# Determination of Possibility of the Segregation Process Intensification Nickel from Ni-ores by Goles Locality,

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**Abstract**

*The same is the interest and perspective of the segregation process. The previous investigations in the field of the metal compounds chlorination, especially the chlorination of the refractory nickel minerals: garnierite and nontronite, by the chlorine, HCl or NaCl or $CaCl_2$, were determined directions, confirming the perspective of the mentioned process for the treatment of the low grade and complex minerals-laterites.*

## 1. Introduction

The principal scheme of the segregation process following by the classical concentration methods - flotation or magnetic separation and hydrometallurgical treatment - ammonia leaching is shown on the figure 1. The combined methods for enriching of the oxide-silicate nickel ores are these through which by heating the ore with coke and $CaCl_2$ at high temperature metal nickel is formed on the present coke, or on the silicates which are the component parts of the ore.

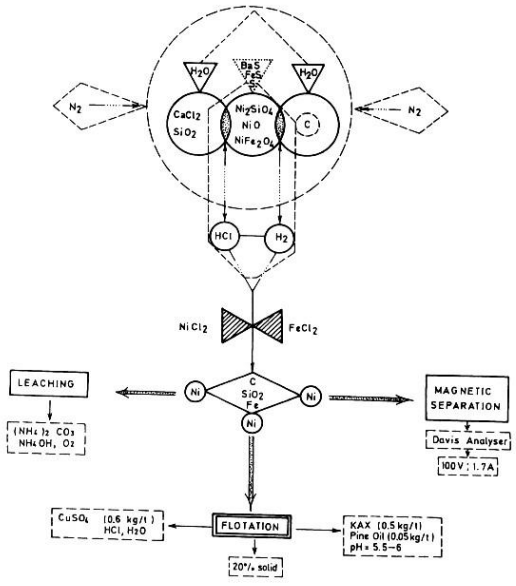


Fig. 1 Principal scheme of segregation process

## 2. The general behaviour of the nickel bearing minerals

For the metallurgical calculation Ni in the oxide-silicated minerals may be shown by means of the general formula:

**$NiSiO_3.mMgSiO_3.nH_2O$; $(Si_2O_5)^{2-} \Rightarrow (SiO_4)^{2-} \Rightarrow (SiO_3)^{2-}$; $NiO.2SiO_2 \Rightarrow 2NiO.SiO_2 \Rightarrow NiO.SiO_2$**

The iron in these Ni - bearing minerals and ores is appeared as **$Fe_2O_3.nH_2O$** and as a nontronite **$(Fe,Al)_2(Si_4O_{10})(OH)_2.nH_2O$**. The oxide-laterite ores are with low nickel content. The generaly, nickel and iron are as **Ni-Fe-limonite $(Fe,Ni)O(OH).nH_2O$** or in the talc form, **$(Mg, Ni)_3 (Si_4O_{10}) (OH)_2 H_2O$**.

***Serpentine:*** $Mg_6 (Si_4O_{10}) (OH)_8$

$Fe^{2+}$; $Fe^{3+}$ Al; Cr — $Fe^{3+}$; Al; Cr

$(Mg, Fe^{2+}, Ni)_{6-x} (Fe^{3+}, Al, Cr)_x / Si_{4-x} (Fe^{3+}, AL, Cr)_x O_{10} / (OH)_8$

***Talc***: $(Mg, Ni)_3 (Si_4O_{10}) (OH)_2 H_2O$

$Fe^{3+}$, $Fe^{2+}$ — Al

$(Mg, Ni)_3 / Si_{3,75} Al_{0,25} O_{10} / (OH)_2 H_2O$ - chlorite (saponit)

