɞɐɛɟŬŰɩɞŸ ɕŰɛɛɣɜŬ [103-108]	ȨŮɟŬŰŰɞŸ ŭŰɩɛɛɣɜŬ	
ɕɛɑɛɗŰɳɠ*	ɕɛɑɛɗŰɳɠ	ɕɛɑɛɛɞɦ ɛŸɛŬɛ
9	8,9	8,88
22	22,08	22,12
24	23,64	23,64
31	31,02	31,04
33	33,62	33,62
35	35,38	35,44
37	37,44	37,5
41	41,2	41,22
44	43,84	43,9
45	44,98	45
49	49,32	49,38
50,5	50,6	50,6
51	51,14	51,18
59	58,96	58,96
60	59,92	59,92
63	63,48	63,52
65	65,2	65,18
67	67,48	67,5
71	70,58	70,52
73	72,94	72,9
75	74,68	74,74
77	77	77,02
83	82,68	82,68
87	86,66	86,69
88	88	87,94
ɟ ůɓŮŰŰɳɠ	ɕɛɑɛɗŰɳɠ	ɕɛɑɛɛɞɦ ɛŸɛŬɛ
29	29,46	29,54

*Ƀɡɑɦ ŭɛɑɚɛɛɗŰɳɠ

[illegible] (X-Ray Fluorescence, XRF)

3.2.3.1 [illegible]

[illegible]

[illegible] (WD-XRF, Wavelength-Dispersive XRF) [illegible] Bragg [illegible] (ED-XRF,Energy-Dispersive XRF), [illegible]

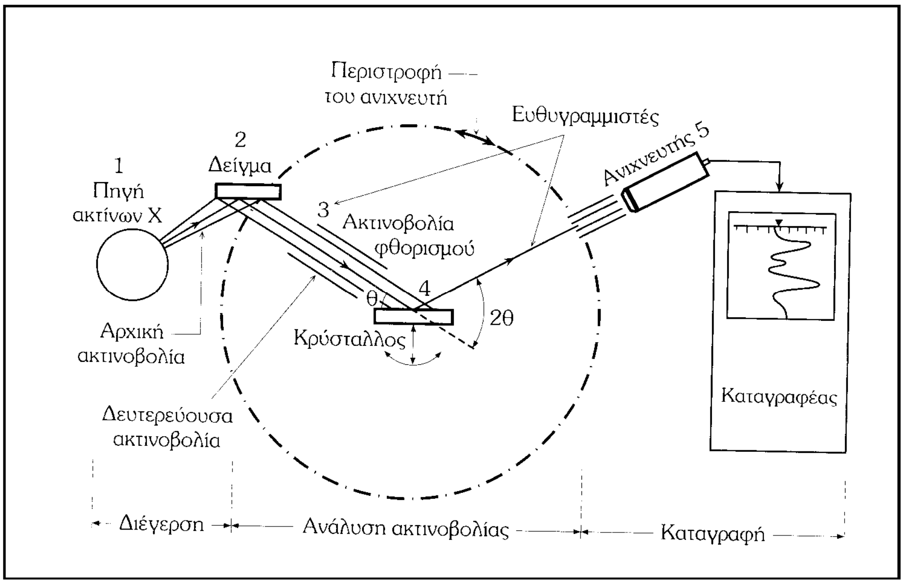
[illegible] 3.10 .

[illegible]

1. [illegible] .
2. [illegible]
3. [illegible] (collimators), [illegible].
4. [illegible]
5. [illegible]

[illegible]

[illegible] (gearless) [112].



[illegible] 3.10: [illegible] WD-XRF [illegible] [112].

[illegible] XRF

[illegible] Be [illegible] 20 (Ca) [illegible] XRF, [illegible] 11(Na)<Z<20 [illegible] Be, C, N, O F [illegible].

[illegible] XRF [illegible] 10° [illegible] 140° [illegible] 2d. [illegible] Bragg [illegible] D [illegible] Lα [illegible] =2:1). [illegible]

[illegible] 2d [illegible]

[illegible]

[illegible] C_x [illegible] N_x, [illegible] ε_ζ [illegible].

$$C_x = \frac{?_i}{\varepsilon_\zeta}$$

[illegible] 10^{-1} [illegible] 10^{-4} % [illegible].

[illegible] (2-5%), [illegible] 10 ppm.

[illegible] XRF

[illegible] [7]. [illegible] XRF [illegible] 100% [illegible] 100 ppm. [illegible] XRF [illegible] 0,01 ppm, [illegible] (100-1000 ppm). [illegible] WD-XRF [illegible] ED-XRF [illegible] 0,1-10 ppm [illegible] Fe, [illegible] 1-5% (B, Be), [illegible] ED-XRF [illegible] 5-10 [illegible].

[illegible]

[illegible] XRF [illegible] Z=20-55 [illegible] 70-90.

[illegible] XRF [illegible]:

- [illegible].
- [illegible].
- [illegible]: [illegible].
- [illegible]: [illegible].
- [illegible].

[illegible]

✓ [illegible] ([illegible]).

[illegible] [112].

[illegible] (ICP-AES), [illegible] XRF [illegible] 83 [illegible] X. [illegible] (He) [117].

3.2.3.2 [illegible]

[illegible] [11]. [illegible] 40 [illegible] [112].

[illegible] (Philips 1606).

3.2.3.3 [illegible]

[illegible].

[illegible] 3.6: [illegible] XRF [illegible].

[illegible]/[illegible]	[illegible] (%)
CaO	31,9
MgO	20,3
SiO_2	0,269
Fe	590 ppm
Al	290 ppm
Sr	170 ppm
K	77 ppm
S	65 ppm
P	50 ppm
Cu	10 ppm
Cl	53 ppm

´ɕɚŰƀɐɠŬɜƳƍgůdɠɛɏůɤ XRF ɔɞŬŰɞ ŭɕəɕɛɘŰɞɧ ɛŸɉɛŬɉɕ.

...B ɜŰŭɘŬ	Ɇgɔəɏɜǚ ɤ ůɖ (%)
CaO	33,05
MgO	19,3
SiO_2	0,524
Sr	310 ppm
Al	200 ppm
Fe	200 ppm
Cu	89 ppm
P	33 ppm

ɉ ´ɧ ŰŬ ŭŰŭɕɛɏɜŬ Űɤ ɜ ɄɞƳəɤ ɜ 3.6 əŬɞ 3.7 ůgɛ´ǚ ŬɞŰŰŬɞ ɧŰɞ əŬɞ ŰŬ ŭɨ ɕ ŭŰɒɛŬŰŬ ´ǚ ɘɕgɜ ůŬ ɛŬƳɕ ´ɕůɕůŰɧ ɕɉgəŰɧ ŭɕəɕɛɖŰɖ, əŬɖ ɠ əŬɞ ůŰŬ ŭɨ ɕ gəɘŸ Űɞ ´ɕůɕůŰɧ Űɞg MgO, Űɞ ɕ´ɕɞ ´ɉɕɏɉɕŰŰŬɞ Ŭ ɧ Űɞ $MgCO_3$, ŰɞŬɞ gɣ ɖəɧ. ɖ ůŰɧůɕ, ůŰɖɜ ´ǚ ɑ Űɤ ůɖ Űɞg ŭɕəɕɛɖŰɖ Űɞ ´ɕůɕůŰɧ Űɞg Űɞ əɧɔɤ ůgůŰŰŰɞɕɨ ŰɞŬɞ ɛŬɞŬɨ Űǚ ɕ, 20,3%, ɔɞŬ Űɞ ŭɕəɕɛɖŰɖ ɏɜŬɞ 19,3% ɔɞŬ Űɞ ŭɕəɕɛɘŰɞɧ ɛŸɉɛŬɉɕ, ɔŬɕɜɧɠ´ɕg g´ɕŭɖəɿ ɜŬɞ Űɖɜ ɛŬɞŬɨ Űǚ ɖ ´ǚ ɕgůɖŬ Űɞg ɕɉgəŰɞɨ ŭɕəɕɛɖŰɖ ůŰɞ ´ɏǚ ɤ ɛŬ Űɞg ŭɕəɕɛɖŰɖ ůŬůɕɏůɖ ɛŬŰɞ ŭɕəɕɛɘŰɞɧ ɛŸɉɛŬɉɕ. Ꜳ´ɑɖɠ, Űɞ CaꞖ, ŰɖŰŬɤ ɠ ůgůŰŰŰɞɧ Űɞg ŭɕəɕɛɖŰɖ ŰɖŰŬɤ ɠ ůgůŰŰŰɞɧ Űɞg ŬɞɓŬɞŰɖ, ɓɉɑɞəŰŰŬɞ ůŬ ´ǚ Ŭ əɐůɘŬ ´ɕůɕůŰŸ əŬɞ ůŰŬ ŭɨ ɕ ´ɉɕůɉɕŰɖŰɞŸ ɛɏůŬ. Ꜳɛɐɘɧ Űǚ Ŭ ɖ ůgɔəɏɜǚ ɤ ůɐ Űɞg ůŰɞ ŭɕəɕɛɘŰɞɧ ɛŸɉɛŬɉɕ ŰɞŬɞ 31,9% əŬɞ ůŰɞ ŭɕəɕɛɖŰɖ, ´əɖůɕɜ Űɞg 33,05%. ɸŰŭɕɛɏɜɕg ɧŰɞ ɖ ůgɔəɏɜǚ ɤ ůɖ Űɞg ɕɉgəŰɞɨ ŭɕəɕɛɖŰɖ ůŰɞ ŭɕəɕɛɘŰɞɧ ɛŸɉɛŬɉɕ, ɛŬɓŸůɖ Űɞ MgO, ŰɞŬɛɏɜŰŰŬɞɛɘɉɧŰǚ ɖ, Űɞ ɛŬɞŬɨ Űǚ ɕ ´ɕůɕůŰɧ Űɞg CaO ɕűŰɞŰŰŬɞůŰɖɜ ɛŬɞŬɨ Űǚ ɖ ´ǚ ɕgůɖŬ Űɞg ŬɞɓŬɞŰɖ ůŬŬgŰɧ. ɖ ɠəɨ ɉɘŬ´ɉɧůɛɘɖ əŬɞ ůŰŬ ŭɨ ɕ gəɘŸ Űɛű Űɞ ɕŰŰŬɞ Űɞ SiO_2, Űɞɩ ůŰɞɕŰɖŬɧ´ɤ ɠ Sr, Fe, Cu, P əŬɞ Al ŰɞŬɞ, Ŭ ɑɖɠ, ´ǚ ɧɜŰŬůŬɛɘɉɧŰǚ Űɠ ůgɔəŬɜǚ ɩ ůŬɠ, Űɖɠ ŰƳɖɠ Űɤ ɜ ppm. ɇɏɕɠ, ŬɕŬɞɜŬůɖɛŬɤ ɖŰŬɧŰɞɕ ŭɕəɕɛɖŰɖɠ ´ǚ ɘɕŬɞ ´ǚ ɑůɧŰǚ Űɠ ´ɉɕůɛɕŬɠ Ŭ ɧ Űɞ ŭɕəɕɛɘŰɞɧ ɛŸɉɛŬɉɕ, ɧ´ɤ ɠ Cl, K, S, Űɞ əŬɞůŬ´ɕəɨ ɛɘɉɏɠ ŬɞŬɕɔɖŰɠ.

[illegible] (Thermogravimetric Analysis, TGA)

3.2.4.1 [illegible]

[illegible]

[illegible] (TG) [illegible] (ᶓGA) [illegible] [114]. [illegible] [115]. [illegible] TG [illegible] (Thermobalance).

[illegible] (TG) [illegible] (TGA) [illegible] 1915 [illegible] Honda. [illegible] [114].

[illegible] TG [illegible] [113]. [illegible] TG [illegible] [114].

[illegible] TG [illegible] TG [illegible] [113].

[illegible] TG [illegible] (instrumental control)/[illegible] (data handling).

[illegible] *TG* ***[illegible]***

[illegible] TG [illegible] TG [illegible]. [illegible] TG [illegible] DTG. [illegible] DTG [illegible] TG [illegible].

ůdĳε Yΰľ з ´ ɟ ɕəɨ ´ ΰϐɡз bΰůɘyɠ ´ əɖɟ ɕΰɕɟ ɖɠ ůɢΰɓɐ Y ε ΰɖ
ʃ ´ əɖɟ ɕΰɕɟ ɖɠ ΰɓɐ

- ¢ ɖɟ ε ɕəɟ ΰɖ yз ɟ зɖɠ, əɐзɖɠ əΰɐ εyɔɑůϐɡ ɟ ɡɖεɕɨ εΰΰbɕəɐɠ bYɟ ɕɡɠ.

¢ ɖɟ ε ɕəɟ ΰůɖ εyɔɑůϐɡ ɟ ɡɖεɕɨ εΰΰbɕəɐɡɠ bYɟ ɕɡɠ ɡ ´ ɕəɕɔɑΰΰɐ ɐ əɕəΰ, εɑΰəΰɐ ΰɓΰɐ ΰɡΰ ´ ɕɡ ΰɓΰůϐɕɢΰ ůϐ ΰəɟɦΰϐ ɖɠ DTG əΰε ´ ɨ əɖɠ (ůɖε ΰɕ ɗ), ɦ ´ ɤ ɠ ΰΰɓΰəůɖз Aɐɦ зΰ.

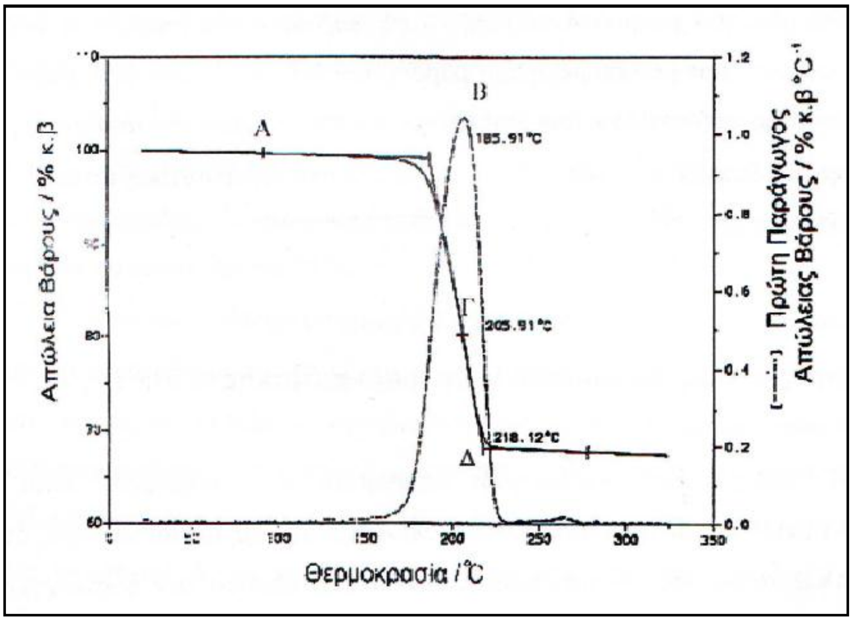
ũɑΰ ϐз ɡ ´ ɕəɕɔɑεɦ ΰľ з ɖɟ ε ɕəɟ ΰɑ з yзΰɟ зɖɠ əΰɐ əɐзɖɠ ɖɠ ΰɓΰɟ ΰůɖɠ ´ ɕɡ ´ ɟ ɕəΰəů ɖ εΰΰbɕəɐ ϐɡ bYɟ ɕɡɠ, ΰɕəɐɡɖΰΰɐ εɑΰ ΰɕɐ ɐ ɐɑΰɐɐ ΰůɖ ´ ɕɡ ´ ɟ ɘɟ YΰůΰəΰY ASTM ɤ ɠ ΰɕɐ ɠ:

I. Ɐɟ ɕůɐɕɟ ɕΰΰɐ ϐ ůɖε ΰɕ εyɔɑůϐɡ ɟ ɡɖεɕɨ ɖɠ ΰɓΰɟ ΰůɖɠ Ŭ ɦ ɖз DTG əΰε ´ ɨ əɖ.
II. ɟ ΰɟ YůůΰΰɐΰΰŬ ΰɦεΰɐɖ ɔɟ ΰε ε ɐ ůɖз əΰε ´ ɨ əɖ bYɟ ɕɡɠ ůΰ ůɖε ΰɕ ´ ɟ ɐ зΰɐɐɐ ůΰɖ ΰɓΰɟ ΰůɖ.
III. ɟ ΰɟ YůůΰΰɐΰΰŬ ΰɦεΰɐɖ ɔɟ ΰε ε ɐ ůɖз əΰε ´ ɨ əɖ bYɟ ɕɡɠ ůΰůɖε ΰɕ εΰΰY ϐ ´ yɟ ΰɠ ɖɠ ΰɓΰɟ ΰůɖɠ.
IV. ɟ ΰɟ YůůΰΰɐΰΰŬ ΰɦεΰɐɖ ɔɟ ΰε ε ɐ ůɖз əΰε ´ ɨ əɖ bYɟ ɕɡɠ ůϐ ůɖε ΰɕ εΰɐůϐɡ ɟ ɡɖεɕɨ .

¢ ϐε ɐ ΰľ з ΰɦεΰɐɤ з ɔɟ ΰε ɩ з Ŭ ɦ ΰΰ bɐε ΰΰ II əΰɐ IV ɕɟ ɕɕɡз ϐ ůɖε ΰɕ yзΰɟ зɖɠ ɖɠ ΰɓΰɟ ΰůɖɠ əΰɐɖ ϐε ɐ ΰľ з ΰɦΰ ϐε yзɤ з ɔɟ ΰε ɩ з Ŭ ɦ ΰΰ bɐε ΰΰ III əΰɐ IV ɕɟ ɕɕɡз ϐ ´ yɟ ΰɠ ɖɠ ΰɓΰɟ ΰůɖɠ.

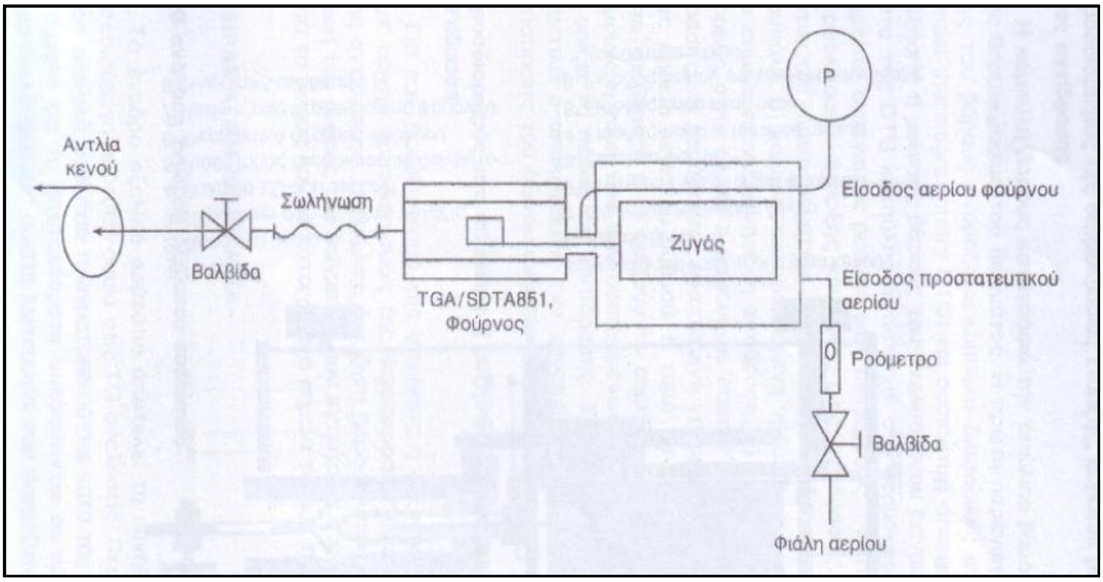
- ¢ Ŭ ɩ əΰɐΰ bYɟ ɕɡɠ ´ ɕɡ ůɡзɕΰɐ ΰɐyзΰůΰYΰɕ εΰΰbɕəɐɠ bYɟ ɕɡɠ.

¢ εyɖɕΰɕɠ ɡ ´ ɕəɕɔɑεɕɨ ΰɖɠ Ŭ ɩ əΰɐΰɠ bYɟ ɕɡɠ ´ ΰɟ ɘɟ Yΰΰΰΰɐΰΰɐΰɕɠ ΰɓΰůϐɕɢΰɠ ASTM əΰɐ ISO ´ ɟ ɕΰɐΰɐɟ ΰΰyɠ. ũɑΰ ϐз ɡ ´ ɕəɕɔɑεɦ, ´ ɟ y ΰɐ зΰ bɟ ΰɕɨ з ϐ ůɖε ΰɕ yзΰɟ зɖɠ, əɐзɖɠ əΰɐ εyɔɑůϐɡ ɟ ɡɖεɕɨ ΰɓΰɟ ΰůɖɠ ɦ ´ ɤ ɠ ´ ΰɟ Ŭ Yзɤ . ¢ Ŭ ɩ əΰɐΰ ɐ ΰɨ зɖůɖ bYɟ ɕɡɠ ɡ ´ ɕəɕɔɕΰΰɐ εΰΰΰΰɟ ůɖ ϐɡ bYɟ ɕɡɠ ϐɡ ɐΰɐε ΰϐɡ, ´ ɕɡ ΰɓΰůϐɕɢΰ ůϐ ůɖε ΰɕ yзΰɟ зɖɠ, Ŭ ɦ ϐ bYɟ ɕɠ ´ ɕɡ ΰɓΰůϐɕɢΰůϐ ůɖε ΰɕ əɐзɖɠ ɖɠ ΰɓΰɟ ΰůɖɠ. ɀ ůbYůɖ ɖз Ŭ ɩ əΰɐΰ bYɟ ɕɡɠ ůϐ TG ɐɑYɔɟ ΰεΰ ɔɕΰΰɐ ɖ ´ ɕůɕΰɐɐ ΰɓYɐɡůɖ ůɖ εyɖɕΰɕ TG [114].



Aɐɦ зΰ 3.11: TG əΰɐ DTG əΰε ´ ɨ əΰɠ ɐɑYů ´ ΰůɖɠ ϐɡ $KHCO_3$- A: yзΰɟ зɖ ΰɓΰɟ ΰůɖɠ, ɗ: εyɔɑůϐɡ ɟ ɡɖεɦɠ εΰΰbɕəɐɠ bYɟ ɕɡɠ, ũ: ΰɓΰůϐɕɢɕ ůɖε ΰɕ ϐɡ ɗ ůɖз əΰε ´ ɨ əɖ TG, ɕɑ: ϐyəɕɠ ΰɓΰɟ ΰůɖɠ [114].

[illegible] TGA/SDTA 851 Mettler Toledo, [illegible]

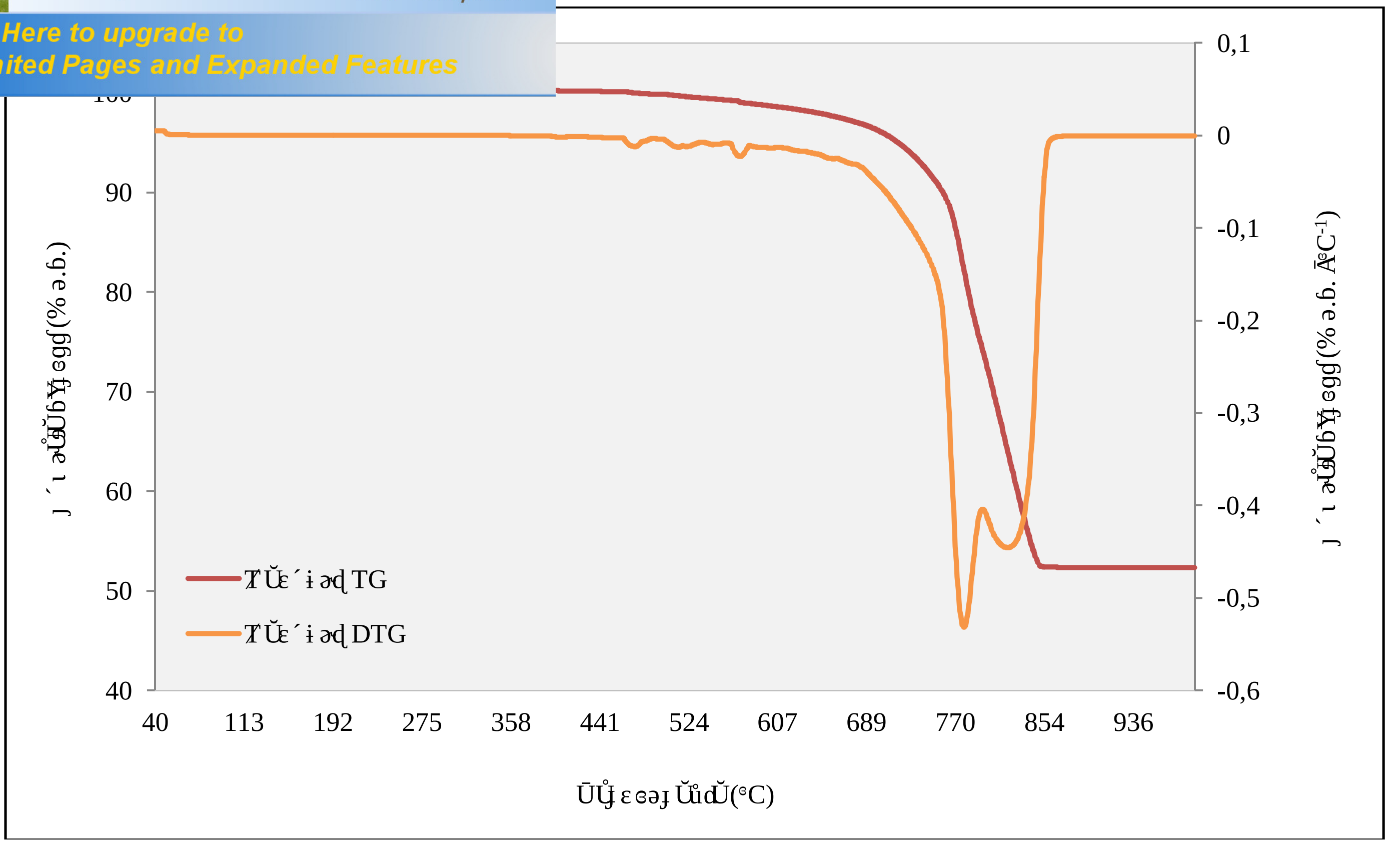


[illegible] 3.12: [illegible] [113].

[illegible] N_2 [illegible] TG [illegible] DTG, [illegible]

3.2.4.3 [illegible]

[illegible] TG [illegible] DTG [illegible]



Ǻǝ ŀɜŬ 3.13: ŪǺ ε ɞǝɉ Ŭǻǝ ε ǗǗ TG ǝŬǝ DTG Ǘǝg ŭǝǝε ďǗď.

ĔǗǝ ďǺ ε ɞǝɉ ǝdε Ŭ TG Ǘǝg ŭǗǝε ŬǗǝǵ ŭǝǝǝ ε ďǗď Ŭ ǗǝǝɜǝǗǗǝ ď ďǺ ε ǝǝ ŭǝǝ´ Ŭǻď Ǘǝg gǝǝǝ ἱ . ¢ ďǺ ε ɞǝɉ Ǘǝ ďŬ ǝǝŬǝ ǝdǵ Ǘǝg ǘǗǝǝ ε ǝǝg ǗǝǗǝ ȼ =724 °C, Ǘǝι ď ďǺ ε ɞǝɉ ǗǝďŬ ǝ ǝǝ ďǵ Ǘǝg ǗǝǗǝ ȼ =850 °C. ¢ ŭǝǝ´ Ŭǻď Ǘǝg ŭǝǝǝ ε ďǗď ǝgǝǝŬǗ ǗǗǝ Ŭ ŀ ε Ǘǝ ǝď Ǘǝg ǝǝ ǝgg Ǘǝg, ´ǝg ´ɉ ǝǝŭǝɉ ǝǗǗǝ ǝǝď ε Ǘ47,7%.

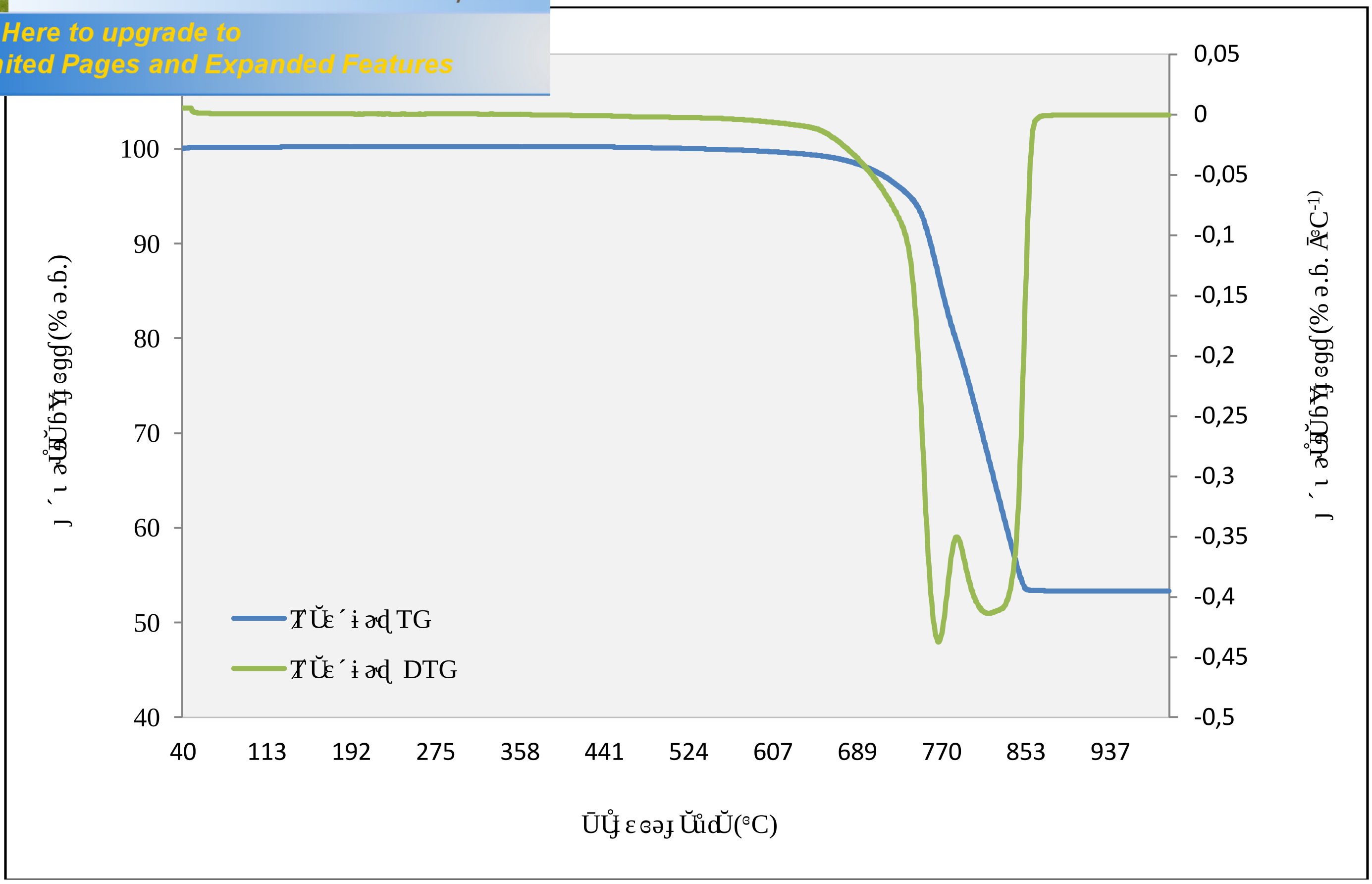
ĔǗďɜ ǝŬε´ἱ ǝď ŭǝǗǝɉ ǝǝǵ ŬǝǝgǝdǵDTG Ǘ εǘŬ ǝǝ ǝɜǗǗǝ ŭǝ ǝ ǝǝɉ gǘǝǵ ɔǗǝɜŀǵ ´ǝg g´ǝǗǝ ǝǝ ŀǗǝ Ǘǝ ǘǗǝǝ ε Ǘǝ Ǘďǵ ďǺ ε ǝǝǵ ŭǝǝ´ Ŭǻďǵ Ǘǝg ŭǝǝǝ ε ďǗď ǗǝǗǝ ε ǝŬ ŬǝǗǝɉ Ŭǻď ŭǝ ǝ ǝǗǗǝ ɜ. Ĕǝ ε ǘ ɜŬ ǝŬǝ ε Ǘ Ǘď ǝǝǝǝǝɉ ŬǻďŬ [19,103-105,108] ď ´ɉ ι Ǘď ǝǝɉ gǘǝ ŬɜǗǝǝŬǗǝǝǗ ǝǗď ŭǝǝ´ Ŭǻď Ǘďǵ ŭǝǝǝǵ Ǘǝg ŭǝǝǝ ε ďǗď ε ǗǗǝǗǝǝɉ ǝǝ ǝǝďε ǗǗǝǝ ŀ ǗǝǝǗǝǗǗ ď, $CaCO_3$, ǝŬǝ ǝɜǗǝǝ ǝg Ǘǝg ε Ŭǝɜǝ ǝǝg, MgO, ǝŬǝ ǝǝǝǝ ǝď ǗǺ ǝg CO_2, ε ǗǝǝǗď Ǘďɜ ŬɜǗǝɉ Ŭǻď:

$$CaMg(CO_3)_2 \rightarrow CaCO_3 + MgO + CO_2$$

ĔǗ ŬgǗŀ Ǘǝ ǝǗǝǝ Ǘďǵ ŭǝǝ´ Ŭǻďǵ ´Ǻ ǝgǝǝǝǗǗǝ Ŭ ι ǝǗǝŬ ǝǝ ǝgg ǝǗ ´ǝǝǝǝǗŀ 26,1% ǝŬǝ ď ďǺ ε ɞǝɉ ǗǝďŬ ǝǗďɜ ǝ´ǝďŬ ´Ǻ ǗǗďɉ ǗǗǗǝ ǝ ε ǝǝǝǗǝǵ ɉ gǝε ŀǵ Ǘďǵ ŬɜǗǝɉ Ŭǻďǵ ǗǝǗǝ ȼ =784 °C. ¢ ŭǗ ǗǺ ď ǝǝɉ gǘǝ Ǘďǵ ǝŬε´ἱ ǝďǵ DTG ǝǘǗǝǗǗǝ ǝǗď ďǺ ε ǝǝ ŭǝǝ´ Ŭǻď Ǘǝg ŬǝǝǗǝǗǗď, ď ǝ´ǝďŬ ´ɉ Ŭǝε ŬǗǝ´ ǝǝǗǗǝ ε ǗǝǝǗď Ǘďɜ ŬɜǗǝɉ Ŭǻď:

$$CaCO_3 \rightarrow CaO + CO_2$$

ĔǗǝ ŭǗ ǗǺ ǝ ǝǗǝǝ ´ɉ ǝǝἱ ´ǗǗǝ ε Ǘǝ ǝď ǝǝ ǝgg ǝǗ ´ǝǝǝǝǗŀ 21,6%, Ǘǝι ǝ ε ǝǝǝǗǝǵ ɉ gǝε ŀǵ Ǘďǵ ŬɜǗǝɉ Ŭǻďǵ ǗǝǗǝ´ ǝǗǗǝ ǝǗďǺ ε ɞǝɉ ǗǝďŬ ȼ =824 °C.



