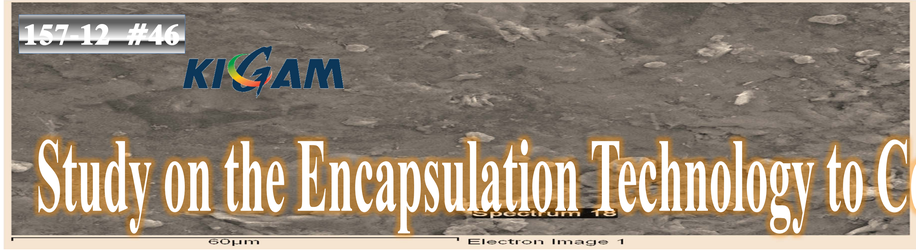


Study on the Encapsulation Technology to Control the Acid Mine Drainage Development

Yim Gil-Jae[1], Ji Sang-Woo[1], Cheong Young -Wook[1], Seo Eui-Young[2], Chae Byung-Gon[1]

1) Korea Institute of Geoscience and Mineral Resources (KIGAM), 92 Gwahang-no, Yuseong-Gu, Daejeon 305-350, Korea, gjyim@kigam.re.kr

2) Kangwon National University, Chuncheon, 200-701, Korea

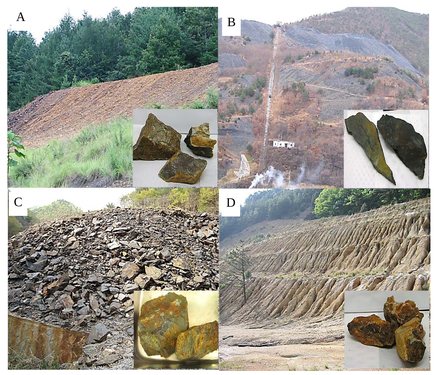
ABSTRACT: The purpose of this study is to develop the technology which prevents the acid mine drainage and the contaminations due to surrounding rock wastes for mine cavities generated by mining developments. To achieve the goals, encapsulation studies on the sulfide minerals existed in the mine cavities will be executed as one of the source control water contamination preventing technology to suppress the acid mine drainage development. For the source control, from the results of rice meter tests for applying calcium silicate as encapsulation liquid, specimens from 4 other zones maintain the encapsulation effects after 3 months (Most specimen of calcium silicate 1M and 0.5M increase from pH3 to pH6-7.). Increasing effects of pH have been confirmed through encapsulation, and encapsulation effects based on proper particle size were increased. Liquid using calcium silicate has been developed as the encapsulation liquid to suppress the acid mine drainage development and process which applies this liquid to mine cavities and mine waste dumps has been established. Also, from encapsulations, pH increasing effects and decreasing of Fe and sulphate were confirmed. From these results, it is judged that 1M (mole) of liquid is the liquid which can be applied to the mine cavity and mine waste dump.

key words : Acid mine drainage, Encapsulation, Calcium silicate, Goaf

Introduction

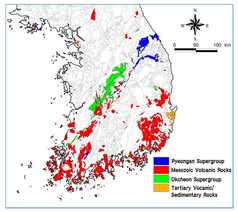
Acid mine drainage generated in mining areas are created by reactions between rocks containing sulfide minerals and oxygen in the atmosphere or surface water. If metal mine or coal mine is abandoned, and pump drainage in the mine is stopped, mine cavity, shaft and conveyance road will be filled with ground water. Because these kinds of underground spaces will be the path of mine water, stratum of vadose zone is contacted with mine water while water level is increased as time passes, geochemical properties of mine water will be changed. This change generates the acid mine drainage or leachate from goaf or rock waste resulting contaminations. Because there are a lot of pyrites in the sulfide mineral causing acid mine drainage, it is recognized as the main reason for acid mine drainage development. Other than this, sulfide minerals such as pyrrohotite, marcasite, chalcopyrite and asenopyrite generates the acid if they are exposed to the surface, they lower pH of surrounding natural water. Also, due to elutions of Al, Mn, Zn, Cd and Pb, acid mine drainage containing heavy metals can be generated. It has been reported that water contamination in the mine water is expected when total sulfur contents in the stratum is more than 1% (Younger et al., 2002). Because acid mine drainage is discharged for long time continuously, it causes serious contamination on the surrounding watershed or soil environment. This will cause serious economic losses. Thus, basic establishing the plan to prevent the acid mine drainage development before mine is abandoned will be prepared