**$NiSiO_3 + 2HCl = NiCl_2 + H_2O + SiO_2$**

**$Ni_2SiO_4 + 4HCl = 2NiCl_2 + 2H_2O + SiO_2$**

**$NiFe_2O_4 + 6HCl = NiCl_2 = 3H_2O + 2FeCl_2$**

**$2NiO.SiO_2 + 6HCl + BaS\ (FeS) = 2NiCl_2 + BaCl_2\ (FeCl_2) + 2SiO_2 + 2H_2O + H_2S$**

**$NiFe_2O_4 + 8HCl + BaS\ (FeS) = NiCl_2 + BaCl_2\ (FeCl_2) + 2FeCl_2 + 3H_2O + +H_2S + ½\ O_2$**

The thermodynamic characteristic of the above mentioned reactions are performed using the standard isobaric potential and for working on the kinetic characteristic of the chlorination - segregation process have used the equations which describe the reaction controlled by three-dimensioned surfaces advancement (diffusion-controlled reactions and reaction-controlled reactions).

## 3. The experimental investigations from the nickel bearinmg ore Goles by segregation process

The segregation process of the nickel bearing ore Goles and chlorination addition $CaCl_2.2H_2O$, reduction coke is conducted at the temperature (1023-1223$^oK$) with retaining time (20-120 min) in the atmosphere of $N_2$. The experimental investigations by the addition-activator 2% (BaS, FeS, S or $BaSO_4$) influence on the metallurgical indicators from combined processes **segregation-flotation-magnetic separation-ammonia leaching** are shown about the ore samples from various ore samples.

Table 1. Result obtained from segregation - flotation - magnetic separation -ammonia leaching

| ORE GOLES | T ($^0$C) | t (min) | Flotation $R_{Ni}$ (%) | Magnetic sep. $R_{Ni}$ (%) | Leaching $R_{Ni}$ (%) |
|---|---|---|---|---|---|
| | | 20 | 1.62 | 1.50 | 1.70 |
| 1,25%Ni | 750 | 40 | 3.41 | 3.05 | 3.65 |
| | | 60 | 3.89 | 3.20 | 4.10 |
| | | 20 | 8.43 | 7.80 | 8.70 |
| **I** | 850 | 40 | 17.66 | 16.50 | 18.25 |
| **Goles +** | | 60 | 25.43 | 21.25 | 27.10 |
| **2% BaS** | | 120 | 45.40 | 42.30 | 46.50 |
| | | 20 | 28.32 | 25.10 | 30.05 |
| | 950 | 40 | 40.78 | 37.20 | 42.45 |
| | | 60 | 44.78 | 40.00 | 5.75 |
| | | 120 | 60.98 | 56.70 | 65.10 |
| | | 20 | 1.90 | 1.70 | 2.15 |
| | 750 | 40 | 3.82 | 3.25 | 4.20 |
| | | 60 | 5.48 | 4.85 | 6.10 |
| | | 20 | 14.36 | 12.10 | 16.10 |
| **II** | 850 | 40 | 25.17 | 22.10 | 27.10 |
| **Goles +** | | 60 | 37.40 | 33.45 | 40.00 |
| **2% BaS** | | 120 | 55.60 | 51.50 | 56.50 |
| | | 20 | 36.85 | 32.40 | 39.60 |
| | 950 | 40 | 47.24 | 43.70 | 50.00 |
| | | 60 | 58.73 | 55.10 | 64.05 |
| | | 120 | 76.35 | 71.35 | 78.40 |
| | | 20 | 2.18 | 1.70 | 2.55 |
| | 750 | 40 | 3.82 | 3.25 | 4.20 |
| | | 60 | 6.84 | 5.25 | 7.65 |
| | | 20 | 17.55 | 16.50 | 18.25 |
| **III** | 850 | 40 | 28.40 | 25.05 | 30.00 |
| **Goles mix** | | 60 | 44.65 | 40.00 | 46.00 |
| **+** | | | | | |
| **2% BaS** | | 120 | 58.60 | 55.00 | 61.30 |
| | | 20 | 33.42 | 30.15 | 35.10 |
| | 950 | 40 | 50.41 | 44.10 | 52.05 |
| | | 60 | 59.25 | 56.00 | 65.00 |
| | | 120 | 80.70 | 76.40 | 82.10 |

The partial chemistry composition from the ore samples (100% - 0,150mm and 100% - 0,100mm) are from 1,25%Ni, 1,37%Ni Goles I (both in Kosovo-Yugposlavia ), 1,2%Ni and 1,86%Ni Goles II (both in Kosovo-Yugoslavia).