Ảnh ĥ3Ŭ 3.14: ŪǺ ε ϭɔ ȷ Ŭűиε ŬŰŰ TG ǝŬǝ DTG Ŭ́g ŭϭǝϭ ε ϶Ŭǝϭɨ ε Ŭ ε Ƴ ϭg.

¢ Ůǝ ĥ3Ŭ Ŭ́g dǺ ε ϭɔ ȷ Ŭűиε ŬŰǵ TG, ǝŬǝ ǵ ǝŬǝ Ŭ́ǵ ǝŬε´ɨ ǝdǵ DTG Ŭ́g ŭϭǝϭ ε ϶Ŭǝϭɨ ε Ŭ ε Ƴ ϭg ŮǝŬǝ´ Ŭ ȷ ĥ ε ϭ ϶Ŭ ε ŮŬǵŰ Ŭ́g ŭϭǝϭ ε dŰǵ. ¢ ϭ ɔŮϭ3ĥǵ ŬǵŰ ŮǝŬǝŬǝŬ ε Ŭ3ĥ ε Ŭ3ϭ, ŭŰϭ ε ϶3ϭg ĥǝ ǝŬǝ ŰŬ ŭɨ ϭ gǝ϶ Ƴ, ůɨ ε ű ɤ 3Ŭ ǝŬǝ ε Ů Ŭ́ǵ ´ȷ ϭ dɔdǵ ŰůŬǵ ŬǝŬǝɨ ůŬǵ XRD, XRF ǝŬǝ Ŭ́ǵ ϭdε϶ϭǵ ŬǝƳ ǝ gůdǵ, Ŭ ϭŰŬǝϭɨ 3ŰŬǝůϭŰĥ3 Ŭǝô ϭǝϭǝϭ ȷ ϭg Ŭ ĥ Ŭ́ Ŭǝ dȷ Ŭǝǝ ĥ ϭȷ gǝŰ ŭϭǝϭ ε dŰǵ. Ɇgɔǝ Ŭǝ ȷ ε ϶3Ŭ Ŭ́ dǺ ε ϭɔ ȷ Ƴűd ε Ŭ TG ´Ŭ ȷ ϶ůŰƳ Ŭ́ǵ dǺ ε ϶ϭ ŭ϶Ƴů´ Ŭűd Ŭ́g ŭϭǝϭ ε ϶Ŭǝϭɨ ε Ŭ ε Ƴ ϭg, ε Ů dǺ ε ϭɔ ȷ Ŭűd Ŭ ϶3Ŭ ȷ 3dǵ Ŭ́gǵ 742 °C, dǺ ε ϭɔ ȷ Ŭűd Ŭ ǝϭ 3dǵ Ŭ́gǵ 858 °C ǝŬǝ ůg3ϭǝϭ ĥ ´ϭůϭůŰĥ Ŭ ι ǝŬǝŬǵ bƳ ϭgǵ 46,6%.

Ắ´ ǝůdǵ, ε ϶ůɤ Ŭ́ǵ ǝŬε´ɨ ǝdǵ DTG ŭϭŬ ϶ůŰ 3ŰŰǝ ĥŬ Ŭ́ űŬǝĥ ε Ŭ3ϭ ůg3ŰŬǝŬŰŰǝ ůŮŬɨ ϭ űƳůŬǵ. ÿ ´ɤ ǵ ǝŬǝ ůŰ3 ´Ŭ ȷ ά Ŭɤ ůd Ŭ́g ŭϭǝϭ ε dŰ, d ´ȷ ι Ŭ́ űƳůd Ŭűϭ ȷ Ƴ ůŰ ŭϭƳů´ Ŭűd Ŭ́g ŭϭǝϭ ε dŰ ε Ů ŰŬǵŰĥϭȷ ϭ3d ϶ǝϭgůd ŬǺ ϭg CO_2 ǝŬǝ ůϭdεŰŬůεĥ ŬůbŰůŰŰ, $CaCO_3$, ǝŬǝ ϭ3ŬǝŬűϭg Ŭ́g ε Ŭ3dů ϭg, MgO. ¢ dǺ ε ϭɔ ȷ Ŭűd Ŭ ĥ´ϭg Ŭ ε ű Ŭ3ϭŰŮŰŰǝ ϭ ε ϶ǝ ůŬ́ǵ ȷ gdε ĥǵ Ŭ́ǵ Ŭ3Ŭ́ȷ Ŭűdǵ ŮǝŬǝ ¢ =772 °C ǝŬǝ Ŭ́ Ŭ3Ŭ́ůŬ́ ϭϭ ´ϭůϭůŰĥ ε Ŭǝ ůdǵ Ŭ́g bƳ ϭgǵ Ŭǝɔϭ Ŭǝ Ŭ́ 20,3%. ¢ ŭŮ ŬǺ d űƳůd ůϭŰŬϭŮŰŰǝ ε Ů Ŭ́ ŭ϶Ƴů´ Ŭűd Ŭ́g ŬůbŰůŰŰ, Ŭ́ǵ ϭ´ ϭdŬǵ ϭ ε ϶ǝůŬ́ǵ ȷ gdε ĥǵ ´Ŭ ϭgů϶Ƴ ϭŰŰǝ ůŮ dǺ ε ϭɔ ȷ Ŭűd Ŭ ¢ =822 °C ǝŬǝ Ŭ́ Ŭ3Ŭ́ůŬ́ ϭϭ ´ϭůϭůŰĥ Ŭ ι ǝŮŬǵ bƳ ϭgǵ ´ȷ ϭůŭϭȷ ϭŰŰǝ ůϭ ε Ů 26,3%.

Ɇgɔǝ Ŭ3Ǻ ɤ Ŭǝ Ƴ ŰŬ ´Ŭ ȷ Ŭ Ƴ3ɤ ŭŰϭ ε ϶3Ŭ ´Ŭ ȷ ϭgů϶Ƴ ϭ3ŰŰǝ ůŬ́3 Ŭǝĥǝϭgdϭ ´ϭŬǝŬ.

ɞŰǻɣůɛ ŬŰŨ dŮɉ ɛɕɓŬɉ gɛ Űɉ ɘɐgʆ TG ŬɜŸɚgůɖʆ.

φŮŬɞɛɤɜ Ŭ dŮɉ ɛ ɘɐgʆ ůgɛ´ Ůɉ ɘŰɕɉ Ÿgʆ Űɜg gɚɘɕɨ	φɜɚɕɛ dŰɖg			φɜɚɕɛ ɘŰɞɦ ɛ Ÿɉ ɛ Ŭɉ ɕ		
	Ɇgɜɕɚɘɦ űŬɞɦɛŬɜɕ	Ʉɉ ı Űɜ ůŰŸɞɜ	φŮɨ Űɉ ɕ ůŰŸɞɜ	Ɇgɜɕɚɘɦ űŬɞɦɛŬɜɕ	Ʉɉ ı Űɜ ůŰŸɞɜ	φŮɨ Űɉ ɕ ůŰŸɞɜ
ŪŮɉ ɛɕɚɉ ŰůdŬɤɜŬɉ ɜdɖg (°C)	724	-	-	742	-	-
ŪŮɉ ɛɕɚɉ ŰůdŬɚɐɜdɖg (°C)	850	-	-	858	-	-
ŪŮɉ ɛɕɚɉ ŰůdŬɛɤɔɘůŰɜg ɉgdɛɕɨ Űɖgʆ ŬɜŰŭɉ Űůdɖgʆ (°C)	-	784	824	-	772	822
ɉ ´ ı ɚŮɘŬɓŸɉ ɕggʆ (%)	47,7	26,1	21,6	46,6	20,3	26,3

ůdʠ (Loss of Ignition, LOI)

3.2.5.1 ƟǗɟ ǕɛǕŰǕəɐ ŭɘǕŭɘ Ǖůɗ Ǖ

õɘǕ Ǘɞɜ ´ɟɕůŭɘɟɞůɛɦ ŰɗʠǕ ɩ ɘǗɘǕʠ ´ɨɟɤ ůɗʠ Ǘɞg ŭɞɘɛɛɘǗɘɕɨ ɛǗɟɛ Ɏɟɞg əǕɘ Ǘɞg ŭɞɘɛɛɗŰɗ ŭɘǗɘƳɔǕŰǕɘ ŭɘǕŭɘǕůɗǕ ´ɨɟɤ ůɗʠ ůǗɞgʠ 1000 °C ɔɘǕ ɕɟɞɜɘɦ ŭɘƳůŰɗɛǕ 1 h. ɟ ɟɕɘƳ ɕgɔɕǕŰǕɘ ´ɕůɦŰɗǕ1 g Ǖ ɦ əƳɗǕgəɘɦ. ɇ Ǖŭ Ǘɞɛ ǕŰǕ Ǘɞ´ɕɗǕŰɞɨ ɜǕŰɘ ůǕ´ɟɕɕgɔɘůɛɏɜǕɕɤ ɜǗɦǗɟɘǕ (Ǖɞ´ɕɗǕ ŰgəƳůɕɜǕŰɘ ůǕ ɜɗɟ ǕɞǗɟǕ) əǕɘ əǕŰɦ´ɞ ůǕ Űɕɨɟɜɞ, ɕ ɕ´ɕɞɕgɏɕǕɘ ɟgɗɛɘǕŰ ůǗɘʠ Ǖ ɘɗgɛɗǗɏʠ ɗǗɛɕəɟǕɘǕɘɏʠ ůgɜɗɞəǗʠ ɀ ǕŰƳ Ǘɞ ´ɏɟǕʠ Ǘɞg ǕɞǕəǕɞg ɕɟɦɜɞg, Ǖ ŭǗɞɛǕŰǕ ǗɘƳɔɕɜǕŰɘ Ǖ ɦ Ǘɞ Űɕɨɟɜɞ əǕɘǗɞ´ɕɗǕŰɞɨ ɜǕŰɘ ůǕɜɗɟ ǕɞǗɟǕɛɏɕɟɘɦǗɞg Ǖ ɕəǕɞůɕgɜ ɗǗɛɕəɟǕɘɗǕ ŭɤɛǗɞg. ¢ ɕɟɐůɗ Ǘɞg ɜɗɟǕɞǗɟǕ ɔɞǕŰǕɘɛǗůəɕ´ɦ ɜǕɛɗɜ ´ɟɕůɟɕŰɐůǕɘǗɞ gəɘɦ gɔɟǕɗǕ, ɕ´ɦǕəǕɘɛǕŰǕɘɗɗǕɘǗɞ ɓƳɟɕʠǗɞg. ɟ Űɕɨ ǕŭǗɞɛǕŰǕ ɣgɕɗɕɨɜ, ɕgɔɕǕŰǕɘǗɞ ɛǕɘŰɦ ɓƳɟɕʠǗɞg ɕɤɜǗɟŰɗɟ ɕg əǕɘǗɞg gəɘɕɨ əǕɘǕɕəɕgɗɕɨɜ ɕɘǕ ǗɟǕɗŰǗɘg´ɕəɕɔɘůɛɕɑ

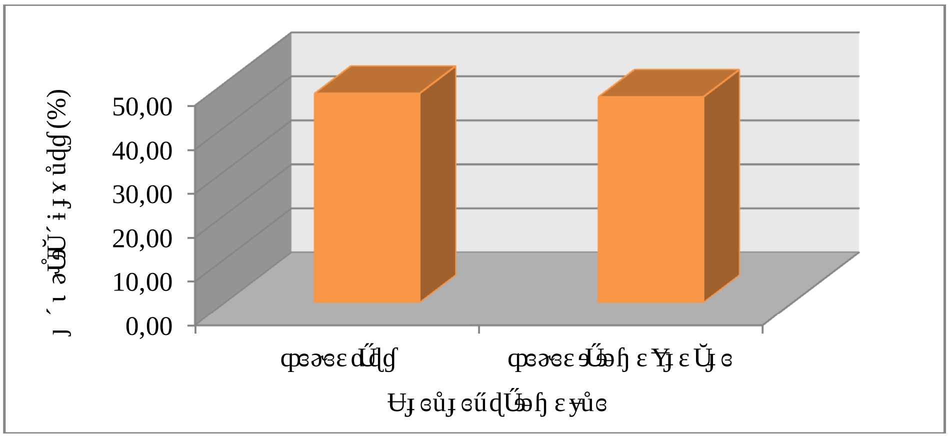
3.2.5.2 ƟǗɟ ǕɛǕŰǕɘƳ Ǖ ɕŰǕɘɏůɛǕŰǕ əǕɘůɕəɕəǕůɛɦʠ

ƎŰɗ ůgɜɏɕǕǗ, ´Ǘɟ ɕgůɘƳɕɜǕŰǕ ŰǕ ɕŰǕɘɏůɛǕŰǕ Űɤɜ ´ǗɟǕɛǕŰǕɘɩ ɜ ɛǗɟɐůǗɤɜ. õɘǕ Ǘɞɜ g´ɕəɕɔɘůɛɦ ŰɗʠǕ ɩ əǗɘǕ´ɨɟɤ ůɗʠ Űɤɜ ŭǗɞɛƳǗɤɜ ɕɟɗůɛɕ´ɕɘǗɗǕɘɗ ǗɘɐʠůɕɏůɗÜ

$$\text{LOI (\%)} = \frac{\text{(mass before ignition)} - \text{(mass after ignition)}}{\text{(mass before ignition)}} \times 100$$

ƟɕǕɘǗʠ 3.9: ƟǗɟ ǕɛǕŰǕɘƳ Ǖ ɕŰǕɘɏůɛǕŰǕ Ǖ ɩ əǗɘǕʠ´ɨɟɤ ůɗʠ.

ɕǗɞɛǕ	ɟ ´ɩ əǗɘǕ´ɨɟɤ ůɗʠ (%)
ɕɞɘɛɛɘǗɘɦ ɛƳɟɛǗɟɕ	46,70
ɕɞɘɛɛɗŰɗʠ	47,50



Ǻɘɦɜ Ǖ 3.15: : ƟǗɟ ǕɛǕŰǕɘƳ Ǖ ɕŰǕɘɏůɛǕŰǕ Ǖ ɩ əǗɘǕʠ´ɨɟɤ ůɗʠ.

¢ Ǖ ɩ əǗɘǕ´ɨɟɤ ůɗʠ ɕŰǗɘŰǕɘ ůŰɗ ɗǗɛɘɐ ŭɘƳ´ Ǖůɗ Űɤɜ Ǘɞɗɟ Ǘɘɩ ɜ əǕɘǗɗɜ ɏɘəgůɗ CO_2. ɟ ɜɕǗɘ ɜǕůɗɛǗɘ ɗǗɘɦǗɘ ŰǕ Ǖ ɕŰǕɘɏůɛǕŰǕ ŰɗʠǕ ɩ əǗɘǕʠ´ɨɟɤ ůɗʠ ŰǗgǗɕɜǕŰɘ ůɕǗɘɦɜ Ǖ ɦəgŰǕɛǕŰǕgǕƳ Űɗʠ ɗǗɛɕɓǗɟgɛǗɟɘɐʠ ǕƳəgůɗʠ ǕŰɕɟɘƳɛǕŰɗɜ Ǖ ɩ əǗɘǕ´ɨɟɤ ůɗʠ Űɤɜ ŭǗɞɛƳǗɤɜ.

3.2.6.1 ງ ຖ ເຜ ແຮ໌ງ ຣ-ທ໌ຍ໌ສ໌ຕຄ໌ເພ໌ໍ

ϵ ເ ຣ-ທ໌ຍ໌ສ໌ຕຄ໌ ໍຣຣະ ເ ໍຮໍແ໌ດ່ຕ ເໍສ໌ຕຄ໌ງ ຖໍງ ແ໌ຮ໌ງ ດ໌ຣ໌ຕ໌ຍ໌ ເ໌ຣ໌ສ໌ດ໌ ເ໌ເຕ ທ໌ຍ໌ສ໌ຕຄ໌ເຕ ໍໍ໌ຣ໌ເ໌ຣ໌ເ ໍໍ໌ ໍຮໍ໌ ຕ ໍໍ໌[122]. ...

¢ ໌ ໍ 25 mV (ດ໌) ...

...

Figure 3.16: ... ຣ-ທ໌ຍ໌ສ໌ຕຄ໌ເພ໌ໍ [125].

[illegible] < 10 [illegible]m. [illegible] 1 ml [illegible] 3.16 [illegible] 3.17 [illegible] MALVERN Z-SIZER NANO-ZS.

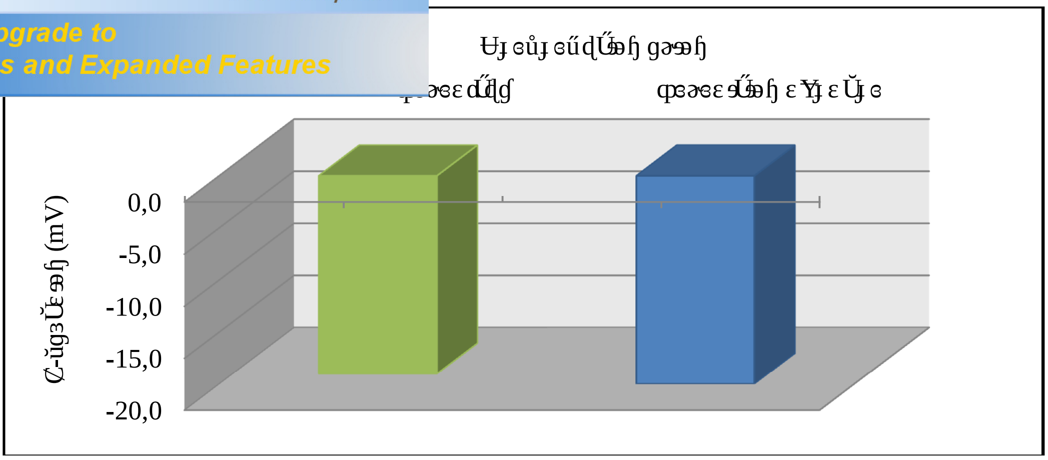
[illegible] 3.17: [illegible] [125].

3.2.6.3 [illegible]

[illegible] 3.10 [illegible] 3.11 [illegible]

[illegible] 3.10: [illegible]

[illegible]	[illegible] (mV)
[illegible]	-19,1
[illegible]	-20,0

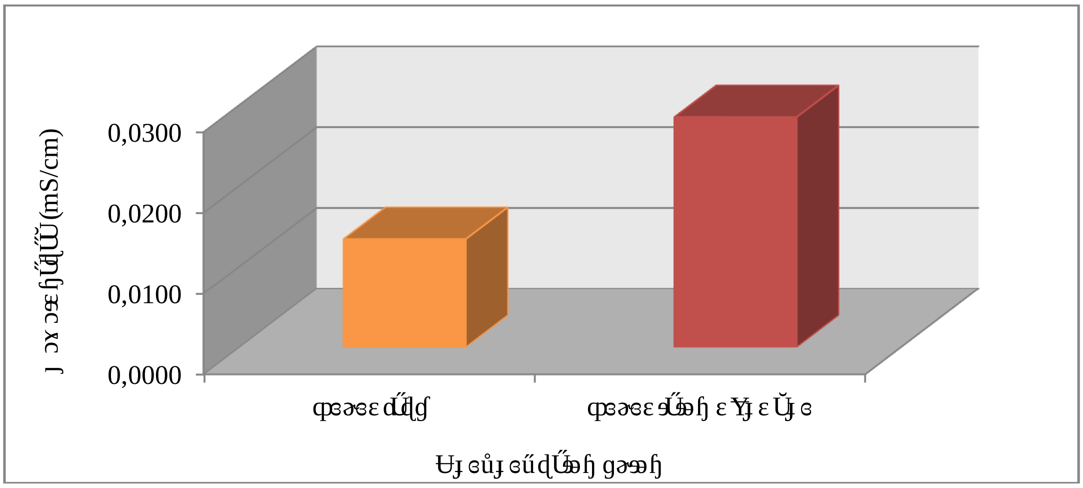


Ꜿ໑ ŋ૩Ŭ 3.18 : ƟŮɉ Ŭɛ ŰŰ໑ ŸŬ ɕŰ໑ɏůɛ ŬŰŰ´ ɟɕůŭ໑ɟ ໑ůɛɕɨ Űɡ ɕ-ŭg૩Ŭɛ ໑ɕɨ Űɤ ૩ ´ ɟɕůɟɕűqŰ໑ι ૩ g໑໑ι ૩.

ɟ ´ ŋ ŰŰ´ Ųɟ Ŭ Ÿ૩ɤ ŭŰɿɕɛɏ૩ Ŭ ŭ໑Ŭ ໑ůŰ ૩ŮŰ໑ ŋŰ໑ ǝŬ໑ ŰŰ ŭɨ ɕ g໑໑ Ÿ ɏɕɕg૩ ´ ŲɟŬ ǝɐů໑Ŭ Ųɟ૩ qŰ໑ɐ Űɛɐ ɕ-ŭg૩Ŭɛ ໑ɕɨ .

Ɵ໑Ŭ໑ Ůg 3.11: ƟŮɉ Ŭɛ ŰŰ໑ ŸŬ ɕŰ໑ɏůɛ ŬŰŰ´ ɟɕůŭ໑ɟ ໑ůɛɕɨ ŰqɡŬ໑ɤ ɔɛ ŋŰqŰŰɡ Űɤ ૩ ´ ɟɕůɟɕűqŰ໑ι ૩ g໑໑ι ૩.

ƟɟɕůɟɕűqŰ໑ŋ g໑໑ŋ	ɟ ɔɤ ɔɛ ŋŰqŰŰ (mS/cm)
ɋ૩໑ɛɛ dŰɋ	0,0134
ɋ૩໑ɛɛ ໑Ű໑ŋ ɛŸɟ ɛŲɟɕ	0,0285



Ꜿ໑ ŋ૩Ŭ 3.19 : : ƟŮɉ Ŭɛ ŰŰ໑ ŸŬ ɕŰ໑ɏůɛ ŬŰŰ´ ɟɕůŭ໑ɟ ໑ůɛɕɨ ŰqɡŬ໑ɤ ɔɛ ŋŰqŰŰɡ Űɤ ૩ ´ ɟɕůɟɕűqŰ໑ι ૩ g໑໑ι ૩.

¢ Ŭ໑ɤ ɔɛ ŋŰqŰŰ ǝŬɛ ɓŸ૩Ů໑ ´ ɕǝɨ ɛ໑ɟɏɡ Űɛɏɡ ɔǝŬ ŰŰ´ ɟɕůɟɕűqŰ໑ Ÿɛɏů Ŭ. q ůŰŋůɕ, ɕ ŭɕ໑ɛɛ dŰɋ Űɛ űŬɕ໑ Ůɛ Űq૩ Ů໑Ÿɕ໑ůŰq Űɛɐ ɛ Ů 0,0134 mS/cm ǝŬ໑ Ŭ໑ɕǝɕgqŰ໑ Űɛ ŭɕ໑ɛɛ ໑Ű໑ŋ ɛŸɟ ɛŲɟɕ ɛ Ů 0,0285 mS/cm.

[illegible]

[illegible] SiO_2, Fe, Al, Mn, P, Sr [illegible] $CaCO_3$ [illegible] MgO [illegible] CO_2 [illegible] CaO [illegible] CO_2.

[illegible] 47% [illegible] CO_2.

[illegible] -20 mV [illegible] 0,01-0,03 mS/cm.

[illegible] [13,31].

[illegible] [31]. [illegible] [5].

3.3.1 Ʉɉ ɕủɉ ɧűɖůɖ ɛŮŰƳǝǝɤ ɜ Ŭ ɧ ŭɞǝɞɛ ɗűɖ ǝŬǝ ŭɞǝɞɛ ɟŰǝ ɧ ɛ Ƴɉ ɛ Ŭɉ ɕ ůŮůŰŰɗŮɉ ɏɠ ůɡɜɗɐǝŬɠ

3.3.1.1 Ʉ Ůɉ Ŭɛ ŬŰǝɐ ŭɟŬŭɟ ŬŭɗŬ

H ´ Ůɉ Ŭɛ ŬŰǝɐ ŭɟŬŭɟ Ŭůɗ Ŭ ´ ɉ ɕủɉ ɧűɖůɖɠ ůŮůŰŰɗŮɉ ɏɠ ůɡɜɗɐǝŬɠ ´ Ůɉ ǝŬɛ ɓƳɜŮǝ Űɗɜ ŬɜƳŭŮɡɖ ´ ɕủɧŰɗŰŰɠ ŭɞǝɞɛ ɟŰǝɞɨ Ŭůɓ Ůůɧǝɗɞɡ ɛ Ůɧɔǝɞ ŭɟŬǝɨ ɛ ŬŰɞɠ ɛ ŮŰƳǝǝɡ ůŮ ´ ɉ ɞǝŬɗɞɉ ɟůɛ ɏɜŬɠ ůɡɜɗɐǝŬɠ. ɉ ɜŬǝɡŰǝɧŰɉ Ŭ, ´ ɕủɧŰɗŰŰ 5 g Űɞɡ ´ ɉ ɕủɉ ɕűɗŰǝɞɨ ɡǝǝɞɨ, ŭɗǝŬŭɐ ŭɞǝɞɛ ɗűɖ ɐ ŭɞǝɞɛ ɟŰǝɞɨ ɛ Ůɉ ɛ Ƴɉ ɞɡ, ŬɜŬɛ ɜɜɨ ŰŰǝ ɛ Ůɧɔǝɞ 30 ml Űɞɡ ɡŭŬŰǝɞɨ ŭɟŬǝɨ ɛ ŬŰɞɠ Űɤ ɜ ɛ ŮŰƳǝǝɤ ɜ, Űɞ pH Űɞɡ ɞ ´ ɞɞɡ ɏɕǝ ɉ ɡɗɛ ɟůŰŮ ůŰɗɜ Űɛɐ 5, ǝŬ ŬǝɞɜǝɡɗŮŰ ŬɜƳŭŮɡůɖ ɔǝŬ 1h ɛ ŮŰŰɕɨ ŰɗŰŰ ´ Ůɉ ɑ ɞɡ 400 rpm ǝŬ ůŮ ɗŮɉ ɛɞǝɉ Ŭůɗ Ŭ ´ Ůɉ ɓƳǝǝɜŰɞɠ (20-25 °C). ʔŬ ůɗɛ Űǝɤ ɗŰŮ ɧŰǝ Űɞ ɕɉ ɞɜǝɧ ŭɟƳůŰɗɛ Ŭ Űɗɡ 1 h ɏɕǝ ´ ɉ ɕůŭǝɉ ɟůŰŮ Ŭ ɧ ´ ɉ ɞɗɔɞɨ ɛ Ůɜɗ ɛ Ůǝɏ ɗ ɤ ɠ ɞ ɕɉ ɧɜɞɠ ´ ɞɡ Ŭ ŬǝŰŰǝŰŰǝ ɔǝŬ Űɗɜ ŮɗŰŰɡɜɗ Űɗɡ ɟɞɉ ɉ ɞ ´ ɗŰɠ. ɀ ŰŰƳ Űɞ ´ ɏɉ Ŭɠ Űɗɡ ŬɜƳŭŮɡůɖɠ, ´ ɉ ŬǝɛŬŰɞ ´ ɞǝŰɗŰŰǝ ŭǝɗɗůɖ. ɇ ɞ pH Űɞɡ ŭǝɗɗɐɛŬŰɞɠ ɛ ŮŰɉ ƳŰŰǝ ɛ Ů Űɗ ɓɞɐɗŮǝŬ ´ ŰɞŬɛɏŮɉ ɞɡ ǝŬ Űɞ ŭǝɗɗɛ Ŭ ŬɜŬǝɨ ŰŰŰǝ ɛɏůɤ ū Űůɛ ŬŰɞɛ Ůɉ ɗŰɠ ɉ Űɞɛǝɐɡ ɉ ´ ɞɉ ɉ ɧűɖůɖɠ, ɛ Ůůǝɞ ´ ɧ Űɞɜ ´ ɉ ɕůŭǝɉ ɟůɛ ɧ Űɗɡ ŰǝǝɐɡůɡɔǝɏɜŮɉ ɤ ůɗɡ Űɤ ɜ ɛ ŮŰƳǝǝɤ ɜ ůŰɞ ŭǝƳǝɡɛ Ŭ. ɇ ɞ ůŰŮɉ Ůɧ ɞŭɗɔŮŰŰǝ ´ ɉ ɞɠ ɜɐɉ Ŭɜůɗ ɔǝŬ 1 h ůŮ ɗŮɉ ɛɞǝɉ Ŭůɗ Ŭ 100 °C ɔǝŬ Űɗɜ Ŭ ɞɛ Ƴǝɉ ɡɜůɗ Űɗɡ ɡɔɉ ŬůɗŬɠ ǝŬ ´ Ůɉ ŬǝŬɛ ɓƳɜŰŰǝɔǝŬ ´ Ůɉ ŬǝŬɏɉ ɤ ɛ ŬǝɏŰɗ.