Materials & Methods

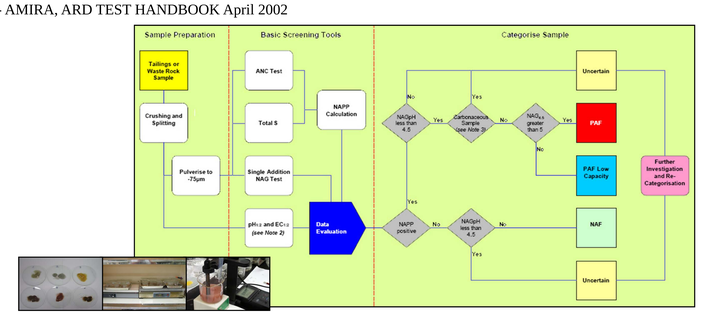


A : Gneiss of abandoned metal mine
B : Shale of abandoned coal mine
C : Phyllite of construction area
D : Andesite of abandoned nonmetal mine

Fig 1. Distribution of Sulfidic Mineral Bearing Rocks in Korea (Lee et al. 2005).



- ABA(Acid Base Accounting) test - Sobek method (EPA-600/2-78-054)
  - AMIRA, ARD TEST HANDBOOK April 2002



1. Fizz Test : achieved by placing a small amount of pulverised sample (approximately 0.5 g) on a ceramic plate. One or two drops of 1:3 HCl (approximately 8% HCl) is then added to the sample. The presence of CaCO3 is indicated by a bubbling or audible "fizz" (effervescence). A rating is then given to the scale of reaction obtained as indicated in Table 1.

Table 1."Fizz Ratings" and Associated Acid Quantities and Concentrations to be used in the ANC Determination.

Reaction	Fizz Rating	HCl		NaOH Molarity (M)
		Molarity (M)	Vol. (ml)	
No Reaction	0	0.5	4	0.1
Slight Reaction	1	0.5	8	0.1
Moderate Reaction	2	0.5	20	0.5
Strong Reaction	3	0.5	40	0.5
Very strong reaction	4	1	40	0.5
	5*	1	60	0.5

*5 is used for very high ANC material (> 400 kgH2SO4/t)
e.g. limestone

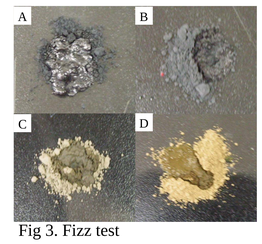


Fig 3. Fizz test

2. ANC (Acid Neutralizing Capacity) test

measure of the buffering capacity or inherent neutralising ability of the material (often due to the presence of carbonate minerals).

ANC (kg H_2SO_4/t) = [Y × M_{HCl} / wt] × C

Y = (Vol. of HCl added) - (Vol. of NaOH titrated × B)
B = (Vol. of HCl in Blank) / (Vol. of NaOH titrated in Blank)
M_{HCl} : Molarity of HCl
wt : Sample weight in grams
C : Conversion factor (C = 49.0 to calculate kg H_2SO_4/t)

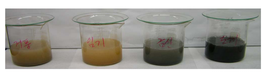


Fig 4. ANC test

3. MPA (Maximum Potential Acidity) test

can be generated by a sample is determined from the sample sulphur content.

MPA (kg H_2SO_4/t) = total S(%) x 30.6

4. NAPP (Net Acid Producing Potential)

used to indicate if a material has potential to generate ARD.

NAPP (kg H_2SO_4/t) = MPA - ANC

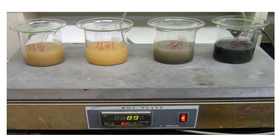


Fig 5. NAGpH test

5. paste pH and EC (Electric Conductivity)

determined by equilibrating the sample in deionised water for 12 –16 hours (or overnight), at a solid to water ratio of 1:2 (w/w).

gives an indication of the inherent acidity and salinity of the waste material when initially exposed in a waste emplacement area.

6. NAG (Net Acid Generation) pH

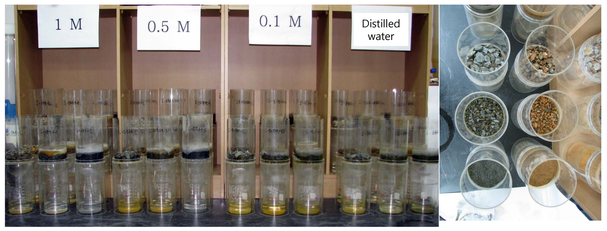
reaction of a sample with hydrogen peroxide to rapidly oxidise any sulphide minerals contained within a sample.

end result represents a direct measurement of the net amount of acid generated by the sample.