## 4. The experimental investigations from the nickel natural ores by segregation process

The experimental investigations by the addition-activator 2% (BaS,FeS,S or $BaSO_4$) influence on the metallurgical indicators from combined processes **segregation-flotation-magnetic separation-ammonia leaching** are shown about the ore samples from various deposits. The partial chemistry composition from the ore samples (100% - 0,150mm and 100% - 0,100mm) are from 0,85%Ni Studena voda, 0,97%Ni Rzanovo (both in Macedonia), 1,2%Ni and 1,86%Ni Rudjinci I & II (both in Yugoslavia).

Table 3. Results obtained from segregation - flotation of the ore samples (100% -0.150mm)

| Ore sample | BaS (%) | Recovery (%), $R_{Ni}$ | | |
|---|---|---|---|---|
| | | Flotation | Magnetic separat. | Leaching |
| Goles I | 0.0 | 46.50 | 54.70 | 60.20 |
| | 2.0 | 55.45 | 60.85 | 66.10 |
| | 3.5 | 63.70 | 65.60 | 69.35 |
| Goles II | 0.0 | 56.85 | 55.30 | 57.60 |
| | 2.0 | 70.10 | 66.60 | 68.20 |
| | 3.5 | 82.30 | 80.70 | 85.10 |
| Goles I | 0.0 | 62.50 | 60.25 | 63.10 |
| | 2.0 | 78.60 | 75.30 | 80.20 |
| | 3.5 | 85.00 | 83.20 | 86.75 |
| Goles II | 0,0 | 65,00 | 70,00 | 68,00 |
| | 2,0 | 78,50 | 80,50 | 82,30 |
| | 3,5 | 88,00 | 89,50 | 90,50 |

## 5. Conclusion

The combined processes **segregation-flotation-magnetic separation ammonia leaching** by the synthetic mixures and appropriate ore samples (various nickel content) have achieved satisfactory results related on the metal recoveries. The existing environmental problems will lead to increased interest in combined processes or hydrometallurgical processes. These include combined processes: **segregation-flotation-ammonia leaching** or some other process as an oxidation and bio oxidation.

## 6. References


1. KRSTEV B.: Research into Possibilies of Intenzification of Segregation Roasting of Laterite Nickel Ores at Localite from Cikatovo and Rudjinci Subject to Nickel Concentration, TEHNIKA, RGM 38 1987, N$^{o}$ 2, p.171-174, Belgrade, YU
2. KRSTEV B.: Detarmination of Possibility of the Segregation Process Intenzification Nickel from Ni-ores by Goles Locality,Third Meeting of CTK & Second YU Simposium of RM, Pristina , YU, 1986
3. KRSTEV B.: Summary of a Situation from Laboratory Investigation of Yugoslav Nickel Bearing Ores by Segregation-Flotation-Magnetic Separation, IV Simposium of Metal-lurgy, SHD, Belgrade, YU, 1988
4. KRSTEV B.: A Contribution of Research by Chlorinaton from Nickelsilicate and Nickelferite in the Presence of Calciumchloride and Coke with Possibilities of their Intenzification,IV Simposium of Metallurgy, SHD, Belgrade, YU, 1988
5. KRSTEV B.: The Kinetic of the Flotation Process by Chlorinated Nickel Compounds from Mixures after Segregation, YU-Simposium of Mineral Processing, Smederevo,YU, 1995
6. TAYLOR A.: Laterites-has the time finally come, Mining Magazine, 1995
7. TAYLOR A.: Nickel Laterites Processing, Mining Magazine, 1996
8. KRSTEV B.: Processing of Low-Grade Nickel Bearing Laterites, NEW TREND in MINERAL ROCESSING, Ostrava, Chech Republic 1999