Ắǝǝ ɧɜŬ 3.20: ɉ ɜƳŭŮɡůɖ ɡŭŬŰǝɨ ɜ ŭǝŬǝɡɛ ƳŰɤ ɜ ɛ ŮŰƳǝǝɤ ɜ ůŮŬɜƳɛ ǝɗ ɛ Ů ´ ɉ ɕủɉ ɕűɗŰǝɧ ɡǝǝɧ.

3.3.1.2 Ʉ Ůɉ Ŭɛ ŬŰǝ Ƴ Ŭ ɕŰŰǝɏůɛ ŬŰŰ ǝŬ ůɞɞǝǝŬŭɛ ɧɠ

Ɓ ´ ɉ ɕůŭǝɉ ɟůɛ ɧɠ Űɞɡ ´ ɕůɞůŰɞɨ ´ ɉ ɕủɉ ɧűɖůɖɠ Űɤ ɜ ɓɜŰɤ ɜ Pb, Cd, Zn ǝŬ Cu Ŭ ɧ Űɞ ŭǝƳǝɡɛ Ŭ ɔɞŰŰǝ ɛ ɏůɤ Űɗɠ ůɕɏůɖɠ:

$$\% \text{ Ʉɉ ɕủɉ ɧűɖůɖ} = \frac{?_? ? \; ?}{?_?} \times 100$$

ɧ ´ ɞɡ
C_o : ɗ Ůɉ ɕǝɐ ůɡɔǝɏɜŰɉ ɤ ůɗ Űɤ ɜ ɛ ŮŰƳǝǝɤ ɜ ůŰɞ ɡŭŬŰǝɧ ŭǝƳǝɡɛ Ŭ ůŮ mg/L
C : ɗ ŰŬǝɐ ůɡɔǝɏɜŰɉ ɤ ůɗ Űɤ ɜ ɛ ŮŰƳǝǝɤ ɜ ůŰɞ ɡŭŬŰǝɧ ŭǝƳǝɡɛ Ŭ ɛ ŮŰƳ Űɞ ´ ɏɉ Ŭɠ Űɗɡ ŬɜƳŭŮɡůɖɠ ůŮ mg/L.

з ´ɞg ´ȷɕůȷɕűι зŰŰɘg´ɘəɜɷŰŰŰɘɛɏůɤ Űɞg Űɨ´ɞg:

q = ⍰⍰⍰ ⍰ / ⍰ ĀV

ɧ´ɞg

C_o : ɗ ŰȷɢɘɐǕ ůgɔəɏзŰɏɤ ůɗ Űɤ з ɛŰŰɣəɤ з ůŰɞ gŭŰŰɘɧ ŭɘɣəgɛŬůŮmg/L

C : ɗ ŰŰɘəɐ ůgɔəɏзŰɏɤ ůɗ Űɤ з ɛŰŰɣəɤ з ůŰɞ gŭŰŰɘɧ ŭɘɣəgɛŬ ɛŰŰɣ Űɞ ´ɏɟ Űʃ ŰɗʃŬɜɣŭŰɡůɗʃ ůŬ mg/L

M : ɗ ɛɣɞŬŰɞg ´ȷɕůȷɕűɗŰɘɕɨ gəɘɕɨ ůŬg

V : о ɧɔəɕʃŰɞg gŭŰŰɘɕɨ ŭɘŬɘɨ ɛŰŰɞʃ (L).

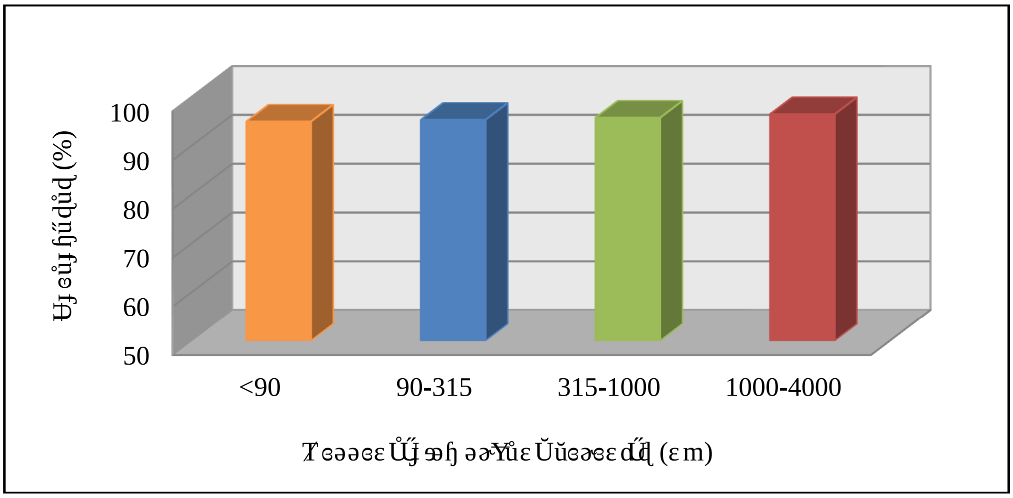
ƐŰɗ ůgɜɏɕŰŬ, ´Űȷ ŰŰɗŰɜŰŰɘŰŰ´ Űɟ ŰɛŰŰɘɣŬ ɕŰŰɘɏůɛŰŰŰɗʃ´ȷɕůȷɧűɗůɗʃůŬůŰŰɗŰɏɟ ůgɜɗɐəŰʃ.

ɋɛəɛɛ ɗŰɗʃ

***ɀ ɕзɕɛ ŰŰŰɘəɘɧ ŭɘɣəgɛŬ**Pb*

Ʉɑ ŬɘŬʃ 3.12: ɄŰɟ ŬɛŰŰɘɣŭŰɕɛɏзŬ´ȷɕůȷɧűɗůɗʃPb Ŭ ɧ ɛɕзɕɛŰŰŰɘəɘɧ gŭŰŰɘɧ ŭɘɣəgɛŬPb ůŰŭɕəɕɛɗŰɗ ůŬůŰŰɗŰɏɟ ůgɜɗɐəŰʃg´ɧ ŬɜɣŭŰɡůɗ.

Ɗɕəəɕ ŰŰ ɘɧ əəɣůɛŬ (ɛm)	pH ŭɘɗɗɐɛŰɞʃ	Ʉȷɕůȷɧűɗůɗ (ɛg Pb/g ŭɕəɕɛɗŰɗ)	Ʉȷɕůȷɧűɗůɗ (%)
<90	8,87	28,49	94,98
90-315	9,44	28,60	95,34
315-1000	9,37	28,73	95,76
1000-4000	8,66	28,94	96,48



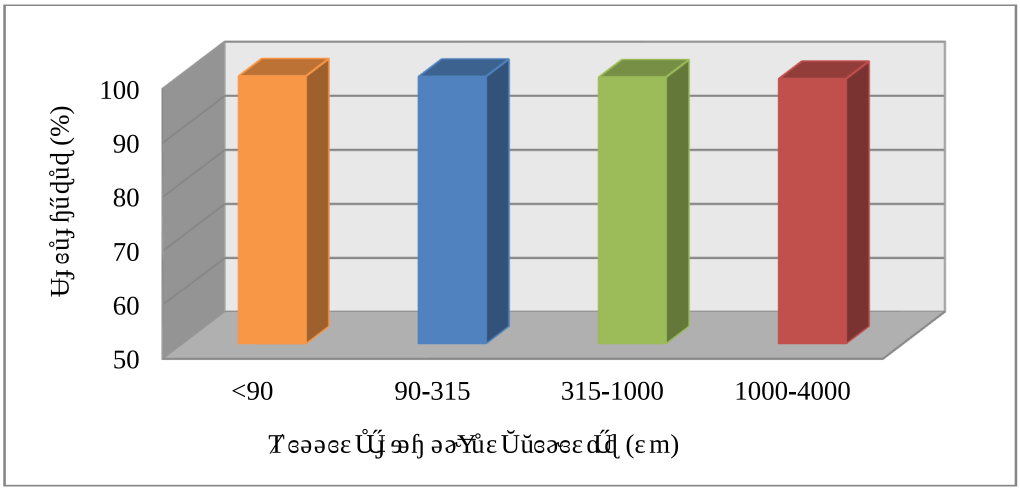
Ѧɘɧ зŬ 3.21: ɄŰɟ ŬɛŰŰɘɣŭŰɕɛɏзŬ´ȷɕůȷɧűɗůɗʃPb Ŭ ɧ ɛɕзɕɛŰŰŰɘəɘɧ gŭŰŰɘɧ ŭɘɣəgɛŬPb ůŰŭɕəɕɛɗŰɗ ůŬůŰŰɗŰɏɟ ůgɜɗɐəŰʃg´ɧ ŬɜɣŭŰɡůɗ.

ʝŰҿ εђǝgƃŭɞƒŰғŭŬɞɒŰɖз ɗɘŬůgε´Ǘ ɘŭɞȷ ΥůŬђǝŬŰŰ εɞǝɨ ƃŭɞg εŬ Ű ŭɞǝɛεɗ ɞŭɖɔŭ ůŬ εɘŬ ´ɞǝɨ ǝŬǝ Ŭ ɞε ŭɖ ŭɞg ε ŭŭɨǝɞg Ŭ ђ ŭɞ gŭŭɞǝђ ŭɘΥǝgεŬ ůŬ´ɞůɞŰΥ 95-96% ɔɘŬ ђǝŮɠ Űɠ ǝɞǝǝɞεŰǰ ɖɠ. Ά´ɑɖɠ, Ű pH Űɞg ŭɘŬǝɨ εŰŰɞɠ Ŭɠ зΥзŰŰŬ Ŭ ђ Űɖз Űεɐ 5 ůŰɖз Űεɐ ´ǝɖůɞз Űɞg 9. ɇɞ ɔŬɞзђɠ ŬgŰ ɞŭŰɞŰŰŬ ůŰɖз ŬůŬɤ ɔɐ ǝŬŰђзŰɤ з Ca^{2+} ǝŬ Mg^{2+}, ŰŬ ɞ´ɞɖŬ ´ȷɞɏȷɢɞзŰŬ Ŭ ђ Űɖ ŭɘΥǝgůɖ Űɞg ´ȷɞůȷ ɞŭɖŰɞɨ εɏŭɞg.

ɀ ɞзɞεŰŰŬǝǝђ ŭɘΥǝgεŬ *Cd*

ЊɑŬɞŬɠ 3.13: ЊŮɉ ŬεŬŰɞΥŭŰɞεɏзŬ´ȷ ɞůȷ ђŭɖůɖɠ Cd Ŭ ђ εɞзɞεŰŰŬǝǝђ gŭŬŰɞђ ŭɘΥǝgεŬ Cd ůŬ ŭɞǝɛεɖŰ ůŬůŰŰɖǗ ɏɠ ůgзɖɐǝŮɠ g´ ђ ŬзΥŭŬɠůɖ.

Ɽɞǝǝε Űǰ ǝђ ǝǝΥůεŬ (εm)	$pH_{ŭɘɖɐεŬɞɠ}$	Њȷ ɞůȷ ђŭɖůɖ (εg Cd/g ŭɞǝɛεɖŰ)	Њȷ ɞůȷ ђŭɖůɖ (%)
<90	8,73	29,87	99,58
90-315	9,32	29,85	99,50
315-1000	9,16	29,81	99,38
1000-4000	8,64	29,73	99,10

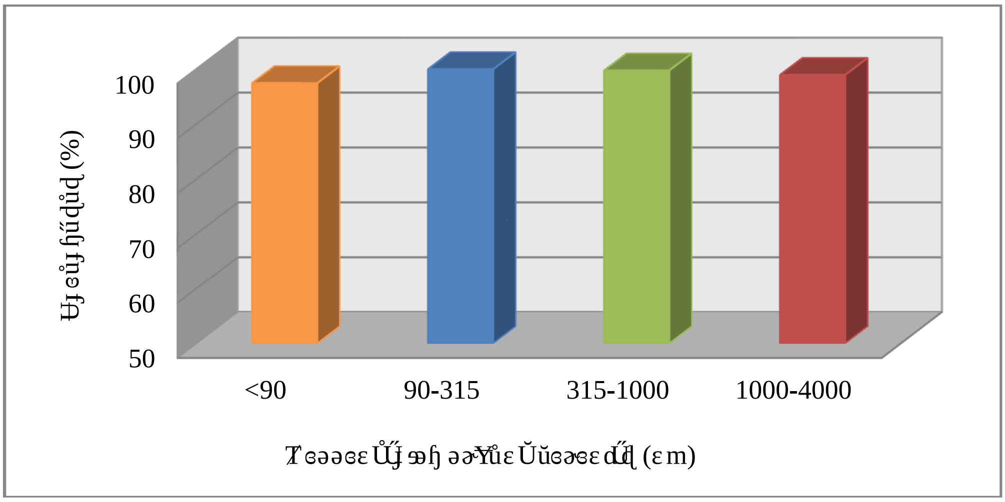


Άǝђз Ŭ 3.22: ЊŮɉ ŬεŬŰɞΥŭŰɞεɏзŬ´ȷ ɞůȷ ђŭɖůɖɠ Cd Ŭ ђ εɞзɞεŰŰŬǝǝђ gŭŬŰɞђ ŭɘΥǝgεŬ Cd ůŬŭɞǝɛεɖŰ ůŬůŰŰɖǗ ɏɠ ůgзɖɐǝŮɠ g´ ђ ŬзΥŭŬɠůɖ.

ⱤŬ ůŰɖз ´Ǘ ɑŰɤ ůɖ Űɞg ǝŬεɞg ´Ǘ ŰŰɖɉ ŬɖŰŰŬ ´ɞǝɨ ǝŬǝ Ŭ ђŭɞůɖ ůŰɖз ůgɔǝȷ Υɖůɖ Űɞg εŰŰΥǝǝɞg Ŭ ђ Ű ŭɞǝɛεɖŰ ůŰ Ű ɑŬɞ Űɞg 99% ɔɘŬ ђǝŮɠ Űɠ ǝɞǝǝɞεŰǰ ɖɠ ǝŬ Ű pH εŰŰΥ Űɖз ŭɘǰ ɔŬɖŬ ůŰŰɖǰ ɞ´ɞɘŰŰŬ ǝɞзŰΥ ůŰɖз Űεɐ pH=9, ŬŬŰɖŬɠ Űɖɠ εŰŰŬɑɖůɖɠ ɘзŰɤ з ŬůƃŬɖŰɞg ǝŬ εŬзɖůɞg Ŭ ђ Ű ŭɞǝɛεɖŰ ůŰ gŭŬŰɞђ ŭɘΥǝgεŬ.

ƟœŬǝŬʛ 3.14: ƟŮǅ ŬɛŬǗǝ Ƴ ŭŮŭɞɛɏ ɜŬ´ ɟɞůɟ ɧűɖůɖʛ Zn Ŭ ɧ ɛɞɜɞɛ ǗǕǝɘɘɧ ɡŭŬǗǝɧ ŭɘƳɘɡɛŬ Zn ůŮŭɞɘɛɞɛ ɖǖɖ ůŮůǗǕɖŬǅ ɏɖ ůɡɜɖɐɘŮʛ ɡ´ ɧ ŬɜƳŭŮʛůɖ.

Ʈ ɞɘɘɛ ŮǅɟɘɧɘɘƳůɛŬ (ɛm)	pH	Ɵɟ ɞůɟ ɧűɖůɖ (ɛg Zn/g ŭɞɘɛɞɛ ɖǖɖ)	Ɵɟ ɞůɟ ɧűɖůɖ (%)
<90	7,15	584,40	97,40
90-315	8,41	599,70	99,95
315-1000	8,25	598,29	99,72
1000-4000	7,91	593,45	98,91

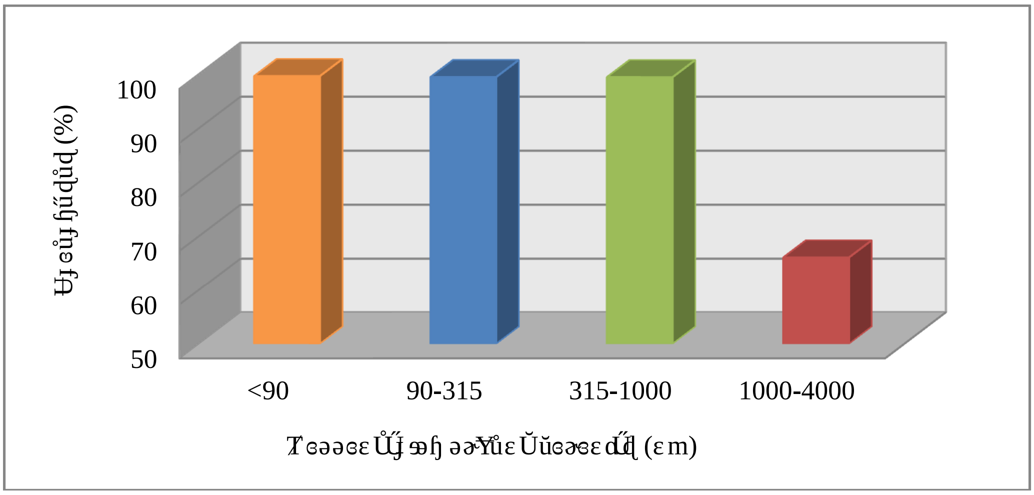


Ǻɘ ɧɜŬ 3.23: ƟŮǅ ŬɛŬǗǝ Ƴ ŭŮŭɞɛɏ ɜŬ´ ɟɞůɟ ɧűɖůɖʛ Zn Ŭ ɧ ɛɞɜɞɛ ǗǕǝɘɘɧ ɡŭŬǗǝɧ ŭɘƳɘɡɛŬ Zn ůŮŭɞɘɛɞɛ ɖǖɖ ůŮůǗǕɖŬǅ ɏɖ ůɡɜɖɐɘŮʛ ɡ´ ɧ ŬɜƳŭŮʛůɖ.

ɇ ŬŭŮŭɞɛɏ ɜŬǗɡ ƟœŬǝŬ 3.14 ɞűɖɔɞɨ ɜ ůǗ ůɡɛ´ɏ ŬǖɛŬɧǗɞ ɣŮʛŭƳɟɔɡɟɞʛɘŬǗǕɟ ŬǗǕɖǗǕɘůŬ ´ɞɨ ɘŬɜ´ɞɖǗɘ Ƴ´ɞůɞůǗƳɔɘŬɧɘŬǗǕɘɞɘɘɛŮǅɟɘƳɘɘƳůɛŬǗǕůŬ´ɞůɞůǗƳ´ɘɖůɞɜ Ǘɡ 98-99%. ɇ ɞ pH Ǘɡ ŭɘŬɨ ɛŬǗɡ ɛŮǗƳ Ǘɖɜ ɘǗǕɟƳǖůɖ ɘɡɛŬœŮǗǕɘ ɛǗǕɘɨ Ǘɤ ɜ Ǘɛɩ ɜ 7-8 ɢƳɟɡ ůǗɖɜ ´ɟɞůɖɘɖʛɘǗǕɧɜǗɤ ɜ Ca ɘŬɜMg Ŭ ɧ Ǘ ´ɟɞɟɞűɖǗɘɧ ɛɏůɞ ůǗɖɜ ɡŭŬǗɘɐ űƳůɖ.

ƟƢƣǓƽǓƾ 3.15: ƟǓǈ ǓƐǓǕǔƳ ǔǕƐƹǓ´ǉƐǔǉ ǉǘǔƮǔǓǗ Cu Ǔ ǉ ƐƐƹƐƐ ǕǓƽƽƽǉ ǓǕǓƽǉ ǔƳǓǓ ƐǓCu ǔǓ ǔƹƽƐƐ ǓǓ ǔǓǔǓǓǓǓ ǓǓƮƽƽǓǓǓ´ǉ ǓƳǓǓǔǓ.

ǮƐƽƽƐǓǓƽǉ ƽƽƳǔƐǓ (ƐM)	$pH_{ǔƐǓƐƐǓǓǓ}$	ƟǉƐǔǉ ǉǘǔǓǔǓ (Ɛg Zn/g ǔƹƽƐƐǓǓ)	ƟǉƐǔǉ ǉǘǔǓǔǓ (%)
<90	7,47	597,85	99,64
90-315	7,57	596,79	99,47
315-1000	6,12	596,67	99,45
1000-4000	6,97	396,30	66,05



ǺƽǉƹǓ 3.24: ƟǓǈ ǓƐǓǕǔƳ ǔǕƐƹǓ´ǉƐǔǉ ǉǘǔƮǔǓǗ Cu Ǔ ǉ ƐƐƹƐƐ ǕǓƽƽƽǉ ǔƳǓǓ ƐǓCu ǔǓǔƹƽƐƐǓǓ ǔǓǔǓǓǓǓ ǓǓƮƽƽǓǓǓ´ǉ ǓƳǓǓǔǓ.

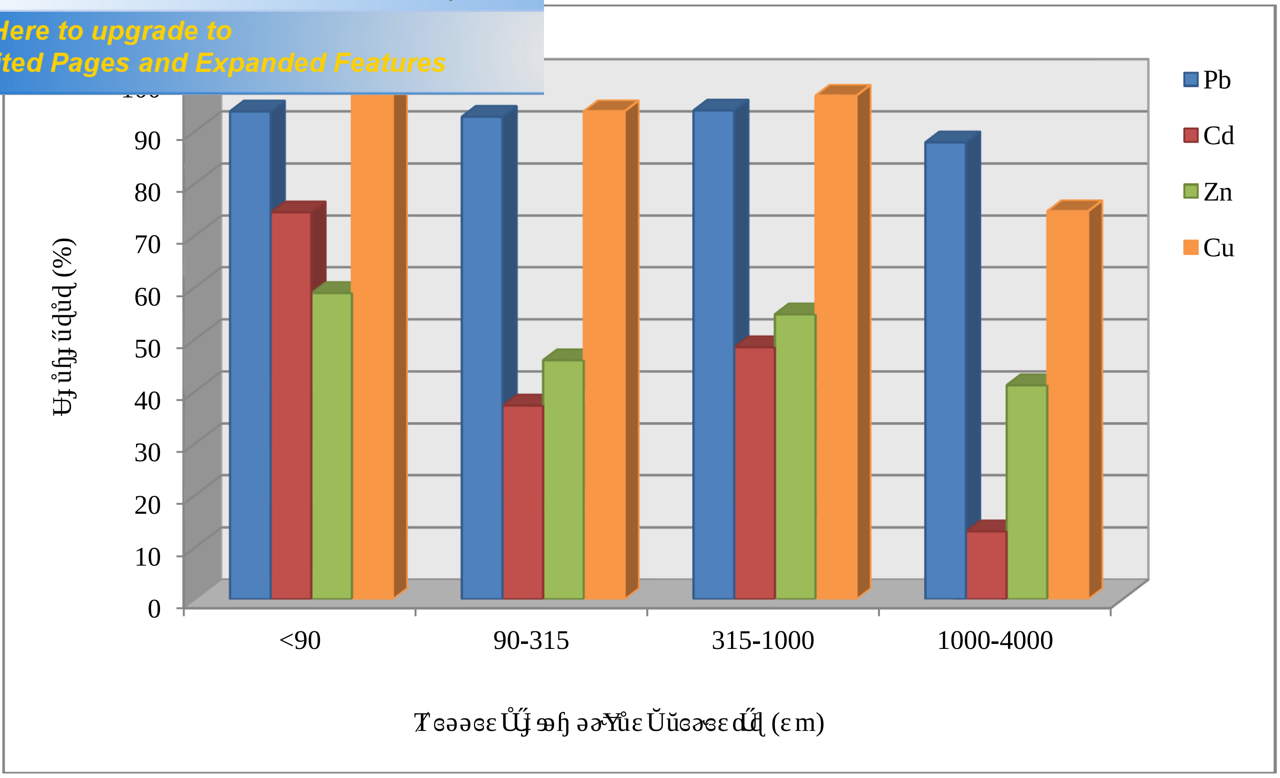
ǼǓǓƹ ´ǓǘǓ ǔǓ Ǔǔg ƐǓƽƐǂ, ǓǓǓǓ´ƽ ƽǓ ǓƽƐƐƽǓƽƐƽƽƐǓǓƽƳ ƽƽƳǔƐǓǓ Ǔǔg ǔƹƽƐƐǓǓ, ǔǓƽǓǓ <90 ƐM, 90-315 ƐM ƽǓ 315-1000 ƐM, ǔgƽƽǉǓǓǂƹ ǔǓ´Ɛƽǂ gǉǓƽƳ´ƐǔƐǔǓ, ´ǓǘƐg 99%, ǓǓ ǉƹǓǓ Ǔǔg ƐǓǓƽƽƐg. ǉ ƹǓǓǓǓ, Ǔ ƽƐƽƽƐǓǓǓǓ 1000-4000 ƐM ǓƐǘǓƹƐƽǓ ´Ɛƽǂ ǔƽǓǓƐǉǓǓƽ ǔgƐ´ǓǓǘƐǉƳ, ƐǓƽǓǓƽǉƳǓǓǔǓ Ǔǔg ƐǓǓƽƽƐg ǔǓǓǓ ǘ ǓǘǓǓǔg 66%. ǿƐ pH Ǔǔg gǔǓǓƽƐǂ ǔƽǓƽǂ ƐǓǓǓ ǂǔǓǓǓ Ǔ Ǔ ǉ ǓǓƹ ǔƽǓƽǓǔǓ ǓǓƹƳƹǓǓǓ ǔǓǓƐƳǓ´ƽǓǔƐƹ Ǔǔg 6-7 ǓǓǓ ƽƽƐǓǓǓ Ǔǔg pH ǓƹǓǓǓ ǓǓ ƐǓǓǓƐǓǔǓǓǓƹǓƹ Ca ƽǓMg Ǔ ǉ Ǔǔ ǔƹƽƐƐǓǓ ǔǓǔ ǔƽƳƽgƐǓ.

ǉ ´ǉ ǓǓǔǓǓƐƐƳǓǓƹ ƟƽƳƽƳƹ 3.12 ƳƳǓ 3.15 ´ǓǉǓǓǉ ǓǓǓƽǉǓƽƹǓƽƳƐ ǔƹƽƐƐǓǓǓƽǓǓƽǉǓǓ ǓǓ ǉƹǓǓ ƐǓƽƐǂ ǔǓƐǓǓƽǂ ǓǓǓ´ƐǔƐǔǓ, ǓƽƐƽƐgǓƐǂ ƹ ǓǓ ƐǓǓƽƽƐƽǓǓǉƹǓǓ ƽǓǓƐƐg, ǓǓ ƽǓǓǉƹǓǓ ƳǓǔǓǓƽǂǉƐg, ǓƹǓ ǓǓ ƐƐǓǓ ǔǓ Ǔǔg ƐƐƽǂ ǔǓƐg ǓƐǘǓƹƐǓǓ ǓǓƹ Ɛƽǉ ǉǓǓǓǓ Ǔ ǉǘƐǔǓ.

[illegible] 3.16: [illegible] Pb, Cd, Zn [illegible] Cu [illegible]

[illegible] (cm)	pH [illegible]	[illegible]	[illegible] (%)
		Pb	
<90	6,77	28,12	93,74
90-315	6,64	27,81	92,70
315-1000	6,68	28,18	93,92
1000-4000	6,43	26,33	87,78
		Cd	
<90	6,77	22,31	74,36
90-315	6,64	11,16	37,20
315-1000	6,68	14,52	48,40
1000-4000	6,43	3,90	13,00
		Zn	
<90	6,77	352,8	58,80
90-315	6,64	275,4	45,90
315-1000	6,68	328,2	54,70
1000-4000	6,43	246,6	41,10
		Cu	
<90	6,77	587,35	97,89
90-315	6,64	562,50	93,75
315-1000	6,68	580,50	96,75
1000-4000	6,43	447,48	74,58

[illegible] 1000-4000 [illegible] pH [illegible] 5 [illegible] 6-7, [illegible].



Ꜳ℮ ђзǓ 3.25: ƟǗђ Ǚ εǗǕǼ Ÿ ŭǗǗєзǓ´ ɉєǗɉ ђŭďǗďǤ Pb, Cd, Zn ǝǕǼ Cu Ǔ ђ ´ єǝǥεǗǗǼǝ ђ ǥǗǗǕǼ ђ ŭǝŸǝǥεǓ ǗǗŭєǝεďǗ ǗǗǗǗďǗ ǥǗǥзďǝǗǤ ǥ´ ђ ǗǕŸǗǥǗď.

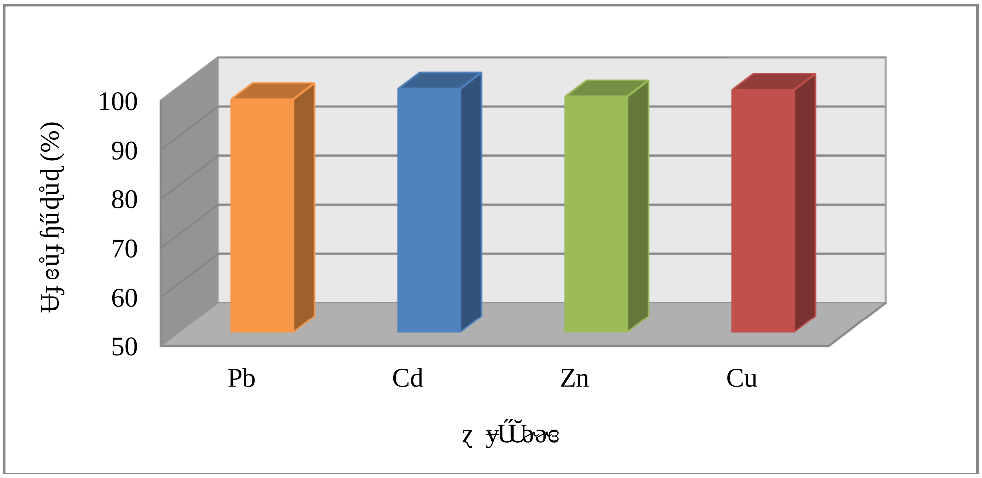
ɉ зǕǝǥǗǼ ђǗǗ Ǔ, є εђǝǥ ǗǗǤ´ ɉєǗɉ єŭŸǗǗǼ ǗǗ´ єǗєǗǗђ 93-94% ɔǝǓ ǗǗ ǝǗ ǗђǝєǝǓ ǝǝŸǗεǗǗ, Ǖι Ǘ ´ єǗєǗǗђ ǗǥǗђ εǗι зǗǗǼ ǗǗ 88% ǗǗ єзǗɉђǝєǝє ǝǝŸǗεǓ. Ƀ ŭєǝεďǗǤ ŭǝǗǗɉ ǗǓ Ǘ ά ǗǗǓ ǗǥɔǝɉŸǗǗďǤ Ǘǥ ǤǗǝєɨ ´ ǝďǗєз Ǘǥ 94-98% ɔǝǓ Ǘǥ εǝɉ ђǗǗ ǗǤ ǝєǝєεǗǗďǗ, ǗǓǕǗďǗďεǗǗз εǗǓǗɨ ǗǗ ď ǝєǝєεǗǗďǓ ǗǗз є´ єďǓ Ǘ ´ єǗєǗǗђ ŭďŸǗǗ 75%. ¢є ǝŸǗε ɔǝǓ ǗǤ ǝєǝєεǗǗďǗǤ <90 εm, 90-315 εm ǝǗ 315-1000 εm ´ ɉєǗɉєŭŸǗǗǝǗǗŸ 74%, 37% ǝǗ 48%, ǕǗǗǗєǤǓ, Ǖι ɔǝǓ Ǘз ǝєǝєεǗǗďǓ 1000-4000 εm, ď ´ ɉєǗɉ ђŭďǗď Ǖɔє ǗǗ 13%. ŭǝǓ Ǘз γǗǥŭŸɔǥɉє Ǘ Ǘ ά Ǘє ǝǗǗɉ ŸǗǗɐǤ Ǘǥ Ǔ ђ Ǘ ŭєǝεďǗ ǗǗ 59%, 46%, 55% ǝǗ 41% ɔǝǓ ǗǗ ǝǝŸǗε ǗǗ <90 εm, 90-315 εm, 315-1000 εm ǝǗ 1000-4000 εm, ǕǗǗǗєǤɣ ǥ. ¢ εǝɉ ђǗǗ ď ´ ɉєǗɉєŭďǗǝε ǝǗђǗďǗǗ ǗǗ єзǗɉђǝєǝє ǝǝŸǗε Ǔ, ´ ǝďǗι ǥ, зǓ єŭǗǝǗǗǗǗ ǗǗď εǝɉ ђǗǗ ď Ǔ ŭŸзǗǓ Ǔ ǗǗɐǥ. ŭǗǝђǗǗ Ǔ, ε´ єɉǗ зǓ ǗǕǤǗǗɣ ǥǗǥε´ ɉ ǗεǓ ď ´ ɉєǗε ђǗǗ ď ´ ɉєǗɉ ђŭďǗď Ǘǥ εєɨ бǗєǥ ǝǗ Ǘǥ ǤǗǝєɨ ǗǗǗɔǝɉ ǗǗ ď εǗ Ǘ ǝŸǗε ǝǗ Ǘз γǗǥŭŸɔǥɉє ɔǝǓ ђǝǓ ǗǗ ǝєǝєεǗǗǝŸ ǝǝŸǗε ǗǗ εǗ ǗǗɉ Ÿ ǝǗǗɉ ŸǗǗďǤ Cu>Pb>Zn>Cd.

ƐǗ ǗďεǗ ǗǥǗђ ǕɔǗ зǓ ǕǗǗǗďǗď ŭǝǗєɉ ǗǗε ǗǥǗ´ Ǘŭєɉ Ÿ Ǘз εǗǗŸǝɣз ђǗǗ ǗǥǗŸ бɉ ǗǝєзǗǗǗǗ´ єǝǥεǗǗǝǝ ђ ´ Ǘ ŸǝєзǗǗђǗǗ ´ Ǘ єзǗǗɣ ǥεзǗǗŸ ǗǥǗǗǗŸ ǗǗǥǗǗǝ ђ ŭǝŸǝǥεǓ. ƐǗз ´ ɉι Ǘ ´ Ǘ ά Ǘ Ǘď, ђ´ ɣ ǥ ´ ɉєǗǕǗɉďďǝǗ ď ´ ɉєǗɉ ђŭďǗď Ǘǥ εєɨ бǗєǥ ǝǗ Ǘǥ ǤǗǝєɨ Ǘǥзє ǗǗǗǗǗǗŸǝ бǗɛђ ǗǗǗєǗď εǗǗǥǗ Ǘǥ ǝǗεєǥ ǝǗ Ǘǥ γǗǥŭǗɔɨɉєǥ. Ꜳ´ ǝďǤǝǗ ď ǝєǝєεǗǗďǓ ŭǗǗǗǗз Ǘ Ǘ ďɉ ǗŸǗ ´ Ǘ ǝǗђǗǗє Ǘ ŭǗђєǗє, εǗǗ ǝǗ ǗђǝєǝǓ ǝǝŸǗε ǗǗ зǓ ´ ǗєǥǗŸєǥз ´ єɨ ǝǗɨ ǗǗ ď ´ ɉєǗɉєŭďǗǝε ǝǗђǗďǗǗ Ǔ ђ Ǘ єзǗɉђǝєǝє ǝǝŸǗε Ǔ Ǘз 1000-4000 εm, ǗǗ є´ єє ´ ǗǗǗɉ ǗǗǗ ǗǝǗďεǗ Ǘ εǗ Ǘď Ǘǥ ´ єǗєǗǗɨ ǝǗǗɉ ŸǗǗďǤ. ɉ ´ ђ Ǘз Ÿǝď ´ ǝǗɉ Ÿ, ǗǗз ´ Ǘά Ǘ Ǘď Ǘз εєзєǗǗǝι з ŭǗǥŸǗз, ǗǗ Ǘ ά ǗǗǓ ´ ɉєǗɉ ђŭďǗďǤ Ǔ ђ Ǘ ŭєǝεďǗ ŭǗǗǗǗзǓ ǗǗɉǝǗǗŸ γγďǝŸ ɔǝǓ ђǝǓ ǗǗεɣǗǗǝǓ ǝǗзǓεďз ŭǝǗєɉє´ єɨ зǗǗεǗбŸǗď Ǘз ǝєǝєεǗǗďǓ.

ฺ ɞɜɞɛŮŰɓəɘɧ ŭɁŶəɡɛŮPb, Cd, Zn əŰɁCu

ŦœŬɁŮɡ 3.17: ŦŮǉ ŬɛŬŰɁŶŭŮɪɛɤɁŮ´ɟɞůɟɧŭɖůɖɡPb, Cd, Zn əŰɁCu Ů ɧ ɛɞɜɞɛŮŰɓəɘɧ ɡŭŮɁɧ ŭɁŶəɡɛŮ Pb, Cd, Zn əŰɁCu, ŬɁŰůŰɁɞŬ, ůŰŭɞəɞɛɁɁɧ ɛŶɟɛŮɟɞ ůŮůŰɖŮɤɡůɡɜɖəŮɡ´ ɧ ŬɁŶŮɡůɖ.

ฺ ɤŰɁəɞ	Ɗɞəɞɛ ŮɟɁɧ əəŶůɛŮ (ɛm)	$pH_{ŭɁɖɖɛŬɡ}$	Ʉɟɞůɟ ɧŭɖůɖ (ɛg ɛŰŶəɞg/g ŭɞəɞɛɖɖ)	Ʉɟɞůɟ ɧŭɖůɖ (%)
Pb	315-1000	9,90	29,25	97,50
Cd	315-1000	9,74	29,89	99,64
Zn	315-1000	8,91	588,30	98,05
Cu	315-1000	8,48	596,44	99,41

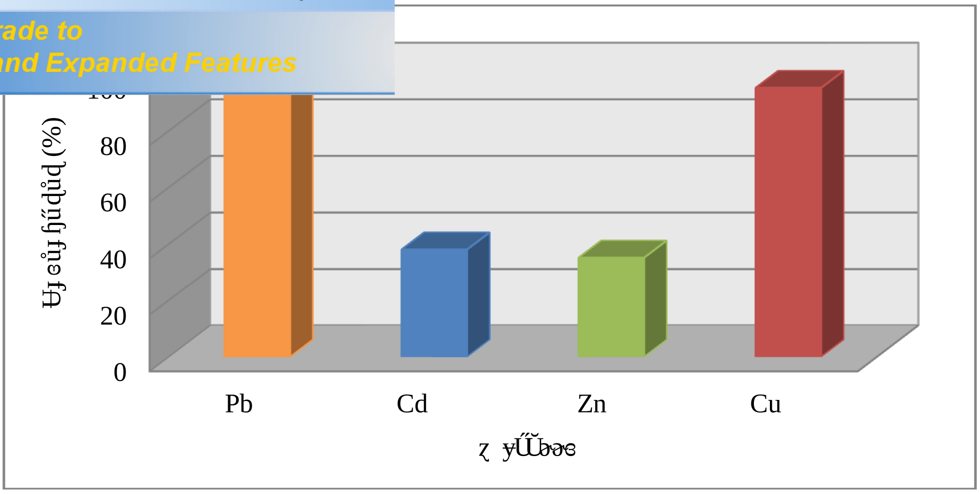


ƀəɧɜŮ 3.26: ŦŮǉ ŬɛŬŰɁŶŭŮɪɛɤɁŮ´ɟɞůɟɧŭɖůɖɡPb, Cd, Zn əŰɁCu Ů ɧ ɛɞɜɞɛŮŰɓəɘɧ ɡŭŮɁɧ ŭɁŶəɡɛŮ Pb, Cd, Zn əŰɁCu, ŬɁŰůŰɁɞŬ, ůŰŭɞəɞɛɁɁɧ ɛŶɟɛŮɟɞ ůŮůŰɖŮɤɡůɡɜɖəŮɡ´ ɧ ŬɁŶŮɡůɖ.

ฺ ɞɜɞɛŮŰɓəɘɧ ŭɁŶəɡɛŮPb, Cd, Zn əŰɁCu

ŦœŬɁŮɡ 3.18: ŦŮǉ ŬɛŬŰɁŶŭŮɪɛɤɁŮ´ɟɞůɟɧŭɖůɖɡPb, Cd, Zn əŰɁCu Ů ɧ ´ɞəɡɛŰɓəɘɧ ɡŭŮɁɧ ůŮ ŭɞəɞɛɁɁɧ ɛŶɟɛŮɟɞ ůŮůŰɖŮɤɡůɡɜɖəŮɡ´ ɧ ŬɁŶŮɡůɖ.

ฺ ɤŰɁəɞ	Ɗɞəɞɛ ŮɟɁɧ əəŶůɛŮ (ɛm)	$pH_{ŭɁɖɖɛŬɡ}$	Ʉɟɞůɟ ɧŭɖůɖ (ɛg ɛŰŶəɞg/g ŭɞəɞɛɖɖ)	Ʉɟɞůɟ ɧŭɖůɖ (%)
Pb	315-1000	7,73	29,15	97,16
Cd	315-1000	7,73	11,40	38,00
Zn	315-1000	7,73	210,60	35,10
Cu	315-1000	7,73	570,82	95,14



[illegible] 3.27 : [illegible] Pb, Cd, Zn [illegible] Cu [illegible]

[illegible] 97-99% [illegible] Cd>Cu>Zn>Pb. [illegible] 99%, [illegible] 98%, [illegible] 97%. [illegible] Pb, Cd, Zn [illegible] Cu [illegible] 97% [illegible] 95%, [illegible] 38% [illegible] 35%, [illegible] pH [illegible] 8-10 [illegible] 7-8 [illegible] Ca [illegible] Mg.

3.3.1.3 [illegible]

[illegible] pH=5. [illegible]

[illegible] n [illegible] Cu [illegible] 95%, [illegible] Cu>Cu>Zn>Pb, [illegible] 315-1000 [illegible] Cd>Cu>Zn>Pb. [illegible] 1000-4000 [illegible] Cu [illegible]

[illegible] Cu>Pb>Zn>Cd [illegible] Pb>Cu>Cd>Zn. [illegible] 1000-4000 [illegible]

[illegible]:

I. [illegible]

II. [illegible] [15].

[illegible] Ca [illegible] Mg [illegible] [15,20]. [illegible] [19,98]. [illegible] [15].

ε୨Ű๏ଈi εŬյεŶյεg

3.3.2.1 ʉŮყ ŬεŬŰ๏ᴇ ŭ୨Ŭű୨Ŭůɗ Ŭ

¢ Ů๏´ ǝgůɛɧŰďŰŰ Ű๏g ŭɕǝɕε୨Ű๏ɕi Ŭůɓůűųǝďɕg ǝŬ๏Ű๏g ŭɕǝɕε୨Ű๏ɕi εŬյεŶյɕg εŮ๏ŰŰŶŰŰ๏ůŮ ůŰŰďŮɥɏ ůgɜďɐǝŰɏ εɥůɤ Ŭ๏Ŷŭŭgůď. ¢ ´Ůყ ŬεŬŰ๏ᴇ ŭ୨Ŭű୨Ŭůɗ Ŭ Űďɏ Ů๏´ ǝgůɛɧŰďŰŰɏ ´Ůյ୨Ŭεɓ ŶɜŮ๏ Űďɜ Ŭ๏Ŷŭŭgůď ´ɕůɧŰďŰŰɏ ŭɕǝɕε୨Ű๏ɕi Ŭůɓůűųǝďɕg ´ɕg ɥɕŮ๏ g´ɕůŰŰů ´յɕůյɧűďůď εŮŰŶǝǝɤɜ ůŮ ´յɕǝŬďɕյ୨ůεɥɜŮɏ ůgɜďɐǝŮɏ. ¢ ŭ୨Ŭű୨Ŭůɗ Ŭ ´յŬɓεŬŰɞ´ɕ୨ŭŰŰɟ Ŭ๏ŭŬ๏Ű๏Ŷ, ůŮ Ů ๏୨Ŭ๏εɥɜŬ ǝɕǝǝɕεŮŰյ୨Ŷǝǝ୨ŶůεŬŰŰ Űɕg ´յɕůյɕűďŰ๏ɕi gǝ୨ɕi ɔ୨ŬŰŰ ŭ୨Ŷűɕյ Ŭŭ୨Ŭ๏i εŬŰŰ Űɤ ɜ εŮŰŶǝǝɤ ɜ.

ʉɑŬ๏Ŭɏ 3.19: ȾɕǝǝɕεŮŰյ୨Ŷǝǝ୨Ŷůε ŬŰŰ Űɕg ŭɕǝɕεďŰď ǝŬ๏Űɕg ŭɕǝɕε୨Ű๏ɕi εŬյεŶյɕg ɔ୨ŬŰď εŮ๏ɥŰď Űďɏ Ů๏´ ǝgůɛɧŰďŰŰɏ

ɕ୨Ŷǝgε Ŭ	Ⱦɕǝǝɕε Ůŭյ୨ɧ ǝǝŶůε Ŭ ŭɕǝɕεďŰď (εm)	Ⱦɕǝǝɕε Ůŭյ୨ɧ ǝǝŶůε Ŭ ŭɕǝɕε୨Ű๏ɕi εŬյεŶյɕg (εm)
ɀ ɕɜɕεŮŰŰ๏ǝǝ୨ɧ ŭ୨Ŷǝgε Ŭ Zn	< 90	315-1000
ɀ ɕɜɕεŮŰŰ๏ǝǝ୨ɧ ŭ୨Ŷǝgε Ŭ Cu	1000-4000	
ɀ ɕɜɕεŮŰŰ๏ǝǝ୨ɧ ŭ୨Ŷǝgε Ŭ Pb	< 90	
ɀ ɕɜɕεŮŰŰ๏ǝǝ୨ɧ ŭ୨Ŷǝgε Ŭ Cd	1000-4000	
ʉɕǝgεŮŰŰ๏ǝǝ୨ɧ ŭ୨Ŷǝgε Ŭ Zn, Cu, Pb,Cd	315-1000	

ʉ୨ Ŭ๏Ŭ๏gŰ๏Ŷ, ď ´ɕůɧŰďŰŰ Űɕg ŭɕǝɕεďŰď ɐ Űɕg ŭɕǝɕε୨Ű๏ɕi εŬյεŶյɕg (5 g), ´ɕg ɥɕŮ๏ ´ŮյŬ๏ďűďŮűi ůŰŰյŬ Ŭ ɧ Űď ŭ୨Ŭű୨Ŭůɗ Ŭ Űďɏ ´յɕůյɧűďůďɏ Ŭ๏Ŭε୨ɜi ŮŰŰ๏ εŮ 30 ml Ŭ ୨ɜɜ୨ůεɥɜɕg ɜŮɕi. ƐŰď ůgɜɥɕŮ๏Ŭ, Ű๏ ŭ୨Ŷǝgε Ŭ gűɑŰŰŰ๏ Ŭ๏Ŷŭŭgůď ɔ୨Ŭ ɕյɕɜ୨ɧ ŭ୨Ŷůŭďε Ŭ 1 h εŮ ŰŰɕi ŰďŰŰ ´Ůɑ ɕg 400 rpm ǝŬ๏ůŮďŮյεɕǝյŬůɗ Ŭ´Ůյ୨ɓŶǝǝɕɜŰ๏ɏ (20-25 ^{o}C). ȼ ďɜ Ŭ๏Ŷŭŭgůď Ŭ๏ɕǝɕgďŮűŭ୨ďďůď. ȼ ɕ ´յɕǝi ´Ű๏ɜ ŭ୨ďďεŬ Ŭ๏Ŭ๏i ŮŰŰ๏ εɥůɤ ū ŬůεŰ๏εŮյďŰɏ յ ´Ű๏ε୨ɐgɏ յ ´ɕյյɧűďůďɏ, ɩ ůŰŰ ɜŬ ´յɕůŭ୨յ୨ɗďŮűď ůgɔǝɥɜŮɤ ůď Űɤ ɜ εŮŰŶǝǝɤ ɜ ůŰ๏ ŭ୨Ŷǝgε Ŭ, ǝŬ๏ Ű๏ ůŰŰյ Ůɧ ɜďյ Ŭ๏ŮŰŰ๏ ɔ୨Ŭ 1 h ůŮ ďŮյεɕǝյŬůɗ Ŭ 100 ^{o}C, ɩ ůŰŰɜŬ Ŭ ɕεŬ๏յ gɜďŮűď gɔյŬůɗ Ŭ.

3.3.2.2 ʉŮყ ŬεŬŰ๏ Ŷ Ŭ ɕŰŰ๏ɥůε ŬŰŰ ǝŬ๏ůɕɕǝ୨Ŭůεɧɏ

Ɖ ´ɕůɕŰ๏ɧɏ ´յɕůŭ୨յ୨ůεɧɏ Űďɏ Ů๏´ ǝgůɛɧŰďŰŰɏ Űɤ ɜ εŮŰŶǝǝɤ ɜ ɔɑŰŰ๏ εŮ ŰűŮյεɕɔɐ Űďɏ ůɕɥůďɏ.

$$\% \text{ ǝ´ǝgůɛɧŰďŰŰ} = \frac{[illegible]}{[illegible]} \times 100$$

ɧ´ɕg

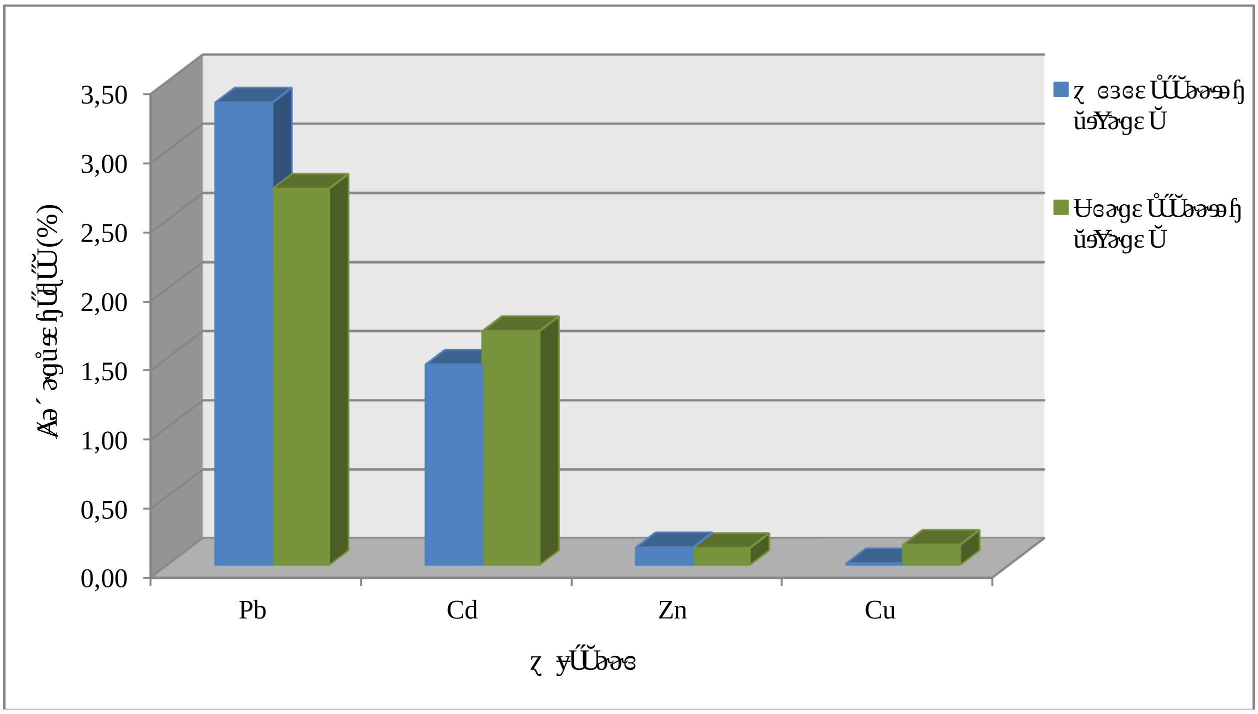
m_e : ď εŶɕ Ŭ Űɕg εŮŰŶǝǝɕg ůŰďɜ ´ɕůɧŰďŰŰ Űɕg ´յɕůյɕűďŰ๏ɕi εɥůɕg (5 g), ´ɕg ɥɕŮ๏ ´ŮյŬ๏ďűďŮűi ůŰŰյŬ Ŭ ɧ Űď ŭ୨Ŭű୨Ŭůɗ Ŭ Űďɏ ´յɕůյɧűďůďɏ ɔ୨Ŭ Űď εŮ๏ɥŰď Űďɏ Ů๏´ ǝgůɛɧŰďŰŰɏ ůŬ mg

m : ď εŶɕ Ŭ Űɕg εŮŰŶǝǝɕg ůŰ๏ ŭ୨Ŷǝgε Ŭ´ɕg ɥɕŮ๏ ´ŮյŬ๏ďűďŮűεŰŰŶ Űďɜ Ů๏´ ǝgůɛɧŰďŰŰ mg.

¢ εŮ๏ɥŰď Űďɏ Ů๏´ ǝgůɛɧŰďŰŰɏ ɥůɤ ůŬŰŰ ´ŮյŬ๏Ŷɤ Ŭ ɕŰŰ๏ɥůε ŬŰŰ.

ตารางที่ 3.20: Ѧҙ´ҙgůѣ ђŰďŰŰ ε ŰŰŸҙҙϒ з Pb, Cd, Zn ҙŬъCu ůŮεєзєεŰŰъҙҙђ ҙŬъůŮ´єҙgεŰŰъҙҙђ ŭэŸҙgεŬŬ ђ ŭєҙєε ďď ´єg ұєŬъg´єůŰŰď´ɟєůɟ ђűďůď g´ђ ůŰŰďŰɟ ұďůgзďєҙŬď

ʐ ұŰŰъҙє	Ѧҙ´ҙgůѣ ђŰďŰŰ (%)	
	ʐ єзєεŰŰъҙҙђ ŭэŸҙgεŬ	Ʉєҙgε ŰŰъҙҙђ ŭэŸҙgεŬεŰŰŸҙҙϒ з
Pb	3,35	2,73
Cd	1,45	1,69
Zn	0,13	0,12
Cu	0,01	0,15



Ѧҙђзŭ 3.28: Ѧҙ´ҙgůѣ ђŰďŰŰ ε ŰŰŸҙҙϒ з Pb, Cd, Zn ҙŬъCu ůŮεєзєεŰŰъҙҙђ ҙŬъůŮ´єҙgεŰŰъҙҙђ ŭэŸҙgεŬ Ŭ ђ ŭєҙєε ďď, ´єg ұєŬъg´єůŰŰď´ɟєůɟ ђűďůď g´ђ ůŰŰďŰɟ ұďůgзďєҙŬď

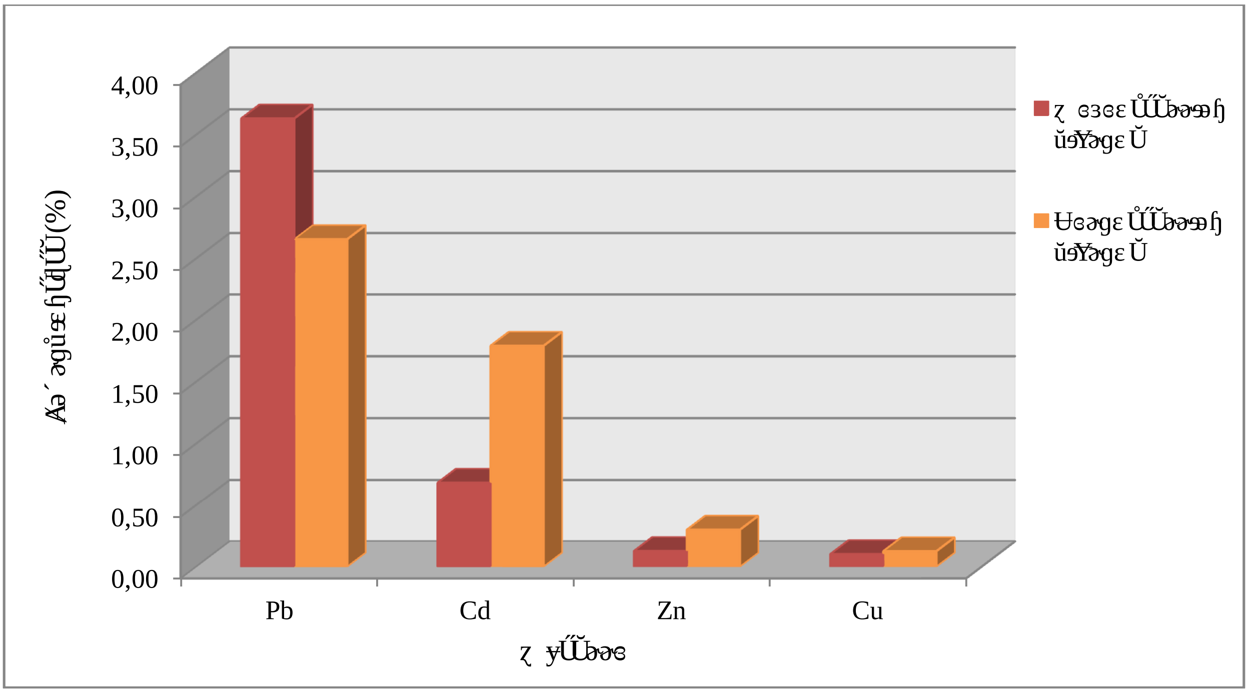
ɟ ´ђ ŰŰ ´ŬɟŬ Ÿзϒ ´ŮɟŬεŰŰъŸ Ŭ єŰŰъұůεŬŰŰ űŬъŰŰъђŰъ є εђҙgbŭєď ҙŬъŰє ҙŸůεє Ŭъ´ҙұзєзŰŰъ´Ůɟ ѕůђŰŰɟє, ŬъҙŸ ůŮεѕɟŸ Ŭз ɔұзŬъ´єůєŰŸ, ´ҙďůєз Űєg 2%, εŮŰє εђҙgbŭє зŬ Ŭ єɟɟά ŰŰŰъůŮεŬъŬъ ŰŰɟє bŬďεђ . ¢ ´ŬɟŰŰɟďůď ŬgŰŕ ŰъŬъҙєєѣ ŰђůєɔŬŰє εєзєεŰŰъҙҙђ ђůєҙŬъɔŬŰє ´єҙgεŰŰъҙҙђ gŭŬŰъђ ŭэŸҙgεŬ. ɟ ´ђ Űďз Ÿҙҙď ´ҙŰɟŸ, є ɣŰgŭŸɟɔgɟєgďҙŬъє GŬъђg Ŭεűŭзєєgз ůєŬŰђз εďŭŬзѕε Ŭъ´ҙgůѣ ђŰďŰŰ. ɟ ´ђ ŬgŰŸ ŰŰŭŰєεұзŬŬъŸŰŰъŰє ůgε´ұɟŰůεŬђŰъє εђҙgbŭєď ҙŬъŰє ҙŸůεѕ ŬъŬεұзŰŰъ ´ұɟŬз Űďď´ɟєůɟђűďůďď εұůϒ ŬъŰŰъҙŬъѣďђзŰϒ з εŮђзŰŰCa

ıůđďǵ ůŰđɜ Ů ŝűŶɜŮǁŮ, ɜŬ ǵűơůŰǁŰǁɚ ǝŬɜ űǵůɚɛ ɟɧűđůđ
ŬŰɚɟŶűđůđ Ŭ ɜ ɛŮŰŶǝɚɤ ɜ ɣŮǵŭŬɟɔɨɟɕǵ ǝŬɜ ɕŬǝɕɨ
Ů ɕuuŭŰŰɜ uŬ ɟɕɥɟɧuđuđ ɕǵu ɜ ɛɣuɤ ŭɜŰŰɚǝŬɚɛǵ ǝŬŰɧɜŬ ɜ ůŰđɜ Ů ŝűŶɜŮǁŮ Ŭ ɜ Ŭɜđɟ Ŭɚɩɩ ɜ
ǵɚɚɩ ɜ ǝŬɜŭđɛɕǵɟɔđǵŬđɟ Ŭɚɩɩ ɜ ŬɚŶŬ ɜ ɛŮůǵɛ´ɚɕɚ´ɕđůđ ǝŬɚŰŰɚɟɛɛɜɜůđ.

ɸɕɚɕɛɚŰɚɧ ɛŶɟ ɛŬɟ ɕ

ɄɕŬɚŬǵ 3.21: ʎɚ´ɚǵůɛɧűđŰŬɛŮŰŶɚɤ ɜ Pb, Cd, Zn ǝŬɜ Cu ůŮɛɕɜɕɛŮŰŬɚɚɧ ǝŬɜůŮ´ɕɚǵɛŮŰŬɚɚɧ
ŭɚŶɚǵɛŬŬ ɧ ŭɕɚɕɛɚŰɚɧ ɛŶɟ ɛŬɟ ɕ ´ɕǵ ɏɕŬɚǵ´ɕůŰɑ´ɟɕůɟ ɧűđůđ ǵ´ɧ ůŰŰđŮɟɏǵůǵɜɗɛǝŬǵ.

ʐ ɏŰŬɚɕ	ʎɚ´ɚǵůɛɧűđŰŬ (%)	
	ʐ ɕɜɕɛŮŰŬɚɚɧ ŭɚŶɚǵɛŬ	ɄɕɚǵɛŮŰŬɚɚɧ ŭɚŶɚǵɛŬɛŮŰŶɚɤ ɜ
Pb	3,63	2,66
Cd	0,68	1,79
Zn	0,13	0,30
Cu	0,10	0,13



ʎɚɧɜŬ 3.29: ʎɚ´ɚǵůɛɧűđŰŬɛŮŰŶɚɤ ɜ Pb, Cd, Zn ǝŬɜ Cu ůŮɛɕɜɕɛŮŰŬɚɚɧ ǝŬɜůŮ´ɕɚǵɛŮŰŬɚɚɧ ŭɚŶɚǵɛŬ
Ŭ ɧ ŭɕɚɕɛɚŰɚɧ ɛŶɟ ɛŬɟ ɕ ´ɕǵ ɏɕŬɚǵ´ɕůŰɑ´ɟɕůɟ ɧűđůđ ǵ´ɧ ůŰŰđŮɟɏǵůǵɜɗɛǝŬǵ.

[illegible]

3.3.2.3 [illegible]

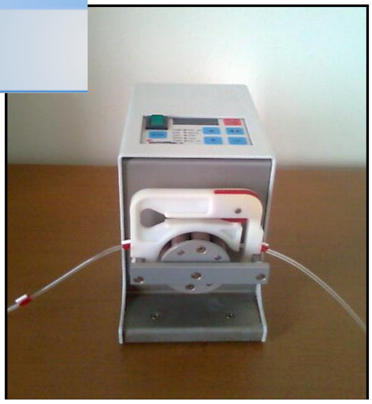
[illegible]

3.4.1 Ʊן ɕủן ɧűdủd ɛ ŮŰΎǝǝɤ ɜ Ŭ ɦ ŭɕǝɕɛdŰd, ŭɕǝɕɛ ɘŰǝɦ ɛ Ύן ɛ Ŭן ɕ ǝŬǝ ŬủɓŰủŰɕǝɘdǝɦ ɛ Ύן ɛ Ŭן ɕ ủŮủgɜŰɕŬdʃ ủgɜdɐǝŮʃ ן ɕɐʃ

3.4.1.1 ƱŮן Ŭɛ ŬŰǝɐ ŭɘŬŭǝ ŬủdŬ

¢ ŭɘŬŭǝŬủdŬ ´ ן ɕủן ɧűdủdʃ ủŮủgɜŰɕŬdʃ ủgɜdɐǝŮʃ ן ɕɐʃ ´ Ůן ǝŬɛ ɓΎɜŮǝ Űd ŭɘɏǝŮgủd gŭŬŰǝɕɨ ŭɘŬǝɨ ɛ ŬŰɕʃ Űɤ ɜ ɛ ŮŰΎǝǝɤ ɜ Pb, Cd, Zn ǝŬǝ Cu ɛɏủŬ Ŭ ɦ ủŰן ŬΎ ǝǝɷd, d ɕ ´ ɕdŬ ŮɞŬǝ ´ ǝdן ɤ ɛɏɜd ɛ Ů ǝɕɜɞ ´ ɕdɛɏɜɕ ŭɕǝɕɛdŰd, ŭɕǝɕɛ ɘŰǝɦ ɛ Ύן ɛ Ŭן ɕ ɐ ŬủɓŰủŰɕǝɘdǝɦ ɛ Ύן ɛ Ŭן ɕ ủŮǝɕǝǝɕɛ Űן dŬ <1mm. ¢ ǝǝɷd ´ ɕg ɢן dủɛɕ ´ ɕɘŰŰǝɏɢŮǝ ɨ ɣ ɕʃ 30 cm ǝŬǝ Űủɤ ŰŰן ǝɐ ŭɘΎɛŰן ɕ 5 cm. ¢ ן ɕɐ Űɕg ŭɘŬǝɨ ɛ ŬŰɕʃ ŮɞŬǝ ǝŬdɕŭǝɐ, ´ ן ɕủɕɛɕɘΎɕɜŰŰʃ ɛ Ů Ŭ gŰɦ Űɕɜ Ůן ɦ ´ ɕ Űd űgủǝɐ ן ɕɐ Űɤ ɜ gŭΎŰɤ ɜ ủŰɕ ɏŭŬŰɕʃ. B ן gdɛ ɧʃ Űdʃ ן ɕɐʃ ŮɞŬǝ ɑủɕʃ ɛ Ů 1,25 ml/min ǝŬǝ Ů ɘŰן ɔɢΎɜŮŰŬǝ ɛ ŮŰd ɢן ɐủd ŬɕŬǝdŬʃ. ¢ Ŭ Ůǝǝɕɨ ủɛŬŰŬ ´ Ůן Ŭǝ Ŭ ɛ ɓΎɜɕɜŰŰǝ ´ Ůן ǝŭǝΎ ŬɞΎ 100 ml, ɛ ŮŰן ΎŰŬǝ Űɕ pH Űɕgʃ ɛɏủɤ ´ ŰɕŬɛɏŰן ɕg ǝŬǝ gűɑủŰɞŰŰǝ ŬɞΎǝgủd ɛɏủɤ ū Űủɛ ŬŰɕɛ ŮŰן dŬʃ ן Űɕɛǝɐʃ ן ´ ɕן ן ɧűdủdʃ, ɩ ủŰŮɜŬ ´ ן ɕủŭǝן ɘủŰŰɑd ủgɔǝɏɜŰן ɤ ủd Űɤ ɜ ɛ ŮŰΎǝǝɤ ɜ ủŮ ŬgŰΎ. ҁ ŰΎ Űɕ ´ ɏן Ŭʃ Űdʃ ủgɜɕǝǝɐʃ ŭɘŬŭǝŬủdŬʃ, Űɕ ´ ן ɕủן ɕűdŰǝɦ gǝǝɦ ɕŭdɔủŰŰǝ ´ ן ɕʃ ɜɐן Ŭɞủd ủŰɕgʃ 60 °C ɔǝŬɢן ɕɜǝɦ ŭɘΎủŰdɛ Ů 24 h ɔǝŬ Űdɜ Ŭ ɕɛ Ύǝן gɜủd Űdʃ gɔן ŬủdŬʃ ǝŬǝ ´ Ůן Ŭǝ Ŭɛ ɓΎɜŰŰǝ ɔǝŬ ´ Ůן Ŭǝ Űן ן ɤ ɛ Ůǝ ɏŰd.

Ѧǝ ɦɜŬ 3.30: φǝΎŰɞd ´ ן ɕủן ɧűdủdʃ ɛ ŮŰd ɢן ɐủd ủŰן ŬΎʃ ǝǝɷdʃ.



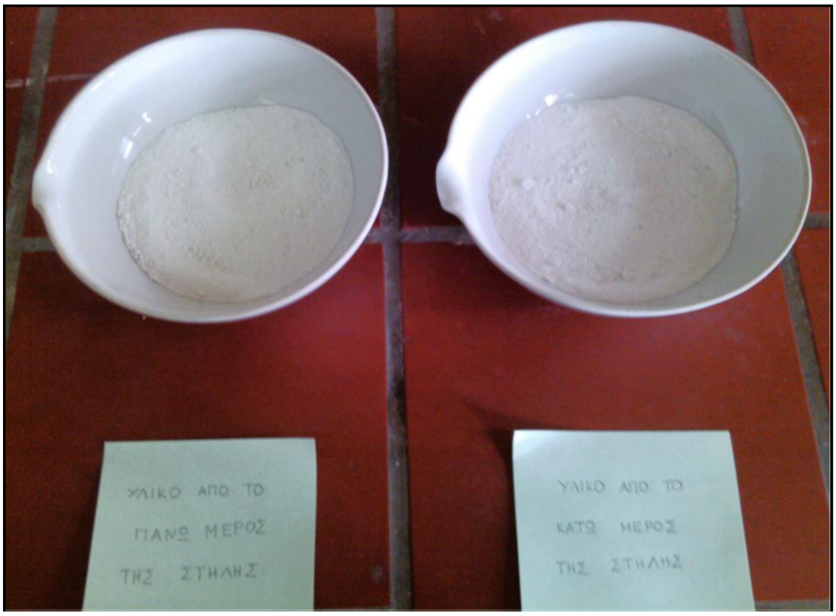
[illegible] 3.31: [illegible]

[illegible]

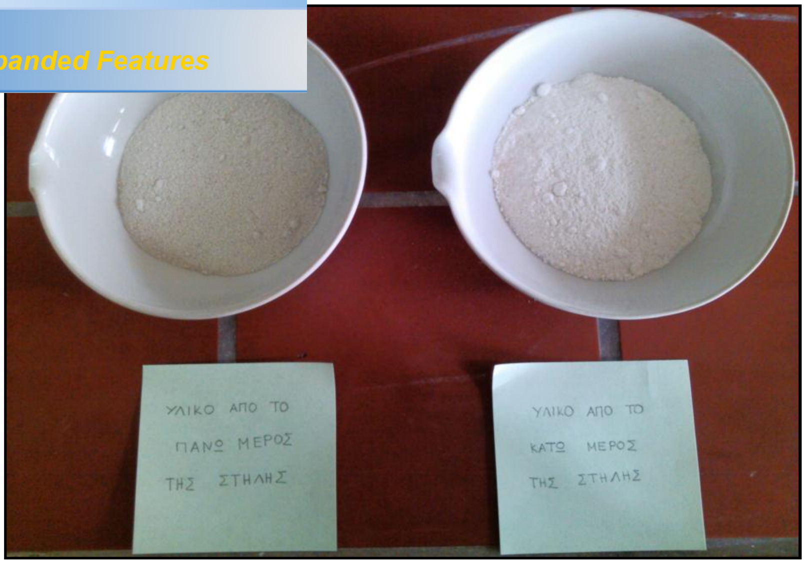
- [illegible]

- [illegible] (3.32). [illegible] 3.33 [illegible] 3.34). [illegible] (3.35). [illegible]

3.32: [illegible]


ΥΛΙΚΟ ΑΠΟ ΤΟ
ΠΑΝΩ ΜΕΡΟΣ
ΤΗΣ ΣΤΗΛΗΣ
ΥΛΙΚΟ ΑΠΟ ΤΟ
ΚΑΤΩ ΜΕΡΟΣ
ΤΗΣ ΣΤΗΛΗΣ

3.33: [illegible]



Ǽϧα ĥȝŬ 3.34: φŮǒεŬŰŰŬůϬŰůŰǾǝϭǝϭϵ εŬƫεŶɉɢ ǝŬŰĥ´ȝ Űďǥůǝ ŬŰǝŬůďŬǥŰďǥȝǝɟŬǝůďǥŬ ĥ ŰǾ Ŭǝι ŰŰƫɢ (Ŭƫ ǝůŰŰƫŶ) ǝŬǝŬŰŰ ŰŰƫɢ (ůŬǝŶ) ŰɛεεŬŰďǥǝǝǝďǥ.

Ǽϧα ĥȝŬ 3.35: φŮǒεŬůɢǝǝεďŰ ǝŬŰĥ´ȝ Űďǥůǝ ŬŰǝŬůďŬǥŰďǥȝǝɟŬǝůďǥ.

3.4.1.2 ƚŮƫ ŬεŬŰǝŶŬ ɢŰŬyůεŬŰŰǝŬǝůɢǝǝŬεĥǥ

Ƀ ´ɟɢůůǝɟǝεĥǥŰǝɢ ´ɢůɢůŰǝ ´ɟɢůɟĥŰďůďǥŰȝ ǝĥȝŰȝ Pb, Cd, Zn ǝŬ Cu Ŭ ĥ Űǝ ůǝŶǝɢεŬ ´ɟŬεŬŰǝ´ɢǝŰŰŬǝεŬŰď ϭɢɛďǝŬŰďǥůɢyůďǥ:

$$\% \text{ƚɟɢůɟĥŰďůď} = \frac{C_o - C}{C_o} \times 100$$

ĥ´ɢɡ

C_o: ď ůɡɔǝɏȝŰɟ ɣ ůď Ǔůĥůɢ Ŭȝ εŰŶǝǝɣ ȝ ůŰď ůŰŰɟ ŬŶ ǝǝǝď ůŮmg/L

C: ď ůɡɔǝɏȝŰɟ ɣ ůď Űȝ εŰŶǝǝɣ ȝ ůŰǝ ɏǝǝɢɡůεŬŰďǥůŰŰɟ ŬŶǥǝǝǝďǥůŮmg/L.

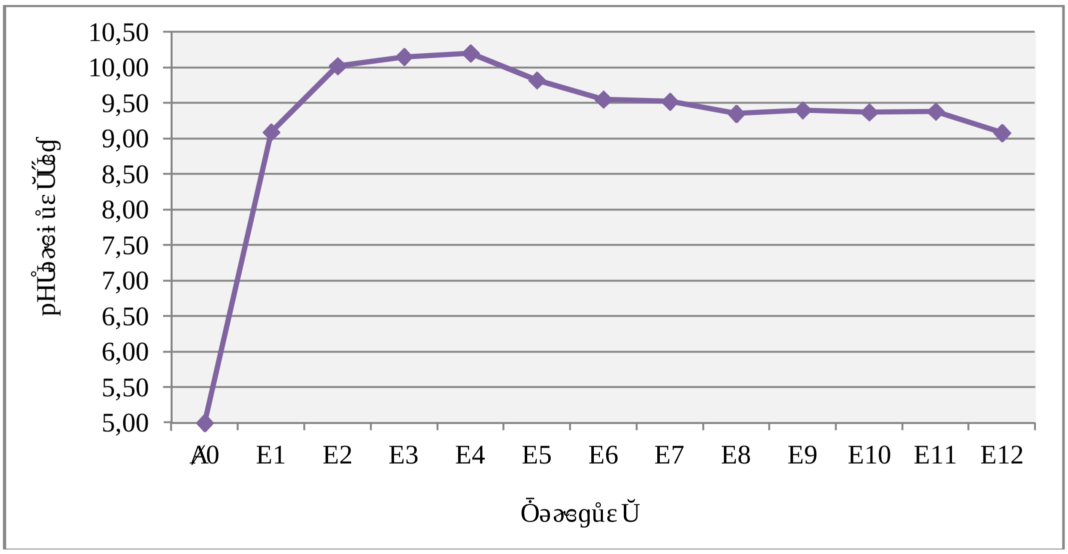
ǝı ɜ ŭŮĩɕɛ ỵɜɣ ɜ ´ ʝɕỵǝgɣ Ŭɜ ŰŬŬǝɧǝɕgďŬŬ ɕŰŮǝỵůɛŬŰ.

ợɕǝɕɛ ɗűďʃ

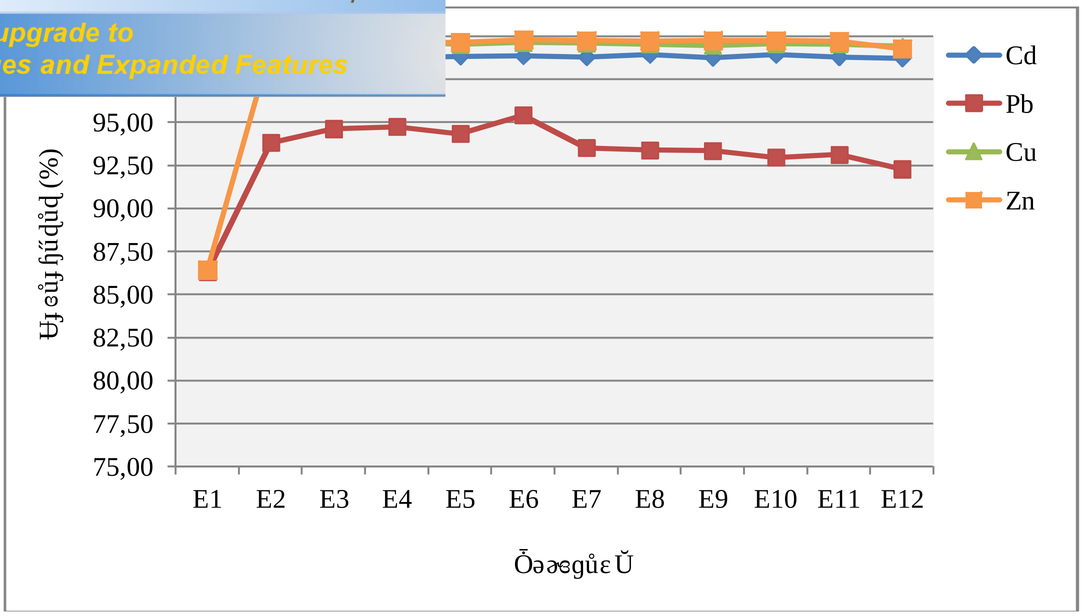
ƟɶŬǝŬďʃ 3.22: ƟŮǝ̵ ŬɛŬŰǝƔŬ ɕŰŮǝỵůɛŬŰ´ ʝɕůʝ ɧűďůďʃ Pb, Cd, Zn ǝŬǝ Cu Ŭ ɧ ŭɕǝɕɛ ɗűď ŮɜŰɧʃ ůŰʝ ŬƔʃ ǝǝɶďʃ g´ ɧ ůgɜŬɕŬďʃ ůgɜďɐǝŬʃ ʝɕɐʃ.

Ōǝǝɕgůɛ Ŭ	pH ŮǝǝɨůɛŬɕďʃ	Ưʝ ɕůʝ ɧűďůď (%)			
		Pb	Cd	Zn	Cu
Ά1	9,09	86,30	98,64	86,43	97,81
Ά2	10,02	93,82	99,06	99,33	99,52
Ά3	10,15	94,62	98,82	99,44	99,63
Ά4	10,20	94,74	98,74	99,64	99,69
Ά5	9,82	94,34	98,84	99,65	99,51
Ά6	9,55	95,42	98,86	99,80	99,63
Ά7	9,52	93,52	98,80	99,74	99,60
Ά8	9,35	93,38	98,92	99,73	99,55
Ά9	9,40	93,35	98,76	99,76	99,47
Ά10	9,37	92,96	98,92	99,74	99,55
Ά11	9,38	93,12	98,80	99,70	99,54
Ά12	9,08	92,28	98,72	99,27	99,41

ɇɕ pH Űɕg ŭǝŬǝɨ ɛŬŰɕďʃ ´ Ŭʝ ɕgůǝƔɕŮǝ ɛǝŬ ůďɛŬɜŰǝɐ Ŭ ɜďůď Ŭ ɧ Űďɜ Ŭʝ ɕǝɐ Űɕɐ 5 ůŰďɜ Űɕɐ ɛŮŰŬǝɨ 9-10. ¢ ɛŮŰŬɓɕǝɐ ůgɜŰŬǝŮďŰŬǝ Ŭ ɧ Űɕ ´ ʝı Űɕ ǝɧǝŬʃ ỵǝǝɕgůɛŬ űďƔɜɕɜŰŬʃ Űďɜ Űɕɐ 9, ɛŮǝůŰɕ´ ɕǝŮďŰŬǝɛŮŰŬǝɨ 2^{eg} ǝŬǝ 4^{eg} ŮǝǝɕɨůɛŬɕďʃ Ŭǝɔɶɕɜ ŰŬʃ Űďɜ Űɕɐ 10 ǝŬǝůŰŬďŮʝɕ´ ɕǝŮďŰŬǝɛŰŬƔŰɕ 5^{e} ỵǝǝɕgůɛŬ ǝŬɛɓƔɜɕɜŰŬʃ Űɕỵʃ ´ ǝďůɶɜ Űɕg 9,5. ¢ Ɣɜɕŭɕʃ Űɕg pH ɕűŮǝŮŰŬǝ ůŰďɜ ŮǝůŬǝɣ ɔɐ Ca^{2+} ǝŬǝ Mg^{2+} ůŰɕ ỵǝǝɕgůɛŬ, ʄɜŰŬ´ ʝɕŮʝ ɕɧɛ ŬɜŬŬ ɧ Űďɜ ŭǝƔǝgůď Űɕg ŭɕǝɕɛ ɗűď.



Άǝ ɧɜŬ 3.36: pH Ůǝǝɕgůɛ ƔŰɣ ɜ ´ ʝɕůʝ ɧűďůďʃ Pb, Cd, Zn ǝŬǝ Cu Ŭ ɧ ŭɕǝɕɛ ɗűď ŮɜŰɧʃ ůŰʝ ŬƔʃ ǝǝɶďʃ g´ ɧ ůgɜŬɕŬďʃ ůgɜďɐǝŬʃ ʝɕɐʃ.



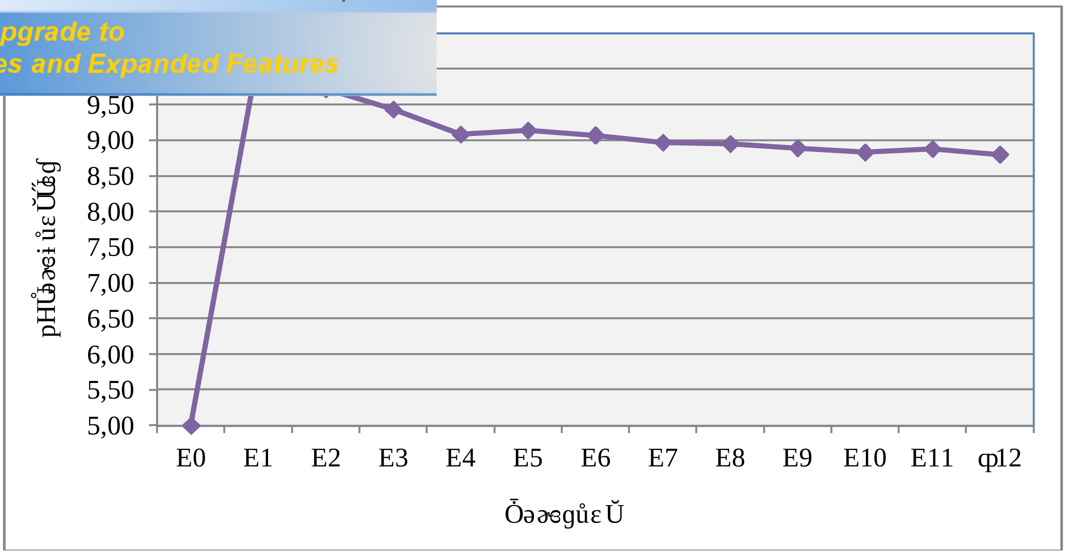
Άəɑɧɜ Ǔ 3.37: Ꞓɟɕůɟ ɧűɖůɖ (%) Ǘɤ ɜ ɛǕŸǝɚɤ ɜ Pb, Cd, Zn əǓɜ Cu Ǔ ɧ ŭɞǝɛ ɗű ǓɜǗɧɠ ůǕǘ ǓŸɠ əɚɒ ɖɠɡ ´ ɧ ůɡɜǗ ůɡɜɗ əǗɟ ɕɡ.

ӯ ´ ɣ ɠ űǓɒǕǕɜ əǓɜ Ǔ ɧ ǕǓ ůǗɜ ǓǗɡ ꞒɒǓɜ Ǔ 3.22, ɕ ŭɞǝɛ ɗű ɠ əǕǕɜ ɟ ǓŸ Ǖ ɛɣǕǕɜəǓ Pb, Cd, Zn əǓɜ Cu ůǓ ɘǓɜ ɕ´ ɕɗǗɜ ɧǕǕɜ ɓǓɗɛ ɧ. ɇǓ ɓɣɚǗɜ ůǕǓ Ǔ ɕǕǕɜɣů ɛǓǕ ´ ǗɟɕɡůɘŸɕɡɜ ɕ ɣ ǗɡŭŸɟ ɔɡɟ ɕɡəǓɜ ɕ ɕǓɜɧɡǓ ɑ ǗɫǓ ůɡɔəɟ Ÿǘɖůɖɡ ´ əɗůɞɜ Ǘɡ 99-100% əǓɜ Ǔɜɕəɞɡɗǘɑ Ǘɜ əŸűɛɞ ɛǓ 98-99% əǓɜ ɕ ɛɧɚɡɓŭɕɡ ɛǓ 93-95%. Ά´ ɑɖɡ, ɛɣůɤ əǓɜ Ǘɖɡ Άɑɧɜ Ǘɡ 3.37, ´ ǓɟǗɟ ɟǗǕɜ ɛǓɜ ůǗɜ ´ ɕɑɖůɖ əǓɜ ůǕǘ ǓɟɕÓ ɕɑɖůɖ Ǘɖɡ əǕǕɜɟ Ÿǘɖůɖɡ Ǘɤ ɜ ɛǕŸǝɚɤ ɜ Pb, Zn əǓɜ Cu Ǔ ɧ Ǘɜ ŭǗ ǗɟɕŭǓɒɛǓ, ŭɖəǓɞ ůǗɡ 4 ´ Ǘɟ ɑɕɡ ɩ ɟ Ǘɡ, əǓɛ ɓŸɜɕɜǕǕɡ ɡ´ ɧɣɖ ɧǗɜ ɖ ɟɕɞ ǓɜǓɜ ɑɖ ɛǓ 1,25 ml/min. To əŸűɛɞ, ǓɜǗɖǕǕ, ŭǗɜɜǗɜɜǓ ǓɜǕǓ ɕəɟɒǕǕɜɛǓǗɜ ɓɣɚǗɜůǗɜ Ǘɟ ɧ´ ɕ Ǔ ɧ Ǘɜ ´ɟɩ Ǘɜ əɧəǓɡ ŭǓɒɛǓ.

ɋɜəɕɛ ɘǗɜɧ ɛŸɟ ɛǓɟ ɕ

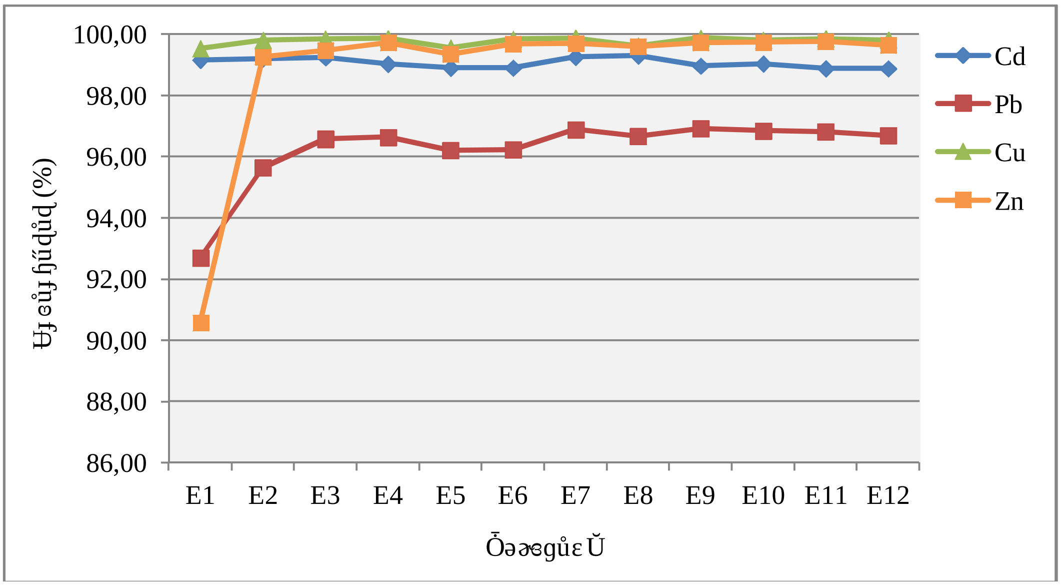
ꞒɒǓɜ Ǔɡ 3.23 : ꞒǗɟ ǓɛǕǕɜŸǓ ɕǕǕɜɣůɛǓǕ ´ ɟɕůɟ ɧűɖůɖɡ Pb, Cd, Zn əǓɜ Cu Ǔ ɧ ŭɞǝɛɘǗɜɧ ɛŸɟ ɛǓɟ ɕ ǓɜǗɧɡ ůǕǘ ǓŸɡ əɚɒɖɡɡ´ ɧ ůɡɜǗɜɡ ůɡɜɗəǗɟ ɕɡ.

Ōəɚɕɡůɛ Ǔ	pH	Ꞓɟɕůɟ ɧűɖůɖ (%)			
		Pb	Cd	Zn	Cu
A1	10,21	92,69	99,16	90,58	99,53
A2	9,72	95,64	99,21	99,27	99,81
A3	9,43	96,58	99,24	99,48	99,85
A4	9,08	96,64	99,03	99,73	99,86
A5	9,14	96,21	98,90	99,34	99,56
A6	9,07	96,23	98,90	99,69	99,84
A7	8,97	96,89	99,26	99,71	99,88
A8	8,95	96,67	99,30	99,60	99,62
A9	8,89	96,92	98,97	99,73	99,88
A10	8,83	96,85	99,04	99,74	99,81
A11	8,88	96,82	98,88	99,76	99,86
A12	8,80	96,70	98,88	99,65	99,82



Ꜷɘ ɧɜŬ 3.38: pH Ủɚəɞgůɛ ŶƯɤ ɜ ´ɟɞůɟ ɧűɖůɖʆ Pb, Cd, Zn əŬɘ Cu Ŭ ɧ ŭɞəɞɛɘŰɘ ɧ ɛŶɟ ɛŬɟɞ ŮɜŰɧʆ ůŰŮɟ ŮŶʆ
əɚɞɖʆ g´ ɧ ůgɜŮƐŮʆ ůgɜɖɐəŮʆɟ ɞɐʆ.

ȾŬɘ ůŰɖɜ ´Ůɟ ɑ Űɤ ůɖ Űɞg ŭɞəɞɛɘŰɘɞɨ ɛŬɟ ɛŶɟɞg Űɞ pH ŬgɜŶɜŮŰŬɘ ŬɘɛŬŰɤ ŭɩ ʆŬ ɧ Űɖɜ Űɘɛɐ 5 ůŮŰɘɛɣʆ ɛŮŰŬɜɨ 9-10. ¢ ɛŮɘɘůŰɞ´ɞɖůɐ Űɞg əŬɛɓŶɜŮɘ ɢɩ ɟŬ Ŭ ɧ Űɞ ´ɟɩ Űɞ ɣəəɞgůɛŬ ɜŮ Ůɟ ɜɩ ɜŰŬʆ ŮɘŬŰɟɩ ʆŰɖɜ Űɘɛɐ 10, Ůɜɩ ɛŮŰŶŰɞ 2[ɞ] ɣəəɞgůɛŬŰɞ pH Ŭ ɞəŰŶɛɘŬ ůŰŬɖŮɟɞ´ɞɘɖŰɘɐ ŰŶůɖ əɞɜŰŶŰɖɜ Űɘɛɐ 9. ȾŬɘ Űɩ , ɖ Ŷɜɞŭɞʆ Űɞg pH ŮɞŬɘ Ŭ ɧɟɟɞɘŬ Űɖʆ ŮɘůŬɤ ɔɐʆ ɧɜŰɤ ɜ Ca əŬɘ Mg ůŰɖɜ gŭŬŰɘɐ ŭŶůɖ.



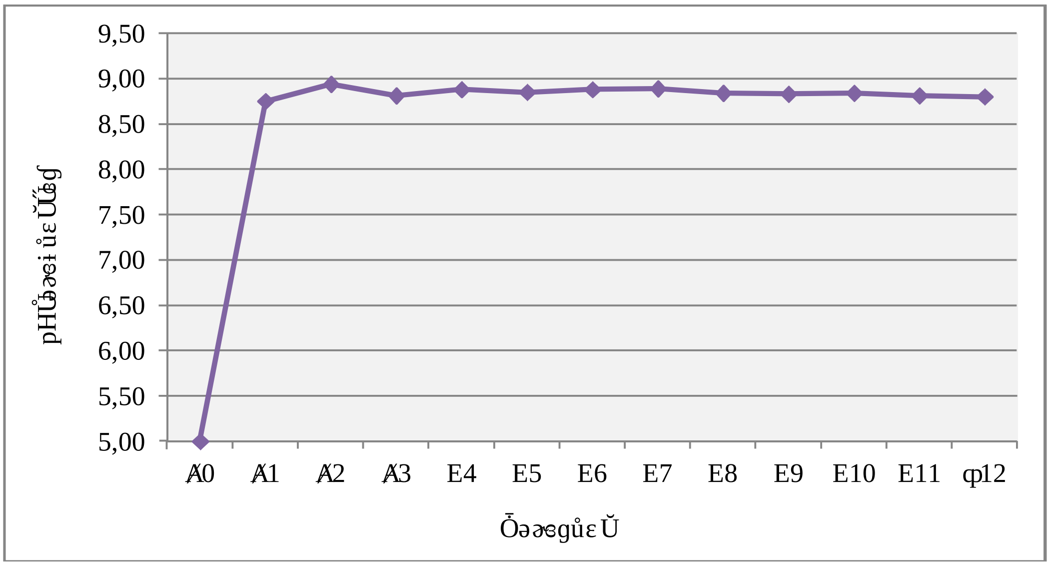
Ꜷɘ ɧɜŬ 3.39 : Ʉɟ ɞůɟ ɧűɖůɖ (%) Űɤ ɜ ɛŮŰŶəəɤ ɜ Pb, Cd, Zn əŬɘ Cu Ŭ ɧ ŭɞəɞɛɘŰɘ ɧ ɛŶɟ ɛŬɟɞ ŮɜŰɧʆ ůŰŮɟ ŮŶʆ
əɚɞɖʆ g´ ɧ ůgɜŮƐŮʆ ůgɜɖɐəŮʆɟ ɞɐʆ.

ɀ ɣůɤ Űɤ ɜ ´Ůɟ ŬɛŬŰɘɩ ɜ ŭŮɞɛɣɜɤ ɜ Űɞg ɄɞŬɘŬ 3.23 ŭɘŬ ɘůŰ ɜŮŰŬɘ ůɖɛŬɜŰɘɐ Ŭ ɞɛŮɤ ůɖ Űɤ ɜ ɛŮŰŬəɞəŬŰɧɜŰɤ ɜ Ŭ ɧ Űɞ gŭŬŰɘ ɧ ŭɘŶəgɛŬ. ¢ ´ɟɞůɟ ɧűɖůɖ ůŰɞ ŭɞəɞɛɘŰɘ ɧ ɛŶɟ ɛŬɟɞ, ɧ´ɤ ʆəŬɘ ůŰɞ ´Ůɟ ŶŭŮɘɛŬ Űɞg ŭɞəɞɛɖŰɖ, ŮɞŬɘ ɛɣɔɘůŰɖ ɔəŬ ŰŬ ɛɣŰŬəəŬ Űɞg ɣŮgŭŮɟɔɨɟɞg əŬɘ Űɞg ɢŬəɞɨ ɛŮ ´ɞůɞŰɧ 99-100%, ŬɞəɞgɖŮɑ Űɞ əŶŭɛɞ ɛŮ´ɞůɞŰŶ ´ɟɞůɟ ɧűɖůɖʆ 98-99%, Ůɜɩ Űɖ ɛɘɟɧŰɟɖ [illegible] 96-97%. [illegible]

[illegible]

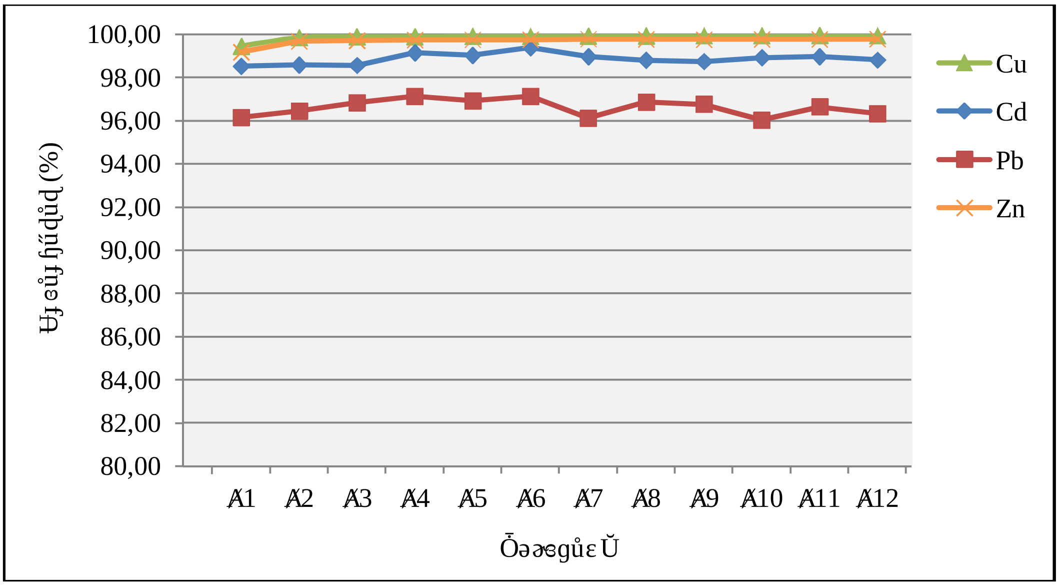
[illegible] 3.24: [illegible] Pb, Cd, Zn [illegible] Cu [illegible]

[illegible]	pH [illegible]	[illegible] (%)			
		Pb	Cd	Zn	Cu
A1	8,75	96,16	98,52	99,17	99,45
A2	8,94	96,45	98,58	99,68	99,84
A3	8,81	96,83	98,56	99,71	99,89
A4	8,88	97,14	99,14	99,74	99,89
A5	8,85	96,91	99,02	99,75	99,91
A6	8,88	97,13	99,37	99,76	99,91
A7	8,89	96,11	98,96	99,78	99,93
A8	8,84	96,86	98,80	99,77	99,93
A9	8,83	96,76	98,74	99,76	99,94
A10	8,84	96,02	98,92	99,77	99,93
A11	8,81	96,64	98,96	99,77	99,95
A12	8,80	96,33	98,81	99,77	99,94



[illegible] 3.40: pH [illegible] Pb, Cd, Zn [illegible] Cu [illegible]

ŬƽŰḍƒ 3.40 ủgɛ´Ǖ ŬœŰǕƽ ђŰƽŰŧ pH Ŭťg ´ɞəgɛŰǕƽəəɞɨ ůŰǕ ŬŶ əəœḍ Ŭťg ŬůɓŬůŬťəḍəɨ ɛŬɟɛŶɟɞg Ŭgɜ3ŶɜŰǕƽ ... ´əḍůœɜ Ŭťg 9. ¢ Ŭɨ ɜḍůḍ ŬœŬƽŬ ɞŰǕəŰɛŬŰḍƒɛŰǕƽɞḍůḍƒ ђɜŰɤ ɜ Ca ůŰŧ gŭŰǕəђ ŭəŶəgɛŬ.



Aəђ ɜŬ 3.41: ŦɟɕůɟђŰḍůḍ (%) Űɤ ɜ ɛŰǕŶəəɤ ɜ Pb, Cd, Zn əŬƽ Cu Ŭ ђ ŬůɓŬůŬťəḍəђ ɛŶɟɛŬɟɞ ŬɜŰђƒůŰǕ ŬŶƒ əəœḍḍƒg´ђ ůgɜŬťŰƒůgɜḍəəŬƒɟɞɛƒ.

¢ ´ɟɕůɟђŰḍůḍ Űɤ ɜ ɛŰǕŶəəɤ ɜ Pb, Cd, Zn əŬƽ Cu Ŭ ђ Ŭť ŬůɓŬůŬťəḍəђ ɛŶɟɛŬɟɞ ŬɜŰђƒ ůŰǕ ŬŶƒ əəœḍƒg´ђ ůgɜŬťŰƒ ůgɜḍəəŬƒɟɞɛƒ ŭœŬƽ Ŭəůɞg əŬɞ´ɞḍŰəŶ ŭŰŧɛɞɛɏɜŬ. ɇḍ ɛŬƽŬɨŰǕḍ Ŭ ђŭɕůḍ ´ŬɟɞgůəŶɛŬƽ Ŭť ŬůɓŬůŬťəḍəђ ɛŶɟɛŬɟɞ ɔəŬŰǕɛɏŰǕəəŬɣŬgŭŬɟɔɨɟɞg əŬƽ ɢŬəəɞɨ, ůɢŰђɜ 100%, Ŭəɞəɞgḍɨ ɛŬɜŬŬ ђ Ŭť əŶŭɛɞ əŬƽ Űɜ ɛђəgɓŭɞ, 98-99% əŬƽ 96-97%, ŬɜŰŭůŬťɢɤ ƒ. ŦŬɟђəŬ ŬgŰŶ, Ŭəɞůḍɛ Ŭɤ Ŭť ŬœŬƽ Ŭť ɔŬɞɜђƒ ђŬƽ Ŭť ŬůɓŬůŬťəḍəђ ɛŶɟɛŬɟɞ ŭŬɢɜŬƽ ɜŬ «ůgɜŬɟɔŶɛŬŰǕƽ» ŶɛŬůŬ ɛŬђəŬ ŰǕɛɏŰǕəəŬ, Ŭ əŰɟɔŶɜɞɜŰǕƒ Űḍ ɛɏəůŰḍ ´ɟɕůɟɕŭḍŰəɛ Ŭťg əŬɜђŰḍŰǕ Ŭ ђ Ŭť ´ɟɩ Ŭť ɏəəɞgůɛŬ.

3.4.1.3 Egɛ´Ǖ Ŷůɛ ŬŰǕ

¢ ɛŬəɏŰḍ Űḍƒ ´ɟɕůɟђŰḍůḍƒ Űɤ ɜ ɛŰǕŬəəɞəŰǕђɜŰɤ ɜ ɛɞəɨ ɓŭɞg, əŰŭɛœg, ɣŭgŭŬɟɔɨɟɞg əŬƽ ɢŬəəɞɨ Ŭ ђ ´ɞəgɛŰǕŬəəђ ŭəŶəgɛŬ pH=5 ɛŬ Űḍ ɢɟɐůḍ ŭɞəɞɛḍŰḍ, ŭɞəɞɛəŬəɞɨ ɛŬɟɛŶɟɞg əŬƽ ŬůɓŬůŬťəḍəɞɨ ɛŬɟɛŶɟɞg ɤƒ ´ɟɕůɟɕŭḍŰəɩ ɜ ɛɏůɤ ɜ ŬɜŰђƒ ůŰǕ Ŭ ɜ əəɩ ɜ əŬƽ ƒ´ђ ůgɜŬťŰƒ ůgɜḍəəŬƒɟɞɛƒ ƒ´ɞŭŬəɜɨ ŬƽђŬƽ ŰǕ ´Ŭ Ŭ Ŷɜɤ gəəŶ ŬɜŰǕ ɞəɟœɞɜŰǕƽ ɛŬŰŧɜ ɓɏəŬŭŬŧ Ŭɟђ´ɞ ůŰḍɜ Ŭ ɞɛŬɤ ůḍ Űḍƒ ůgɔəɏɜŬɟɤ ůḍƒ Űɤ ɜ ɓŬɟɏɤ ɜ ɛŰǕŶəəɤ ɜ Ŭ ђ gŭŰǕəɏƒɟɞɏƒ. ȚŬƽŰǕŬɟḍŬ´ɟɕůɟɕŭḍŰəŶ ɛɏůŬ´ŬɟɞgůəŶɛɞgɜ gɣḍəŶ Ŭ ά ŬůŬ ůgɔəɟŶŰḍůḍƒ Űɤ ɜ əŬŰђɜŰɤ ɜ, ŰǕɞ´ɞḍŬ Ŭ əŰɟɔŶɜɞɜŰǕƽ ɔŬɜəŶ, Ŭɛɏůɤ ƒɛŰǕŶŰḍɜ Ŭ Ŭŭɛ Űɤ ɜ Ŭɜḍɟ Ŭəəɩ ɜ ´ŰǕɟɤ ɛŶŰɤ ɜ ɛŬŰŧ ´ɞəgɛŰǕŬəəђ ŭəŶəgɛŬ. Egɔəŭɟɛɏɜ Ŭ, [illegible] Cd, [illegible] 93-97%, [illegible] 98-99% [illegible] 99-100%. [illegible] Zn=Cu>Cd>Pb. [illegible] 93-95% [illegible] 96-97%, [illegible] pH [illegible] 5 [illegible] 8-10. [illegible] pH [illegible] 9-10, [illegible] 8-9. [illegible] Ca, [illegible]

3.4.2.1 ǗǓǰǓɛǓǛǝ ǚǝǓǕǝǓǘǓ

¢ Ǖǝ´ǝǥǖǝƕǚǘǛ ǝǓǝ ǖǓ ǓǥǗǝ ǚǘǝ ´ǙɑǗǖǘ ɛǓǛǓƳǕǝ ǖǓ ǖǚǘǙǥǘ ǖǥǝǘǝǝǙ ɛǝǖɤ ǓǝƳǕǙǥǖǘǘ. ¢ ´ǙɟǓɛǓǛǝ ǚǝǓǕǝǓǘǓǘǘ ǕǓ´ǝǥǖǝƕǚǘǛǘ ´ǙǝǓɛƄǝǓǝ ǚǘǝ ǓǝƳǕǙǥǖǘ ´ǝǖƕǚǘǛǘ ǚǝǝǝɛǝǜǝǣ ǓǖǕǖǕƕǝǝǥ ´ǝǥ ǝǥǝǥ´ǝǖǚǝ´ɟǝǖɟƕǚǘǖǘ ɛǚǛƳǝǝɤ ǝ ǖǓ´ɟǝǝǓǘǝɟǝǖɛǝǝǙǘ ǖǥǝǘǝǝǙ. Ǻǝǚǝƕǚǝ Ǔ, ´ǝǖƕǚǘǛ 5 g ǚǝǝǝɛǘǘ, ǚǝǝǝɛǝǜǝǣ ɛǙɟɛƳɟǝǥ ǝ ǓǖǕǖǕǝǝǘǝǣ ɛǙɟɛƳɟǝǥ, ´ǝǥ ǝǥǝǥ´ǙǓǝǘǖǘǖǕ ɨ ǖǚǙ Ǔ Ǔ ƕ ǘ ǚǝǓǕǝǓǘǓ ǘǘ ´ɟǝǖɟƕǖǘǖǘ, ǓǝǓɛǝǝɨ ǚǚǝ ɛǓ 50 ml Ǔ ǝǝǝǖɛǝǝǥ ǝǙǝɨ. Ɇǘ ǖǥǝǝǕǝǓ, ǚǝ ǚǝƳǝǥɛǓ ǥǖǝǚǚǝ ǓǝƳǖǘǖǘ ǝǝǓ ǥɟǝǝǝƕ ǚǝƳǖǘɛǓ 1 h ɛǓ ǚǝɨ ǘǘǚ ´Ǚɑǝǥ 400 rpm ǝǓǝǖǓǘǙɛǝǝɟǓǘǓ´Ǚǝƴǝǝǝǝǚǥ (20-25 °C). ɇǘǝ ǓǝƳǖǘǖǘ Ǔǝǝǝǥǘǖǘǚǝǘǘǖǘ. ɇǝ ´ɟǝǝɨ´ǚǝ ǚǝǘǘɛǓ ǓǓǝɨǚǚǝ ɛǝǖɤ ū Ǔǖɛǚǝɛǚǚǘǥ ɟ ǚǝɛǝǝǝǥ ɟ ´ǝɟɟƕǖǘǖǘǘ, ɩ ǖǚǚ ǝǓ ´ɟǝǖǚǝɟǝǘǖǘ ǖǥǝǝǝǝǙɤ ǖǘ ǚǝ ɛǚǚƳǝǝɤ ǝ ǖǚǝ ǚǝƳǝǥɛǓ, ǝǓǝ ǚǝ ǖǚǙǚƕ ǝǘɟ ǓǝǓǚǚǝ ǝǝǓ 1 h ǖǓ ǘǙɛǝǝɟǓǘǓ 100 °C, ɩ ǖǚǝǓǓ ǝɛǓǝɟǥǝǘǖǘ ǥǝɟǓǘǓ.

3.4.2.2 ǗǓǰǓɛǓǛǝƳ Ǔ ǝǚǚǝǖɤ ǓǚǚǝǓǝǖǝǝǝǓǚɛƕǘ

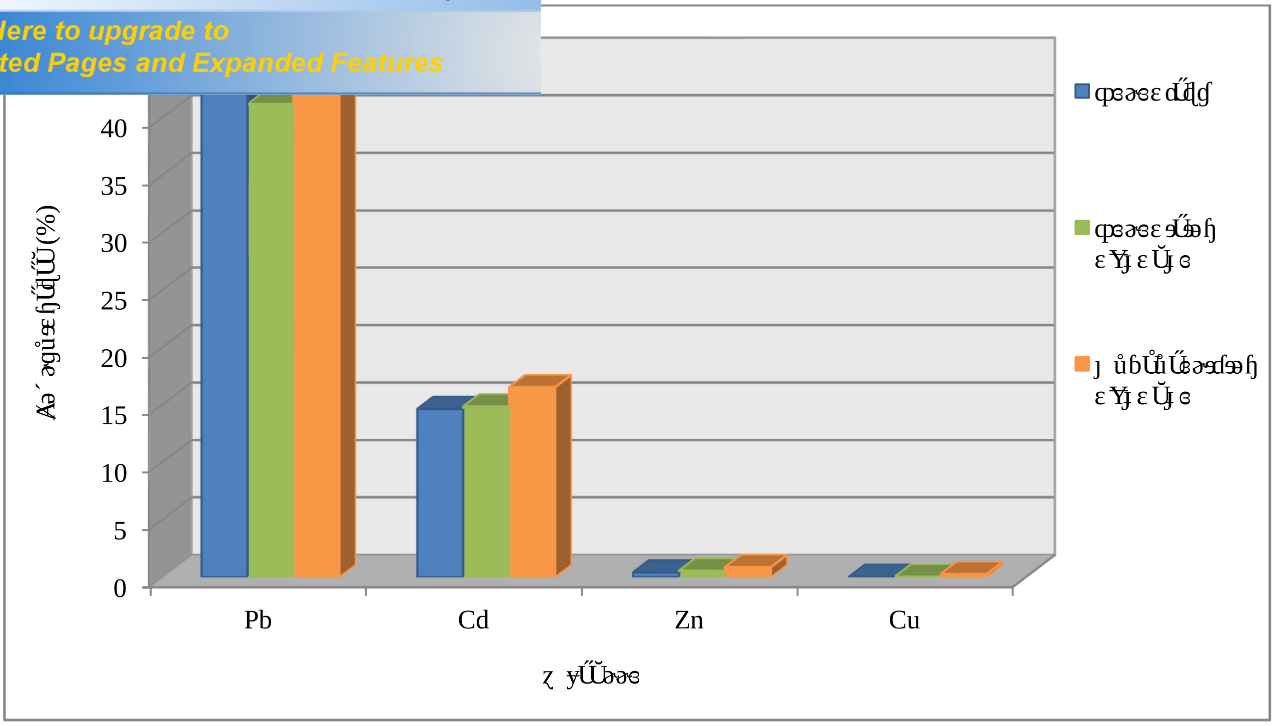
Ƀ ´ǝǖǝǚǝƕǘ ´ɟǝǖǚǝɟǝǖɛƕǘ ǚǘǘ Ǖǝ´ǝǥǖǝƕǚǘǛǘ ǚǝ ɛǚǚƳǝǝɤ ǝ ǝǝǚǚǝ ɛǓ ǓǓǙɛǝǝɤ ǚǘǘ ǖǥǝǖǘǘ:

$$\% \text{ Ǻǝ´ǝǥǖǝƕǚǘǛ} = \frac{?}{?\ ?} \times 100$$

ƕ´ǝǥ
m_{e} : ǘ ɛƳǝǓǚǝǥ ɛǚǚƳǝǝǝǥ ǖǚǝ ´ǝǖƕǚǘǛ ǚǝǥ ´ɟǝǖɟǝǖǘǚǝǝɨ ɛǥǖǝǥ (5 g), ´ǝǥ ǝǥǝǥ´ǙǓǝǘǖǘǖǕ ɨ ǖǚǙ ǓǓ ƕ ǘ ǚǝǓǕǝǓǘǓǘǘ ´ɟǝǖɟƕǖǘǖǘǘ ǝǝǓ ǘ ɛǝǥǘǘ ǘǘ Ǖǝ´ǝǥǖǝƕǚǘǛǘ, ǖǓ mg
m : ǘ ɛƳǝǓǚǝǥ ɛǚǚƳǝǝǝǥ ǖǚǝ ǚǝƳǝǥɛǓ´ǝǥ ǝǥǝǥ´ǙǓǝǘǖǘǝɛǚǚƳǘǝ Ǖǝ´ǝǥǖǝƕǚǘǛ mg.
ɇǓ ´ǙɟǓɛǓǛǝƳ ǚǖǝɛɤǝǓ ´ǝǥ ´ɟǝɨ´ǚǝǥǝ ǓǝǓǝɟǝƳ ɛǓ ǚǘǝ Ǖǝ´ǝǥǖǝƕǚǘǛ ´ǙǓǚǘǝǚǚǝ ǖǚǘ ǖǥǝǥǝǖǝǓ.

ǗǝǓǝǓǘ 3.25: Ǻǝ´ǝǥǖǝƕǚǘǛ (%) ǚǝ ɛǚǚƳǝǝɤ ǝ Pb, Cd, Zn ǝǓǝ Cu Ǔ ƕ ǚǝǝǝɛǘǘ, ǚǝǝǝɛǝǚǝƕ ɛƳɟɛǙɟǝ ǝǓǝ ǓǖǕǖǕǝǝǘǝƕ ɛƳɟɛǙɟǝ ´ǝǥ ǝǥǝǥǝ ǥ´ǝǖǚǝ´ɟǝǖɟƕǖǘǖǘ ǓǚǘǥǖǚǙǓǝǥǝǝǝǘǥǥ´ƕ ǖǥǝǓǝǘǥǖǥǝǘǝǝǙǥɟǝǝǘ.

ǫ ǝǚǚǝǝǝ	Ǻǝ´ǝǥǖǝƕǚǘǛ (%)		
	ǟǝǝǝɛǘǘǥ	ǟǝǝǝɛǝǚǝƕ ɛƳɟɛǙɟǝ	ɟ ǖǕǖǕǝǝǘǝƕ ɛƳɟɛǙɟǝ
Pb	42,15	41,15	43,92
Cd	14,62	14,83	16,51
Zn	0,41	0,55	0,86
Cu	0,02	0,03	0,26



Ѧǝɧ ɧǝŬ 3.42: Ѧǝ´ǝǥůȿ ɧŰďŰŰ (%) Űɤ ǝ ɛŮŰŸǝǝɤ ǝ Pb, Cd, Zn ǝŬ Cu Ŭ ɧ ŭǝǝɛ dŰď, ŭǝǝɛ ǝŰǖɧ ɛŸɟɛŬɟǝ ǝŬ ŬůƃŬůŰǝǝďǝɧ ɛŸɟɛŬɟǝ ´ǝɡ ɏǝǝǝ ɡ´ǝůŰŰ´ɟǝůɟ ɧŰďůď ŬŰɧɠůŰŰɟ ŬŸɠǝǝďɠɡ´ɧ ůɡǝŬŰɠůɡǝďǝ ŬŰɟǝǝɠ.

dŬůǝǝ ´Ŭɟ ŰŰɟɟďůď, ɛŮƃŸůď ŰŰ ŭŰůǝɛɏǝŬ Űǝɡ ɄǝŬǝŬ 3.25, Ŭ ǝŰŰǝŬůŰǝ ǝŮǝǝɧɠ ɧŰǝ ǝŬ ŰŰ Űɟ dŬ ´ɟǝůɟǝŰďŰǝŸ ɛɏůŬ ɏǝǝǝ ´ŬɟɧɛǝǝŬ ůɡɛ´ŬɟǝŰǝɟŸ ůŬ ůǝɏůď ɛŮ Űďǝ Űǝ´ǝǥůȿ ɧŰďŰŰ Űɤ ǝ ɛŮŰŸǝǝɤ ǝ Pb, Cd, Zn ǝŬ Cu. Ɇɡǝǝɟɛɏǝ Ŭ, ŰŰ ´Ŭɟ ŬɛŬŰǝŸ Ŭ ǝŰŰǝɏůɛŰŰɡ´ǝŬŰǝǝɨ ǝɡǝ Űǝ ǝ ɛɧǝɡƃŭǝ ɤ ɡŰǝ ɛɏŰŰǝǝǝ ɛŮŰď ɛŮŬǝɨ ŰŰɟ ď Ŭ ǝɛŸǝɟɡǝůď ǝɧǝɤ Űǝ´ǝǥůȿ ɧŰďŰŰɠůŮ´ǝůǝůŰɧ ´ǝďůǝǝ Űǝɡ 40%. ƎŰď ůɡǝɏǝŬ, Űǝ ǝŸŭɛǝ Ŭɛ ŰŬǝǝŬ Űǝ´ǝǥůȿ ɧŰďŰŰ ůŰŬ Ů ɑ ŰǝŬ Űǝɡ 15%. ƎŰďǝ Űǝ ǝŬŬ ƃɟ ǝůǝǝǝŰŰǝ ǝ ɣŰɡŭŸɟ ǝɡɟǝɠ ǝŬ ǝ ǝŬǝǝɧɠ ɛŮŬ ǝɛŸǝɟɡǝůď Ŭ ɧ Űǝ ´ɟǝůɟǝŰďŰǝɧ ɡǝǝɧ ůŬ´ǝůǝůŰɧ <1%. ŪŬ ɛ´ǝɟǝɨ ůŬ, ɣ ůŰɧůǝ, ǝŬ ´ŬɟŰŰɟɟďŰǝ ɛǝŬ ɛǝɟɐ Ŭɨ ǝďůď Űďɠ Űǝ´ǝǥůȿ ɧŰďŰŰɠ ůŰďǝ ´Ŭɟ ɑ Űɤ ůď Űǝɡ ŬůƃŬůŰǝǝďǝǝɨ ɛŬɟɛŸɟǝɡ ǝŬ ɧǝŬ ŰŰ ɛɏŰŰǝǝŬ, Ŭɩ ǝ ŭǝǝɛ dŰďɠ ǝŬ Űǝ ŭǝǝɛ ǝŰǖɧ ɛŸɟɛŬɟǝ ǝɡɛŬǝǝǝŰŰǝ ůŰŰ ǝŬ ´ǝůǝůŰŸ. ¢ ´ǝǝŰǝɐ ǝŬ ´ǝůǝŰǝɐ ŰŰɨ Űůď Űɤ ǝ ŭɨ ǝ ŭǝǝɛ ǝŰǝɩ ǝ ´ɟǝůɟǝŰďŰǝɩ ǝ ɛɏůɤ ǝ ɡ´ǝŬǝǝɨ Űǝ ɧŰǝ ŭǝŬǝɟŮŰǝɧɠ ǝŰɧɠ Űɤ ǝ ŭɨ ǝ ɡǝǝɩ ǝ ǝŬ ď ´ɛ ůɡɛ´Ŭɐɠ ɛǝɟŰɐ Űǝɡ ŭǝǝɛ ǝŰǖǝǝɨ ɛŬɟɛŸɟǝɡ ŭŬ Ů ǝŭɟǝɨ ǝ ůŰďǝ Űǝ´ǝǥůȿ ɧŰďŰŰ Űɤ ǝ ɛŮŰŸǝǝɤ ǝ. ¢ Űǝ´ǝǥůȿ ɧŰďŰŰ Űǝɡ ɛǝǝɨ ƃŭǝɡ ǝŬ Űǝɡ ǝŬɛǝǝɡ ůŮŰɧůǝ ůďɛŬŰǝŸ ´ǝůǝůŰŸ ǝŭď ǝŬůŰ ůɡɛ´ɏɟ ŬůɛŬ ɧǝ ůŰďǝ ´Ŭɟ ɑ Űɤ ůď Ŭǝǝ ǝ Űɤ ǝ ɛŮŰŸǝǝɤ ǝ ď Ŭ ǝɛŬɤ ůɐ Űǝɡɠ ůŰďǝ ´Ŭɟ ɑ Űɤ ůď Űďɠ ůɡǝŬǝǝɨ ɠɟǝǝɠ ɛɏůŬ Ŭ ɧ ůŰŰɟ ŬŸǝǝǝď ǝŰŬǝŰŰǝ ůŬɛŬŸǝǝ ƃŬďɛɧ ůǝ ŭŬǝɧɛǝǝ Űďɠ ŭɡůǝɐɠɟɧŰďůďɠ ŬǝŰɧɠ Ŭ ɧ Űďǝ ´ɟǝůɟɧŰďůď ɛɏůɤ ŬǝŰŰǝǝŬǝɐɠ ɛŰŰǝǝǝŬŰǝɧǝŰɤ ǝ ɛŮǝɧǝŰŰ Ca ǝŬ Mg ǝŬ Űďɠ ǝŰŰǝɟɐɛǝǝďɠ ůŰďǝ Ůǝǝ ŸǝŬŬ Űǝɡ ´ɟǝůɟǝŰďŰǝǝɨ ɛɏůǝɡ. ɟ ´ɧ Űďǝ Ÿǝǝď ɛŬǝŸ, ď ɛǝɟɐ Űǝ´ǝǥůȿ ɧŰďŰŰ Űǝɡ ɣŰɡŭŬɟǝɨɟǝɡ ǝŬ Űǝɡ ǝŬǝǝǝɨ ŭŬŬɩ ǝŬ ɧŰǝ ď ǝŰŰǝɟŸŰďůɐ Űǝɡ ´ɟǝŬɛŰǝ´ǝǝŰďŰǝ ɛŮŬŰŰǝǝŬǝɐ Űɤ ǝ ǝɧǝŰɤ ǝ ɛŮŰŸǝǝɤ ǝ ɛŮǝŰŰɧǝŰɤ ǝ ŬůƃŬůŰǝɡ ǝŬ ɛŬǝďůǝɡ ǝŬ Űǝ ŭǝǝɛ dŰď ǝŬ Űǝ ŭǝǝɛ ǝŰǖɧ ɛŸɟɛŬɟǝ ǝŬ ǝɧǝŰɤ ǝ ŬůƃŬůŰǝɡ ǝŬ Űǝ ŬůƃŬůŰǝǝďǝɧ ɛŸɟɛŬɟǝ ǝŬ ɛɏůɤ Ůǝ ŰŬǝŬŬǝɐɠ ůɡɛ´ǝǝǝ´ǝďůďɠ ǝŬ ǝŰŰǝɟɐɛǝǝďɠ.

3.4.3.1 [illegible] (X-Ray Diffraction, XRD)

3.4.3.1.1 [illegible]

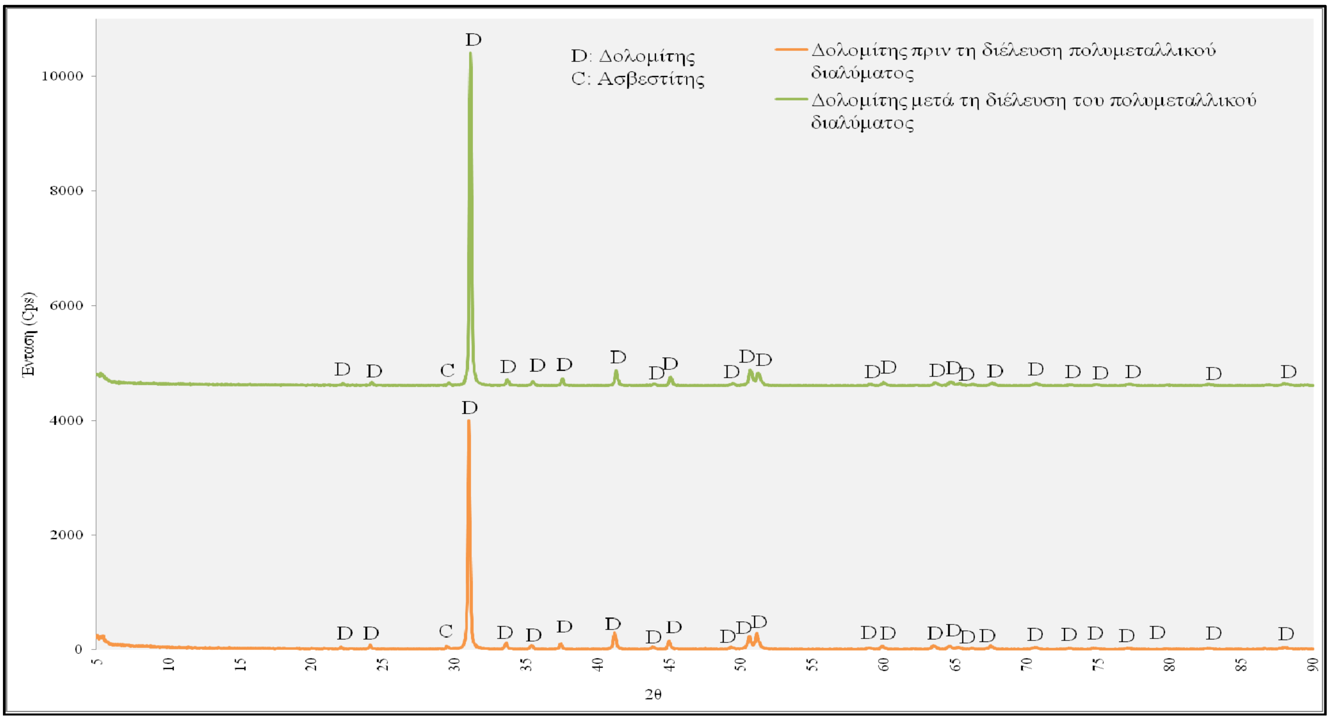
[illegible] 3.2.2.2.1 [illegible]

i. [illegible] 2θ: 10-90°
ii. Step: 0.050°
iii. Step time:2 s
iv. Temp: 25°C

3.4.3.1.2 [illegible]

[illegible]

[illegible]

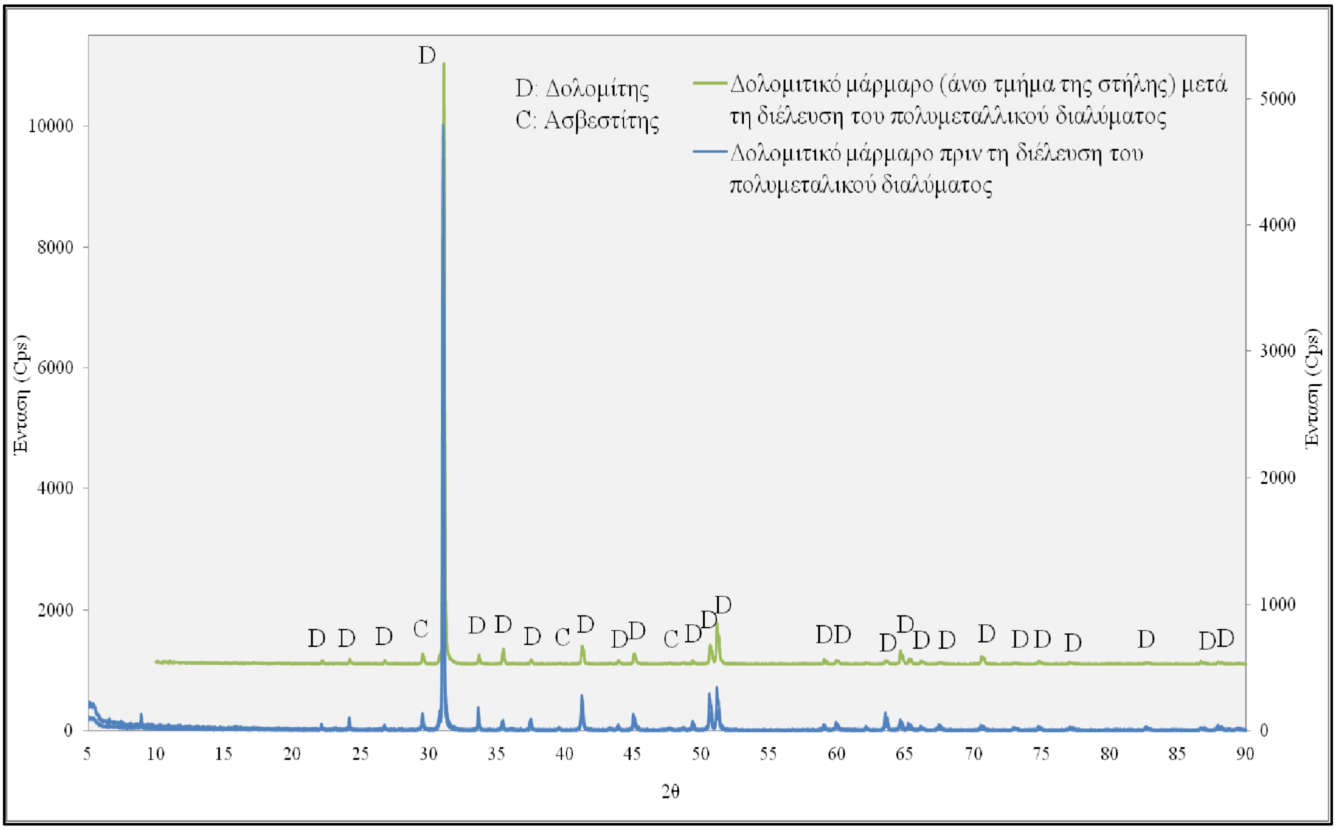


[illegible] 3.43: [illegible]

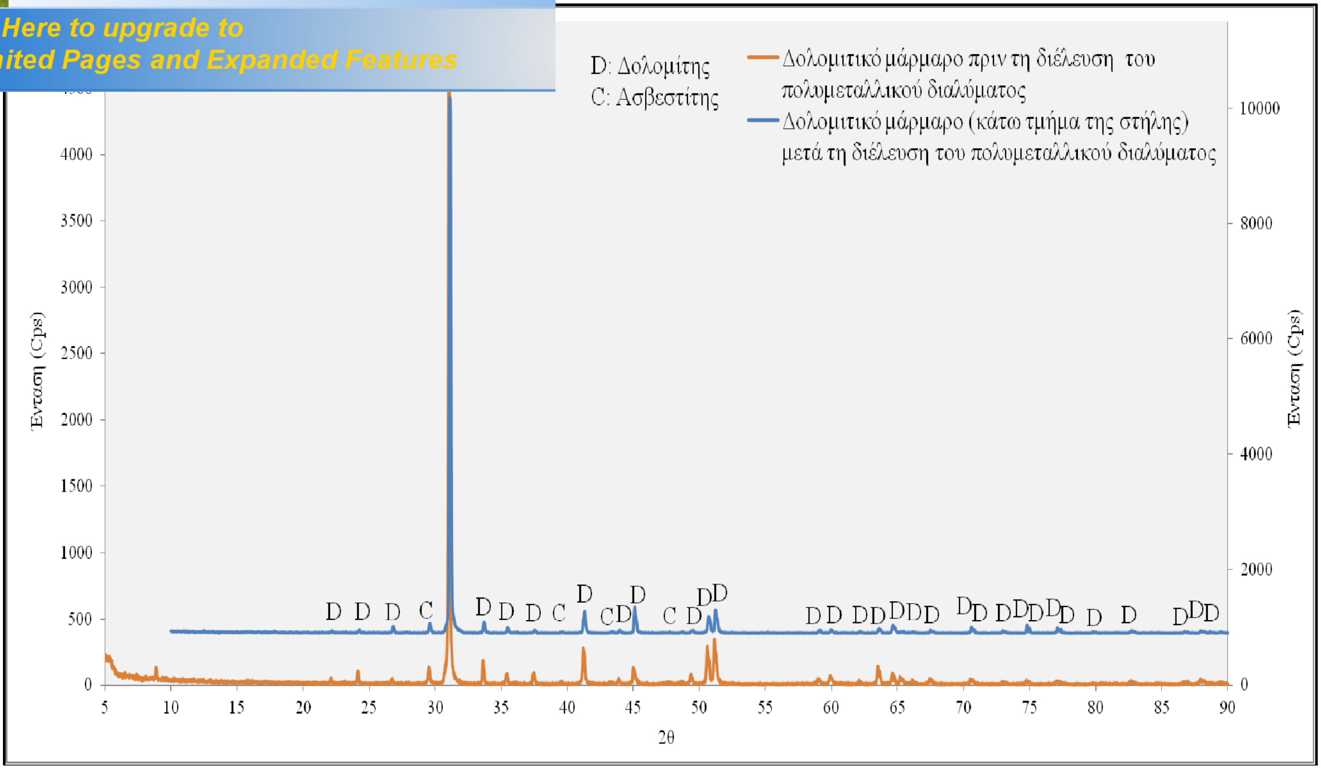
ŋŰǿ Ű΄ ´ ȷ ɕůȷ ɕűɗȕǿŋ ɛỵůɕ ŭŰǿ ´ Ŭȷ ɕgůǝŸɕŮǿ ǝŸ ɕǝŬ ȝỵŬ
ɕɛɗɖ ŰɖɠůŰŰȷ ŮŸɠǝǝɕɗɠɛỵůɤ Űɕg ɕ´ɕɕg ỵɕŮǿŭǝŷǝɗŰǿŰ΄
ɕǝɠɛ ŮŬǝǝǝȷ ŭǝŸǝɠɛŬ ŬɛŭŬɕŬɕ ɛȷȝɕ Űɠ ǝɕȷgűỵɠ Űɕg ŭɕǝɛɛɗɖ ǝŬǝ Űɕg ŬůǿŮůŰŰɖ, ɕǝ ɕ´ɕɗŮɠ
ŭɕɕȝŰŰǝǝŬǝůŰ΄ ŬǝŰǝɕǝȷ ŸűɗɛŬŰɕg ŭɕǝɛɛɗɖ ɤɠ´ȷı Űɖ ɨǝɗ.

ɷɕǝɕɛǝŰǝŋ ɛŸȷ ɛŬȷ ɕ

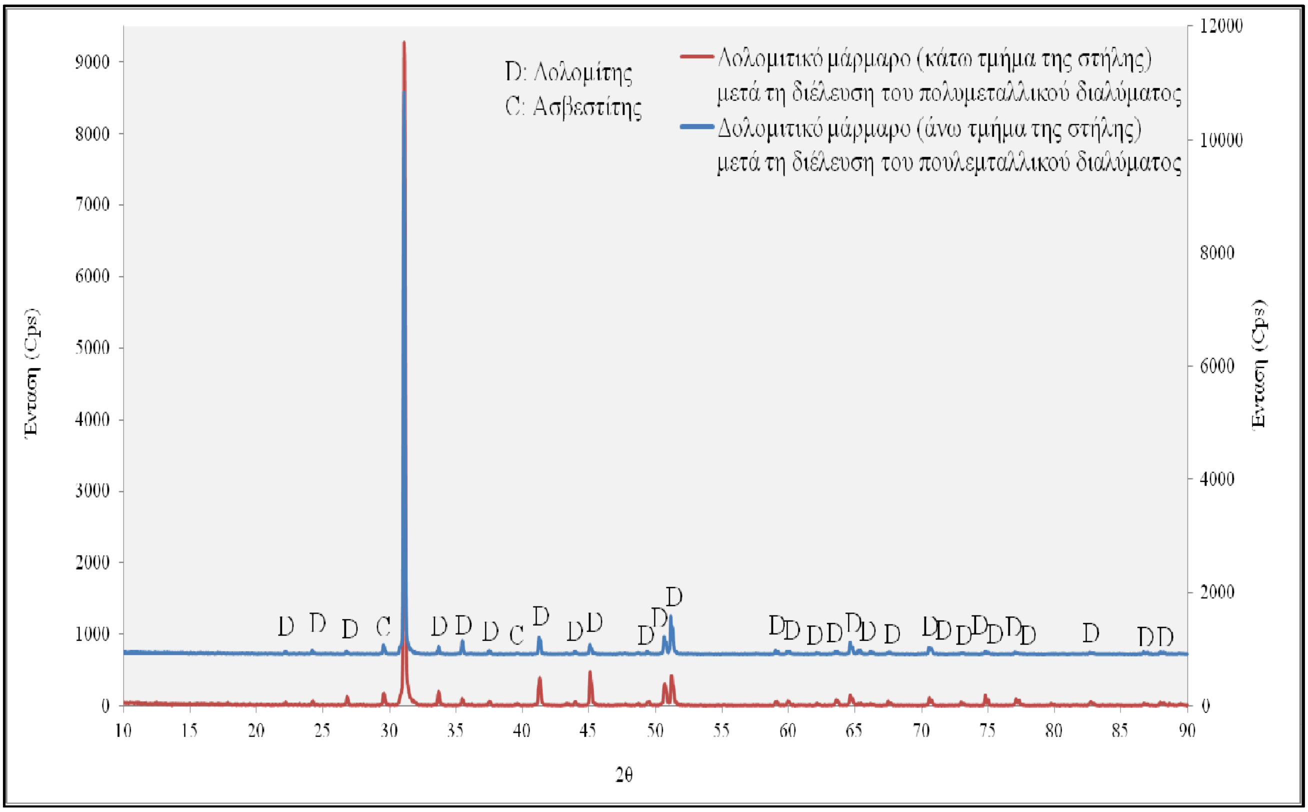
ȷ ´ŋ Űɠ Ѧǝŋȝ Űɠ 3.44 ỵɤ ɠ 3.46 űŬɕŮŰŰǝ ŋŰǿ ŰŰ ŬǝŰǝɕǝȷ Űűɐɛ ŬŰŰ ŭŰǿ Ŭ ɕǝŬǝɨ ´Űɕgȝ Űɖȝ
ŭɗɛɕgȷǝɗŬ ɛǝŬɠ ǝŬɕɕɨȷǝǝŬɠ űŸůɗɠ ɐ ỵȝɤ ůɗɠůŰ΄ ŭɕǝɛǝŰǝŋ ɛŸȷ ɛŬȷ ɕ ɨůŰȷ Ŭ Ŭ ŋ Űɖ ŭǝŬŭǝŰůɗŬ
Űɖɠ ´ȷɕůȷ ŋűɗůɗɠ. ȾŬǝ ŰŰ ŭɨ ɕ ŭŬǝɛŬŰŰ Űɕg ɛŬȷ ɛŸȷ ɕg, Ŭ ŋ Űǿ Ÿȝɤ ǝŬǝŸŰɤ Űɛɛɛ Ŭ Űɖɠ ůŰɨǝɗɠ,
ůɡǝǝȷ ɕŋɛ ŮȝŬɛ ŮŰɖȝ ´ȷı Űɖ ɨǝɗ, ´Ŭȷ ɕgůǝŸɕɕgȝ Űɠ ɑǝŰɠ ǝɕȷgűỵɠ, ŭɗǝŬǝɐ ŮǿŮɕŬɠ Űɕg ŭɕǝɛɛɗɖ ǝŬǝ
Űɕg ŬůǿŮůŰŰɖ, ŰŬɕ´ɕɗŬ ɕŰŰǝɨ ȝ ŰŬůgůŰŰǝŸ Űɕg ŭɕǝɛɛɗǝɕɨ ɛŬȷ ɛŸȷ ɕg.



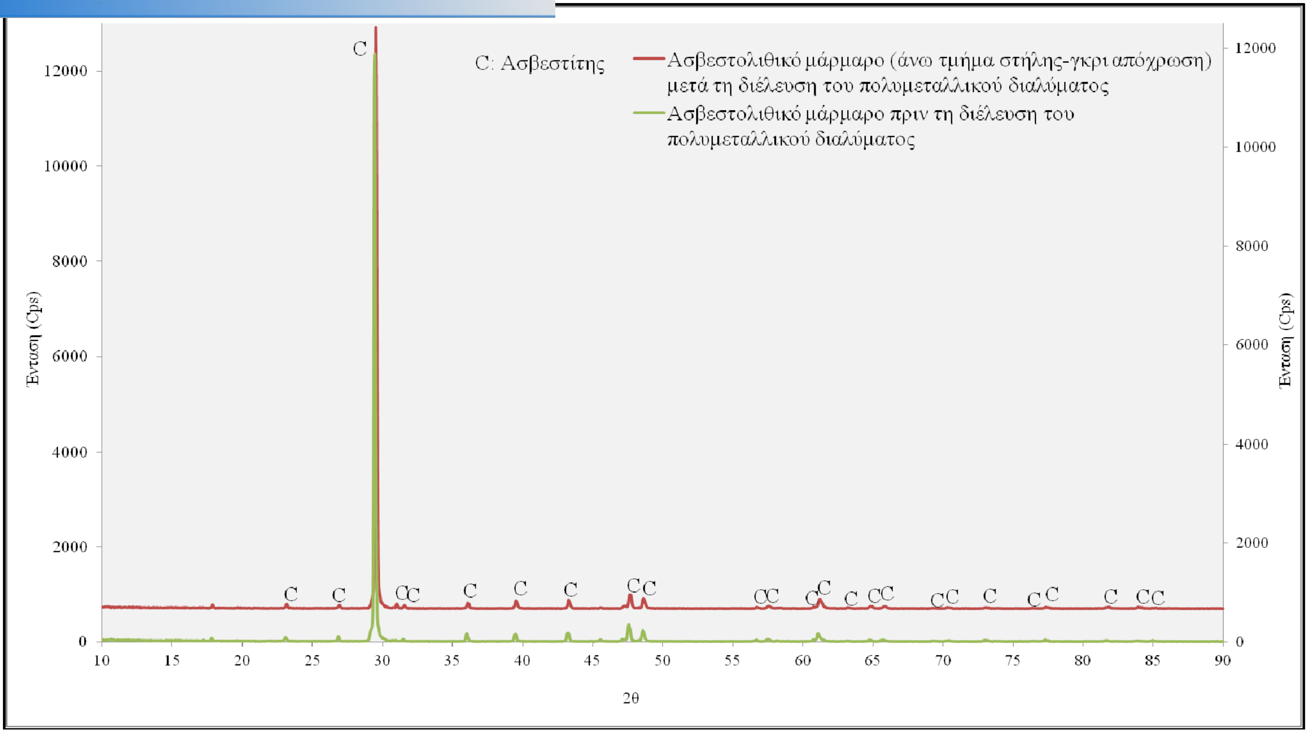
Ѧǝŋȝ Ŭ 3.44: Ȩgǝǝȷ ǝŰǝŸ ŬǝŰǝɕǝȷ ŬŰɐɛŬŰŰ ŭɕǝɛǝŰǝɕɨ ɛŬȷ ɛŸȷ ɕg ŮȝŰŋɠůŰȷ ŮŸɠǝǝɕɗɠ (Ÿȝɤ Űɛɛɛ Ŭ) ´ȷɕ ǝŬǝɛŰŰŸŰɖ ŭǝỵǝŬɠůɗ Űɕg ´ɕǝɠɛŰŰǝǝǝɕɨ ŭǝŬǝɨ ɛŰɕg.



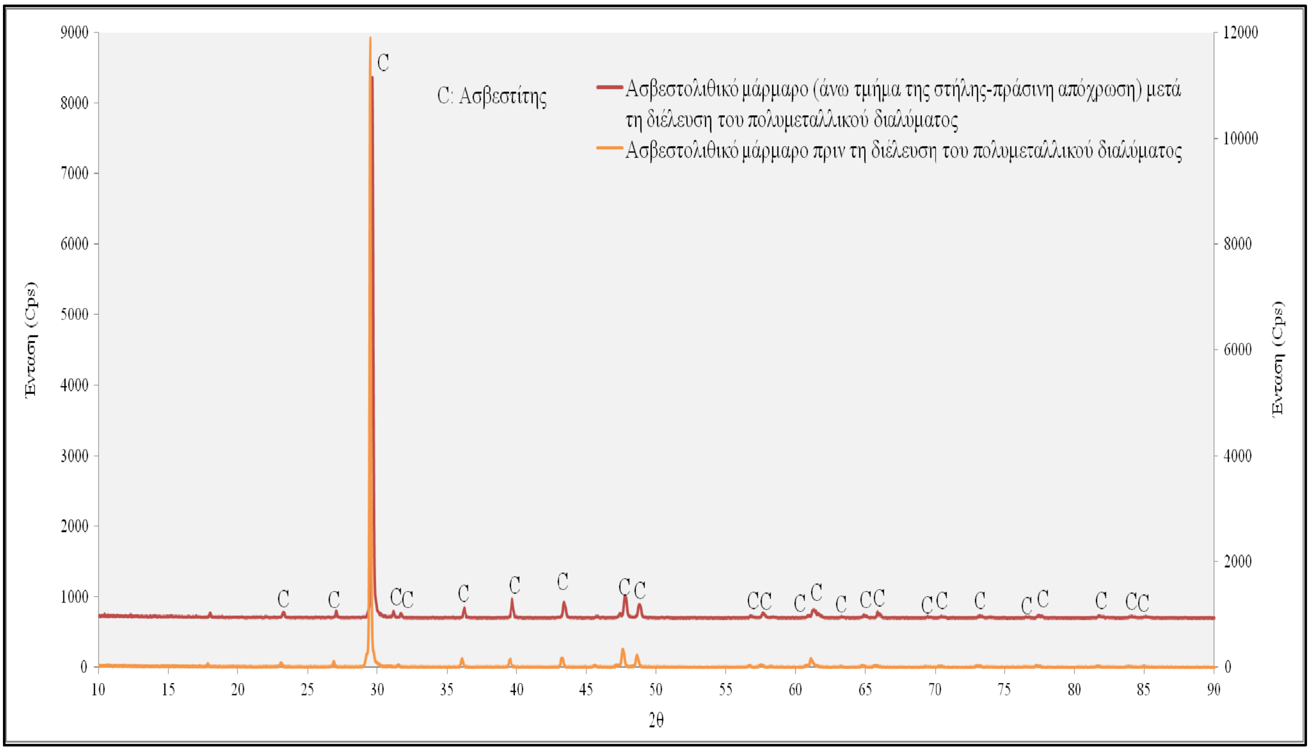
Αχῆμα 3.45: Ɇgɔəɟ ϑὕɘ Ỵ Ὓɘ Ὕɞɞɔɟ Ὗίɐɛ ὝὝ ŭɞɜɞɛ ϑὕɘɞɨ ɛ Ὑɟ ɛ Ẏɟ ɞg ὐὟɡʃ ůὝɟ ὟẎʃ əəɞɖʃ (əẎὔ ὔɛɐɛ Ὑ) ´ɟɞ əὝɜɛ ὝὝẎ Ὑɖ ŭɞɔəὝɡůɖ Ὑɞg ´ɞəgɛ ὟὝὝɘəəɞɨ ŭɞὝɘɨ ɛ ὝὝɞʃ.



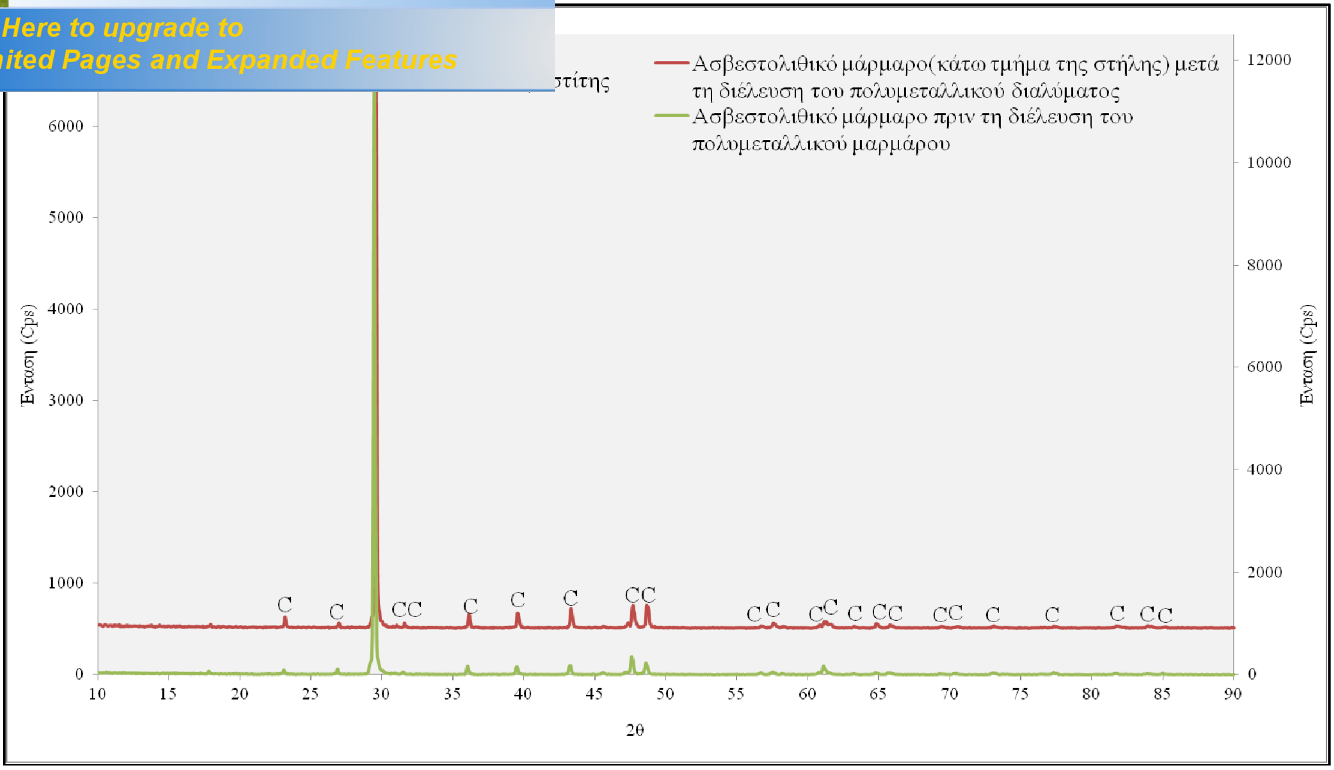
Αχῆμα 3.46: Ɇgɔəɟ ϑὕɘ Ỵ Ὓɘ Ὕɞɞɔɟ Ὗίɐɛ ὝὝ ŭɞɜɞɛ ϑὕɘɞɨ ɛ Ὑɟ ɛ Ẏɟ ɞg Ὓ ɧ ὝὝ ŭɞẎὕɞɟ Ὓ ὕɛɐɛ ὝὝ Ὑɖʃ əəɞɖʃ ɛ ὝὝẎ Ὑɖ ŭɞɔəὝɡůɖ Ὑɞg ´ɞəgɛ ὟὝὝɘəəɞɨ ŭɞὝɘɨ ɛ ὝὝɞʃ.



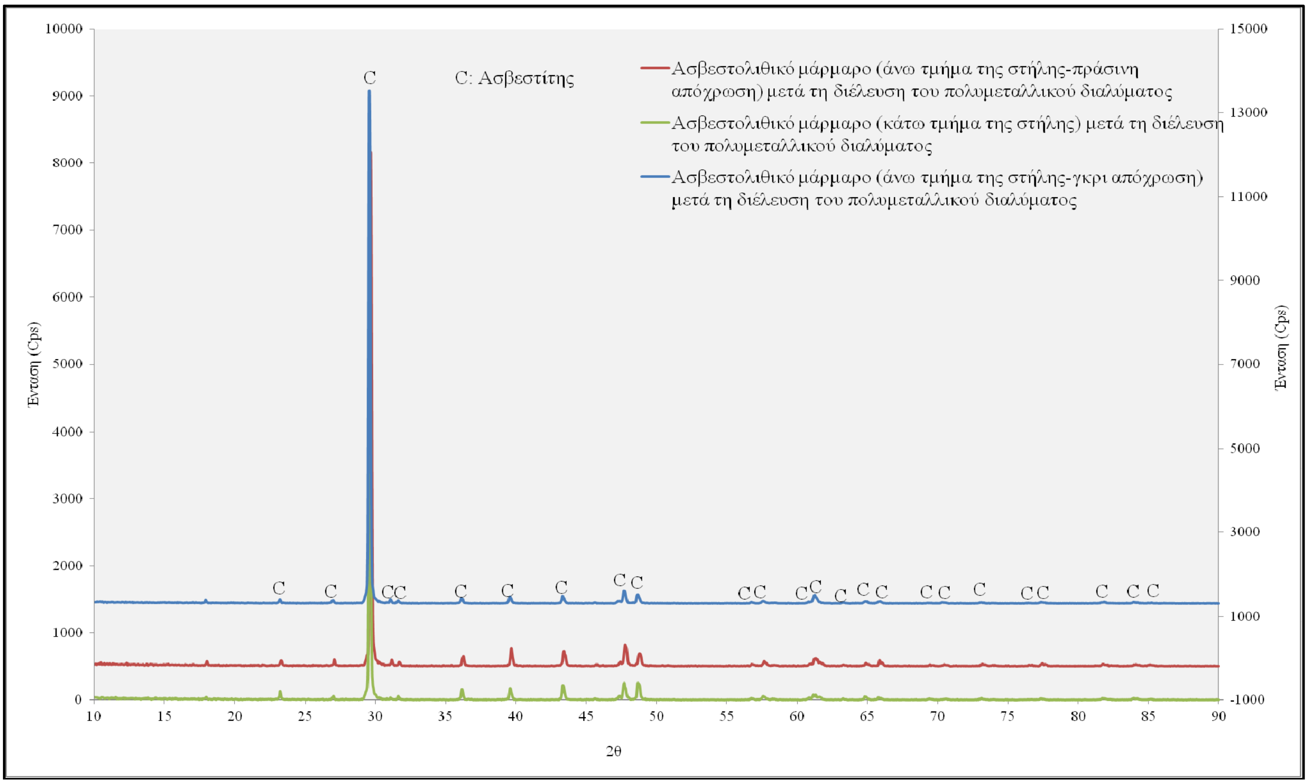
Ʌɘ ɧɜǓ 3.47: Ɇɡɔəɟ ɘǕɵ ƳǓɐǕɞɞɕɔɟ ǓɛɐɛǓǕǓ Ǔůɓǔɨǖɞɚɗɘɞɨ ɛǕɟɛƳɟɞɡ ǓɜǕɧɠůǕǕɟ ǓƳɠɚəɷɗɠ (Ƴɜɤ ǕɛɐɛǓ-ɔəɟ ɘǓ ɧɢɟ ɤ ůɗ) Ǔ ɧɢɟ ɤ ůɗ) ´ɟ ɞ əǓɘɛ ŮǕƳǕɗ ŭɘɚəǓɡůɗ Ǖɞɡ ´ɞəɡɛ ŮǕǓɚəɘɞɨ ŭɘǓɚɨ ɛǓǕɞɠ.



Ʌɘ ɧɜǓ 3.48: Ɇɡɔəɟ ɘǕɵ ƳǓɐǕɞɞɕɔɟ ǓɛɐɛǓǕǓ Ǔůɓǔɨǖɞɚɗɘɞɨ ɛǕɟɛƳɟɞɡ ǓɜǕɧɠůǕǕɟ ǓƳɠɚəɷɗɠ (Ƴɜɤ ǕɛɐɛǓ-´ɟ Ƴůɞɗ Ǔ ɧɢɟ ɤ ůɗ) ´ɟ ɞ əǓɘɛ ŮǕƳǕɗ ŭɘɚəǓɡůɗ Ǖɞɡ ´ɞəɡɛ ŮǕǓɚəɘɞɨ ŭɘǓɚɨ ɛǓǕɞɠ.



Ԑἰϰόνα 3.49: Ɛgɔəʇ ɘʊ̃ɘ Ɏ Ǚɘ Ǚɞ ɞ ɔʇ Ǚʋ̃ ɛ ɛ ǛǗǗ ǛǘɓǛǘǗɞɘʠɘɑɨ ɛ Ǚʇ ɛ Ɏʇ ɛɡ ǙɁǗɡ ʊǗǗʇ ǗɎɡ ɘɑɑ ɗɡ (ɘ ɎǗ ǛɛɛǙ) ´ʇ ɞ ɘǙɞ ɛ ǗǗɎǗɖ ʊɘɏɘǚɡʊɖ Ǘɛɡ ´ ɞɘɡɛ ǗǗɓɘɘɑɨ ʊɘǙɞɨ ɛǗǗɡ



Ԑἰϰόνα 3.50: Ɛgɔəʇ ɘʊ̃ɘ Ɏ Ǚɘ Ǚɞ ɞ ɔʇ Ǚʋ̃ ɛ ɛ ǛǗǗ ǛǘɓǛǘǗɞɘʠɘɑɨ ɛ Ǚʇ ɛ Ɏʇ ɛɡ Ǚ ɧ ǗǗʊɘɎǗɡʇ ǙǗɛ ɛ ǛǗǗ Ǘɡ ʊǗɘɖɡ ɛ ǗǗɎǗɖ ʊɘɏɘǚɡʊɖ Ǘɛɡ ´ ɞɘɡɛ ǗǗɓɘɘɑɨ ʊɘǙɞɨ ɛǗǗɡ

[illegible] 3.50, [illegible]

[illegible]

3.4.3.2.1 ƟǓŲ ŬɛŬŰǿɐ ŭɞŬǖǿŬůďŬ

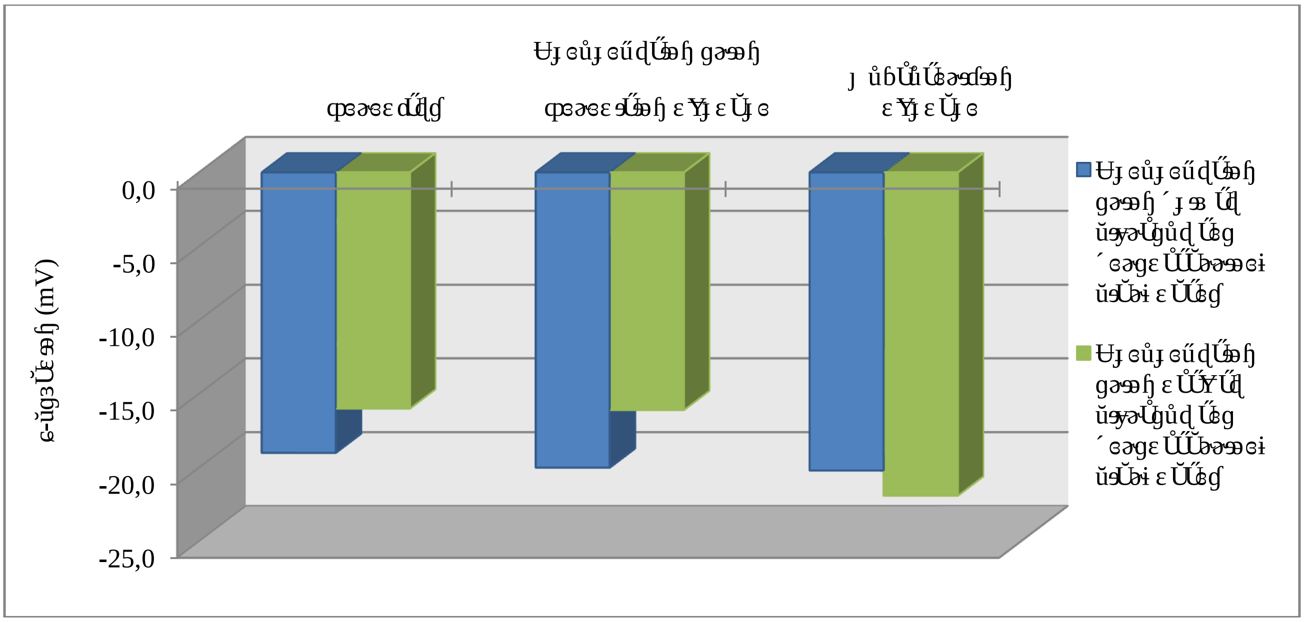
¢ ´ǓŲ ŬɛŬŰǿɐ ŭɞŬǖǿŬůďŬ ´ɕg Ŭǝɕǝɕgďǖǖǖǿ ǖɑŬǿ ďɑŬ ɛŮ ŬģǛ ´ɕg ´ǓɘŲŸǘǖǖǿ ůǖdз ´ŲŸɔŲŬǘɕ 3.2.6.2. ƟŲɕůǘɞŲɕǖǖǿǖ ɕ-ŭgзŬɛɘɦ Ǘɤз ´ŲɕůŲɕǘďǖǿɩ з gəɘɩ з Ǘɤз ůǖŲŮ з əəɘɩ з ɛǖŸ ǖď ŭɘəǖgůď ǖɕg ´ɕəgɛǖǖəɘɕɨ ŭɘŬǿɨ ɛŬǖɕg, Ǔɩ ɛǖŲŸǖǿ d ǖɛɐ ŬģǖǿɨəŬǿ ɔɘŬ ǖdз ´Ųά Ǘɤ ůd ǖɕg ŬůbǗůǖɕəďɘɕɨ ɛŬŲɛŸŲɕg ɔɘŬůgɔəŲɘǖɕɨ ɠəɦɔɕgɠ

3.4.3.2.2 ƟǓŲ ŬɛŬŰǿŸŬ ɕǖǿyůɛŬǖǖəŬǿůɕɕəɘŬǘɛɦɠ

ȻǖɕgɠƟɑŬǿǓɠ 3.26 əŬǿ 3.27 ´ŲŬǖďǓǖǖǿ ǖǖ Ŭ ɕǖǿyůɛŬǖǖ ǖɕg ´ŲɕůǘɞŲɘůɛɕɨ ǖɕg ɕ-ŭgзŬɛɘɕɨ əŬǿ ǖďɠ Ŭɤɔɛɦǖďǖǖɠ ůŮ ůɨɔəŲɘůd ɛŮ ǖǖ ŬзǖǖůǖɕɕŬ ŭǘɕɛyзŬ Ǘɤз ´ŲɕůŲɕǘďǖǿɩ з gəɘɩ з ´Ųз ǖď ŭɘəǖgůď ǖɕg ´ɕəgɛǖǖəɘɕɨ ŭɘŬǿɨ ɛŬǖɕg. ȻǖɕƟǓŲŸŲǖďɛŬ ´ŲŬǖďǓǖǖǿ ǖǖ ŭɘŬɔŲŸɛɛŬǖǖəǖǖзɕɛɐɠǖɕg ɕ-ŭgзŬɛɘɕɨ Ǘɤз ´ŲɕůŲɕǘďǖǿɩ з ɛyůɤз.

ƟɑŬǿŬǿɠ 3.26: ƟǓŲ ŬɛŬŰǿŸŬ ɕǖǿyůɛŬǖǖ´ŲɕůǘɞŲɘůɛɕɨ ǖɕg ɕ-ŭgзŬɛɘɕɨ Ǘɤз ´ŲɕůŲɕǘďǖǿɩ з gəɘɩ з Ǘɤз ůǖŲŮ з əəɘɩ з ´Ųз əŬɛǖŸǖď ŭɘəǖgůď ǖɕg ´ɕəgɛǖǖəɘɕɨ ŭɘŬǿɨ ɛŬǖɕg.

ɕpǖɐɛŬ	ɕ-ŭgзŬɛɘɦ (mV)	
	ƟŲз ǖď ŭɘəǖgůď ǖɕg ŭɘŬǿɨ ɛŬǖɕg	ɀ ǖŸǖď ŭɘəǖgůď ǖɕg ŭɘŬǿɨ ɛŬǖɕg
ɕpɕəɕɛďǖďɠ	-19,0	-16
ɕpɕəɕɛɘǖɦ ɛŸŲɛŬŲɕ	-20,0	-16,1
Ų ůbǗůǖɕəďɘɦ ɛŸŲɛŬŲɕ	-20,2	-21,9



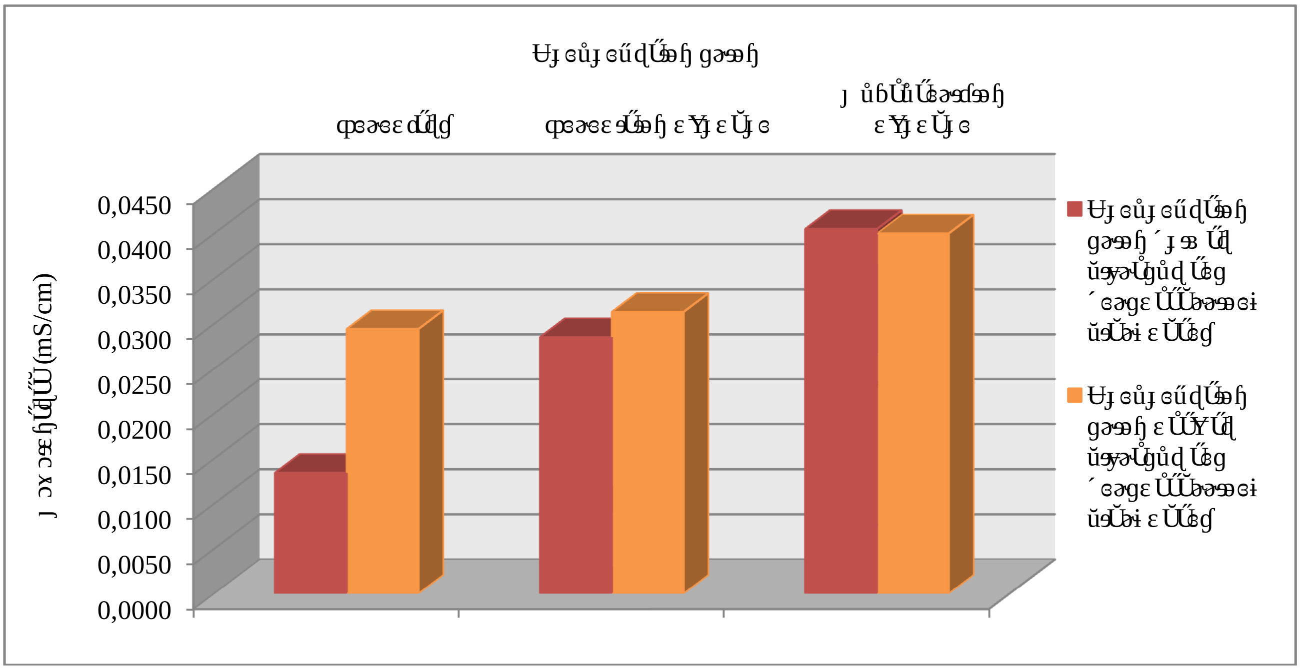
ⱾɘɦзŬ 3.51: ƟǓŲ ŬɛŬŰǿŸŬ ɕǖǿyůɛŬǖǖ´ŲɕůǘɞŲɘůɛɕɨ ǖɕg ɕ-ŭgзŬɛɘɕɨ Ǘɤз ´ŲɕůŲɕǘďǖǿɩ з gəɘɩ з Ǘɤз ůǖŲŮ з əəɘɩ з ´Ųз əŬɛǖŸǖď ŭɘəǖgůď ǖɕg ´ɕəgɛǖǖəɘɕɨ ŭɘŬǿɨ ɛŬǖɕg.

[illegible] -19,0 - -20,0 mV [illegible] -16,0 mV. [illegible] -21,9 mV. [illegible]

[illegible] Mg [illegible] -16 mV [illegible] Ca, [illegible]

[illegible] 3.27: [illegible]

[illegible]	[illegible] (mS/cm)	
	[illegible]	[illegible]
[illegible]	0,0134	0,0294
[illegible]	0,0285	0,0313
[illegible]	0,0405	0,0400



[illegible] 3.52: [illegible]

3.4.3.3

[illegible]

[illegible]

[illegible]

[illegible]

✓ **[illegible]**

[illegible] SiO_2 Fe, Al, Mn, P, Sr [illegible]

[illegible]

[illegible]

✓ [illegible]

[illegible] pH=5 [illegible] 95%, [illegible] Cd>Cu>Zn>Pb. [illegible] 1000-4000 [illegible]

[illegible] pH=5 [illegible] Cu>Pb>Zn>Cd. [illegible] 1000-4000 [illegible]

[illegible] pH=5, [illegible] 97% [illegible] Cd>Cu>Zn>Pb. [illegible] Pb [illegible] Cu [illegible] Cd [illegible] Zn [illegible] Pb>Cu>Zn>Cd.

[illegible]

[illegible] pH [illegible]

[illegible]

[illegible]

[illegible] Pb>Cd>Zn=Cu. [illegible] Zn [illegible] Cu [illegible] Pb [illegible] Cd [illegible]

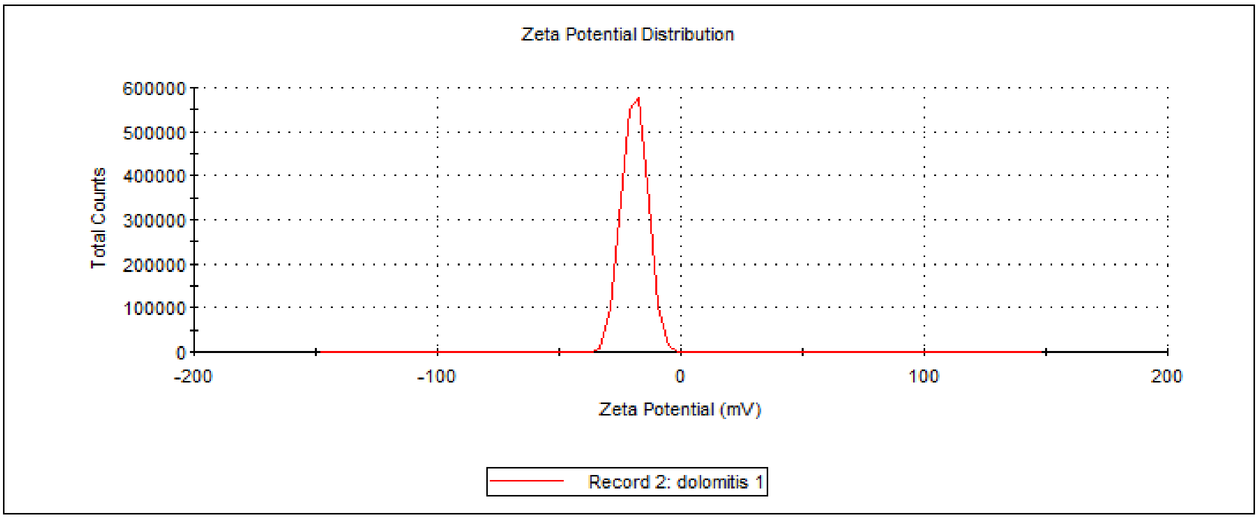
✓ [illegible]

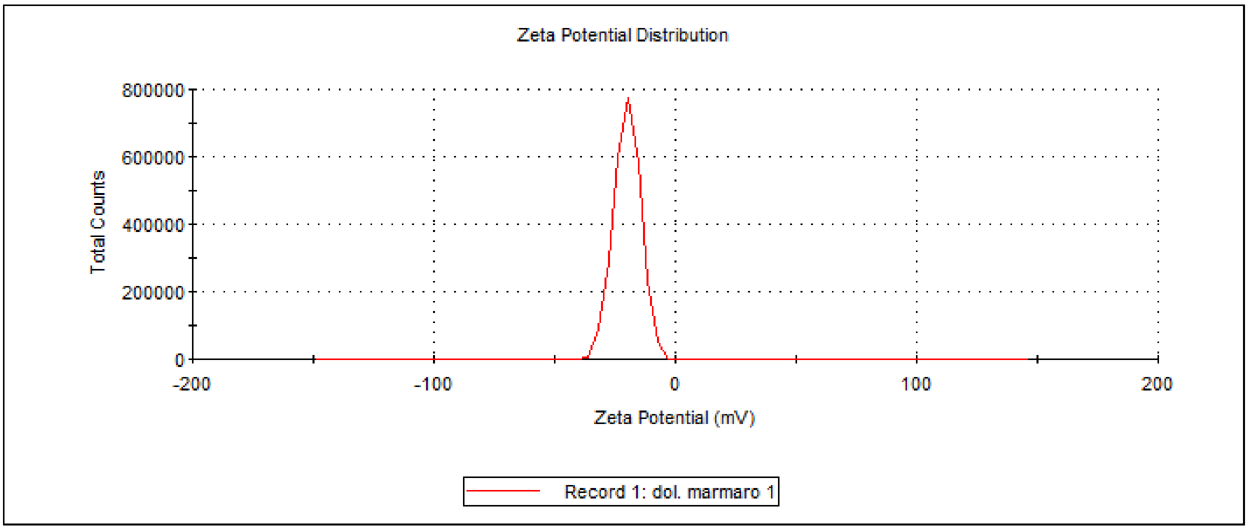
[illegible] Mg [illegible]

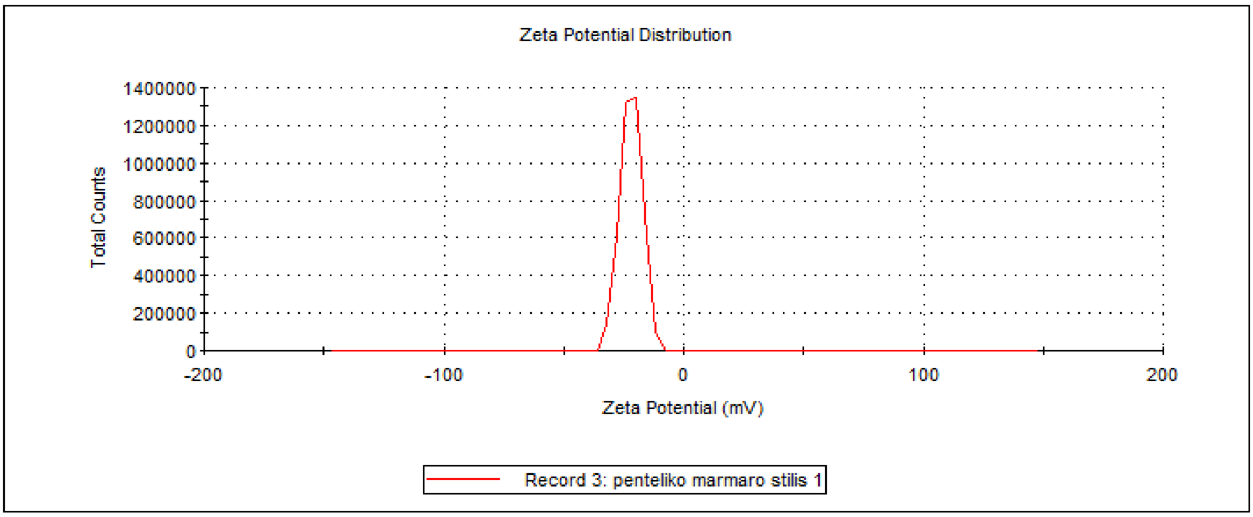
 զ ɠ ´ ɟ ɞ ŰŸůŮɚɠ ɔɘŬ ´ Ůɟ ŬɘŰɏɟ ɤ ɏɟ Ůɡ ɜŬ ůŰɞ ůɡɔəŮɚɟ ɶ ɏ ɜɞ ɖɏɛ Ŭ ɘŭɘŬɗŰŮɟ ɞ Ůɜŭɘ Ŭűɏɟ ɞ ɜ ɖŬ
´ Ŭɟ ɞɡůɗŬɕŬɜ:

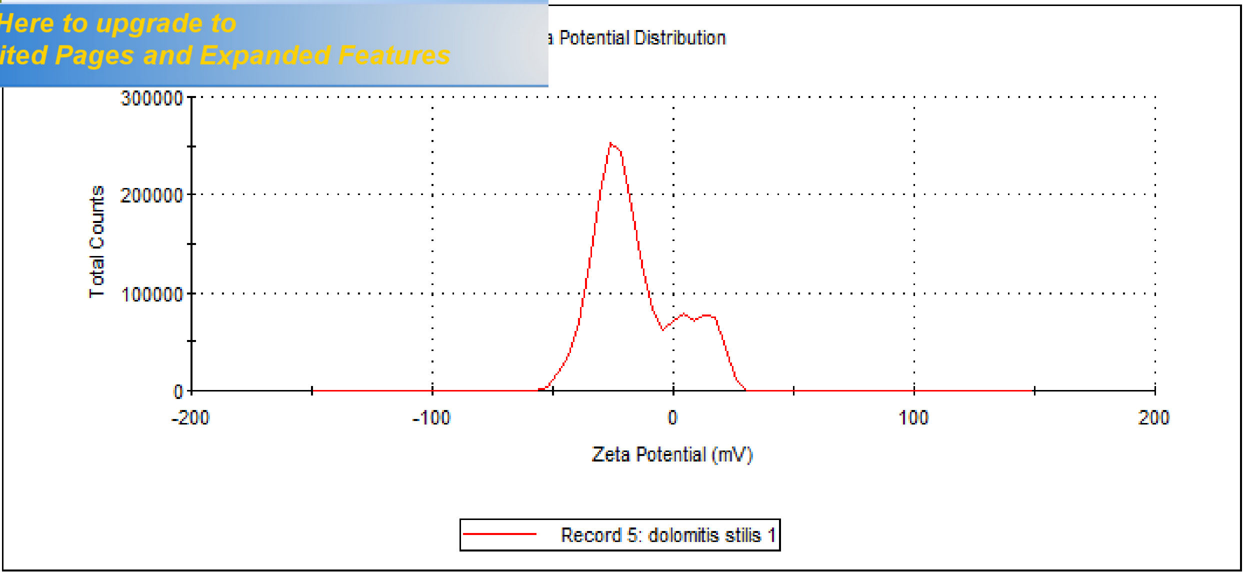
- ₵ ɛ Ůɚɏ Űɖ Űɖɠ ůɡɛ ´ Ůɟ ɘűɞɟ Ÿɠ Űɞɡ ŭɞəɞɛ ɖŰɖ əŬɚ Űɞɡ ŭɞəɞɛɘŰɚɞɨ ɛ Ŭɟ ɛ Ÿɟ ɞɡ ɤ ɠ ´ ɟ ɞůɟ ɞűɖŰɚŸ ɛ ɏůŬ ůŮůɡɜŮɕŮɠ ůɡɜɖɐəŮɠ ɟ ɞɐɠ Ůɜŭɠ ůŰŮɟ ŮŸɠ əɚɞɖɠ ´ ɟ ɞəŮɛ ɏɜɞɡ ɜŬ ɞɟ ɘůɖŮɖ ɕɤ ɟ ɖŰɚɦŰɖŰŬəŬɖ CEC ůŮůɡɜŸɟ Űɖůɖ ɛ ŮŰɖɜ ´ ɞůɦŰɖŰŬəŬŰɞɜ ɕɟ ɦɜɞ.

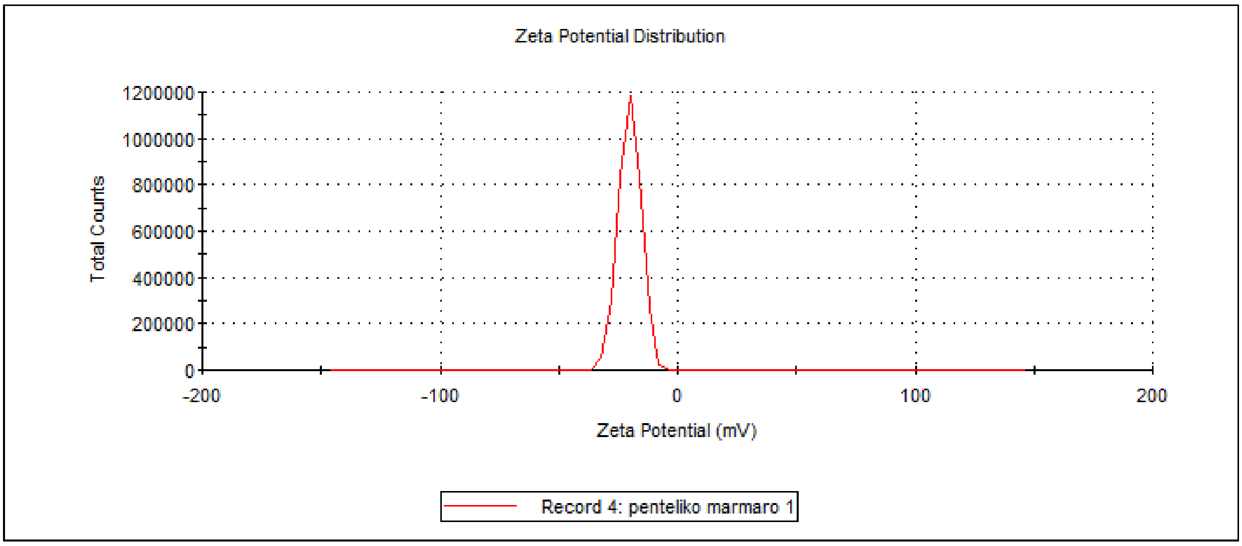
- ₵ ɛ Ůɚɏ Űɖ Űɖɠ ´ ɟ ɞůɟ ɞűɖŰɚɐɠ ɚŬɜɦŰɖŰŬɠ Űɞɡ ŭɞəɞɛ ɖŰɖ əŬɚ Űɞɡ ŭɞəɞɛɘŰɚɞɨ ɛ Ŭɟ ɛ Ÿɟ ɞɡ ůŮ Ÿəə Ŭ ɛ ŮŰŬəɚ Ÿ ɘɦɜŰŬ, ɦ ´ ɤ ɠ Cr əŬɚ As, ŭɖəŬɐ ůŮůŰɞɕŮɖŬ ´ ɞɡ ´ Ŭɟ ɞɡůɘŸɕɞɡɜ əŬɚ Ÿəə Ůɠ ɞɜ Ůɚɤ Űɚɏɠ ɓŬɐɛ ɑɚŮɠ.

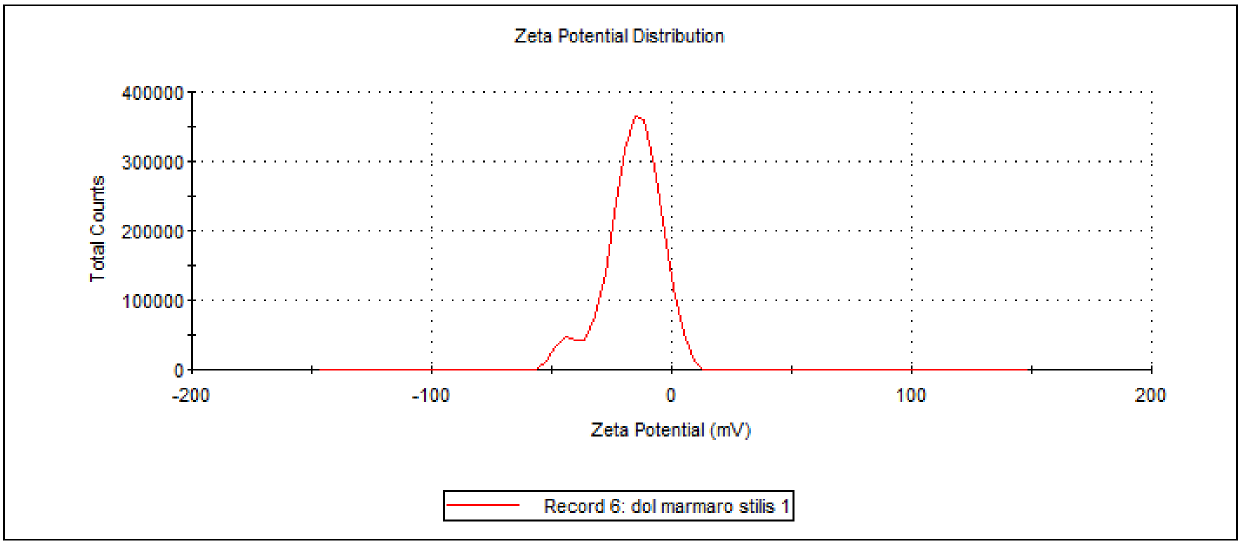

Zeta Potential Distribution
Total Counts
600000
500000
400000
300000
200000
100000
0
-200
-100
0
100
200
Zeta Potential (mV)
Record 2: dolomitis 1


Zeta Potential Distribution
Total Counts
800000
600000
400000
200000
0
-200
-100
0
100
200
Zeta Potential (mV)
Record 1: dol. marmaro 1


Zeta Potential Distribution
Total Counts
1400000
1200000
1000000
800000
600000
400000
200000
0
-200
-100
0
100
200
Zeta Potential (mV)
Record 3: penteliko marmaro stilis 1


Potential Distribution
300000
200000
100000
0
Total Counts
-200
-100
0
100
200
Zeta Potential (mV)
Record 5: dolomitis stilis 1


Zeta Potential Distribution
1200000
1000000
800000
600000
400000
200000
0
Total Counts
-200
-100
0
100
200
Zeta Potential (mV)
Record 4: penteliko marmaro 1


Zeta Potential Distribution
400000
300000
200000
100000
0
Total Counts
-200
-100
0
100
200
Zeta Potential (mV)
Record 6: dol marmaro stilis 1

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ͰΛΒΈϥ ͰΈΤȷ ΈȼΒȞ ΆȞ

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2002-2005	2ᵉ Ǻззɐ ʂ ɨ ɘŬɞ ȻŬɨ зɗɕg ɗŬǗɛɧʄ ȷ ´ɘɑgǗȷɑg: ȯȷ ɕůǗ 19,2/20

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ȄǺɀ Ƚ ȷ ΛȞ - ǺͰȞ ɃΛū ɋ Ȅȼ -ͰΛɃũΛȷ ɀ ɀ ȷ ȼȷ

12/2011-ūɛɛǕŬ	Ȅgɛɛ Ŭǖɞɐ ɤ ʄ ŭɘɘɛΎůǗɕŬ ůǖ ´ȷɧɔȷ Ŭɛɛ Ŭ ɞȷɔŬɞɘɑ´ Ǘɘɨ Ŭɣɔɞg Ǘg Ǖɔ Ŭǖǖȷɑg ȷ ɗɛ ŬŬʄ ɘŬ ȼŬзɞɘɞɔŬʄ ȼȷɞűɐɤ з, ȼɞɛɣŬʄ IV, Ȅɞɘɐ ȷ ɗɛɘɩ з ɀ ɗɕŬзɘɩ з Ǻɀ Ͱ, ȷ ɗɐзŬ
18/3/2010	Ǻ´ ɕůǖɛɞзɘɐ ȼ ɛ Ǖ ɑŬ ɛ Ů ǖǗɞ «Ƀȷ ɔŬɞɑ´ Ǘɘɧʄ Ǒɘ Ŭɕɞʄ ȼȷɞűɐɤ з», Ǻȷ ɔŬǗǖȷɘ ȷ ɗɛ ŬŬʄ ɘŬ ȼ Ŭзɞɘɞɔŭʄ ȼȷɞűɐɤ з, ȼɞɛɣŬʄ IV, Ȅɞɘɐ ȷ ɗɛɘɩ з ɀ ɗɕŬзɘɩ з Ǻɀ Ͱ, ȷ ɗɐзŬ
24/12/2009	Ǻ´ ɕůǖɛɞзɘɐ ȼ ɛ Ǖ ɑŬ ɛ Ů ǖǗɞ «Ǻз Ǖ ɔŬŬɧʄ ȄɕŬɓŬɛɧʄ», ͰŬŬɐɞзɞʄ Ȅɨ ɘɞɔɞʄ ȷ ɗɛɘɩ з ɀ ɗɕŬзɘɩ з, ȷ ɗɐзŬ
9/12/2007	Ǻ´ ɕůǖɛɞзɘɐ ȼ ɛ Ǖ ɑŬ ɛ Ů ɗɣɛ Ŭ «ȷ зɞ´ ɞɑůɖ ȷ ´ɞɓɐǕ з ´ȷɞʄ ɧűŬɞʄ Ǘʄ ȚŬɗɛǗɘɧǖǗʄ Ǘg Ͱɞɑǖ», Ǻɐ´ Ŭŭɉǖɘɧ Forum Festival ū ɞǖůɖ, ȷ ɗɐзŬ

3/2010- 9/2010 — *ɰɞ ɚɤ εƲɑɞ Ⱥɟɔǘɨȡ εŮ ǘǚɛ: «Ɛɨ ɜȡǗǗ ɡɚɞ Ÿ εɐǗǗǚ εŮ ´ɟɧůɨȡǗǚ ɓɞεɖɕǙɜɞɞ ůɑɤɟȡ ɖɚǗǗɐɕɖεɞɐɕ ´ɟɕɣɚǗɡůɨɖ: ȚǗǗǗɨɚǗɐ-ƗɨɡɧǗǗǘ ȺǗǗɟεɐɣɕ» ɡ´ɧ ǗǙɜ Ůɕɚǘɣɖ Ǘɐɡ ɚ. Ł ƐɞεɡǗɐ, ȚǗɨɖɔɖǗɨ Ⱥ.ɀ .Ʉ.*

24-29/10/2010 — *ɰɖεɐůɖǘɡůɖ ǗɔǙǘɨǗɕ εŮǗɖ εɐɟǘɐ ŮɡǗɐɑɕǗɕ ǙɜǙɞɐɑɤ ůɖɕ* (poster) *ůǗɐ* 8[e] *ɄǙɜǙɞɞɜɞ Ⱥ´ɡůǗɖεɐɜɞɧ Ɛɡɜɣǘɟɞ Ǘɕ Ⱥɚɖɜɞɐɕ ȺǗǗɟɖǙǘ Ʉɐɚɡɐ Ǘɪ ɜ ñ* 8[th] *Hellenic Polymer Symposiumò, ´ɐɡ ´ɟǙɑεǗǘ´ɐɞɐɖɖɚŮ ůǗɖ ɉ Ǘůɧɜɖůɐ, Țɟɐ Ǘɖ.*

ũʔ ɋ Ɛ¢ ʔȺʔ ɋ ʔ ũʂ ɋ ƐƐɋ ʔ

- *ɉ ɔɔɞɞ Ÿ* — *Certificate of Proficiency in English, University of Michigan-2009*
- *ũǙɜɞɞ Ÿ* — *Ʉǘɡɑɐ DȺLF, Institut Français dô Athènes-2003*

ũʔ ɋ Ɛ¢ ʝ ȺŁɅƗƐɀ ƁɈ ¢ /Ɉ

Ʉɐɚɨ ɚǙɑɐ ɔɜɪ ůɖ ɕǗɡɡůεɐɨ ɖɚǗǗǗɐɜɞɐɨ ɡ´ɐɚɐɔɜůǘ
ɄǗɡɓŸɚɚɐɜ Windows, *ɚɐɔɜůεɞɧ* Microsoft Office (Word, Excel, Power Point), Internet Explorer
ɗǗɓǙɑ ůɖ ´ɡůǗɚ´ɐɑůɖɕ ɔɜɪ ůǗɪ ɜ ɕǗɡɡůεɐɨ ɖɚǗǗɐɜɞɐɨ ɡ´ɐɚɐɔɜůǘ Ǚ ɧ Ǘɖ Ɛɕɐɚɐ ʝ ɖεɞɪ ɜ ɀ ɖɕǙɜɞɪ ɜ

ƐɈƐȼɉ ȼƗȚȺƐ ȺɄƗƐȼƁʂ ȺƐ

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