1. Test of Calcium Silicate($CaSiO_3$) liquids mixture

Performed using samples pH1:2 & EC1:2, ABA(Acid Base Accounting test), NAPP(Net Acid Producing Potential) and NAG(Net Acid Generation)

- $CaSiO_3$ of three different concentrations (0.1, 0.5 and 1M) and distilled water
- in each container of 300g waste rock
- 300mL of distilled water makes irrigation
- observed of variations of pH, EC, Ca, Fe, Mn and Na

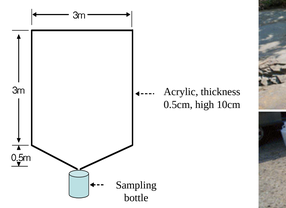


2. Test of Calcium Silicate($CaSiO_3$) encapsulation

- Create a liquids of $CaSiO_3$ 0.1, 0.5 and 1M
- According to the process established
- Liquid encapsulation waste rock and rock fragment

3. Construction site of Calcium Silicate($CaSiO_3$) encapsulation

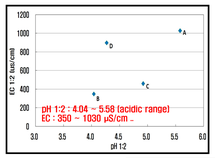
- **Test site :** Road cut slopes



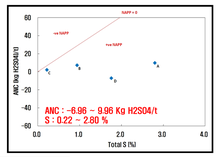
Result and Discussion

Sample	pH1:2	EC1:2 (μS/cm)	Total Sulfur (%)	MPA (kg H2SO4/t)	ANC (kg H2SO4/t)	NAPP (kg H2SO4/t)	NAGpH	$NAGpH_{7.0}$ (kg H2SO4/t)	ANC/MPA	ARD Classification	MPA/ANC
A	5.58	1030	2.80	85.68	9.96	75.72	2.73	5.351	0.12	PAF	8.61
B	4.04	350	0.94	28.79	7.35	21.44	2.46	4.822	0.26	PAF	3.92
C	4.92	460	0.22	6.73	2.25	4.48	2.39	4.684	0.33	PAF	2.99
D	4.27	900	1.76	53.86	-6.96	60.82	2.22	4.351	-0.13	PAF	7.73

- Result of Paste pH and EC : - pH is generally acidic,
  - free hydrogen ions in the waste rock are highly encapsulation,
  - EC also showed high values,
  - Therefore, many containing a soluble substance.

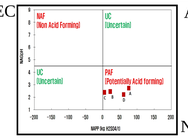


Paste pH vs. EC



ANC vs. Total Sulfur

- Through the relationship of NAG_{pH} and NAPP to classify rocks :
  - All samples corresponds to PAF (Potentially Acid Forming)
  - potential to generate acid rock drainage

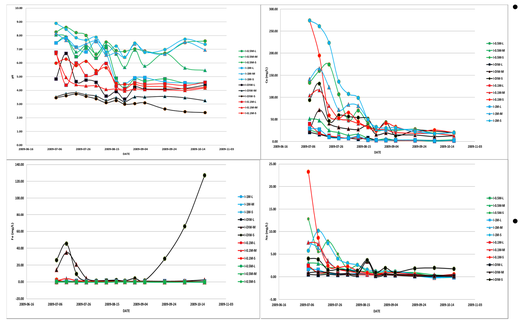


NAGpH vs. NAPP

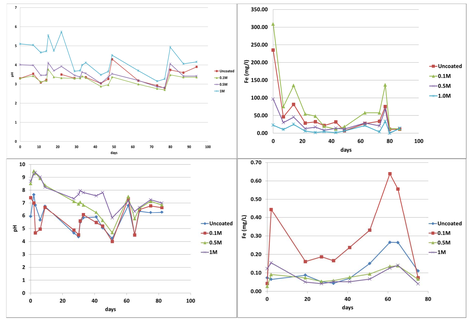
Viscosity test(rpm:250)	Silica sol 5ml Injection (cP value)	Silica sol 15ml Injection (cP value)	Silica sol 30ml Injection (cP value)
1M(each 200ml) cP=2.02	14.0	54.1	Over range
0.5M(each 200ml) cP=1.30	2.72	26.2	Over range
0.1M(each 200ml) cP=1.33	1.40	1.45	3.98
Distilled water(each 200ml) cP=1.37	1.36	1.34	1.36

Mixing ratio of Calcium silicate and Silica sol

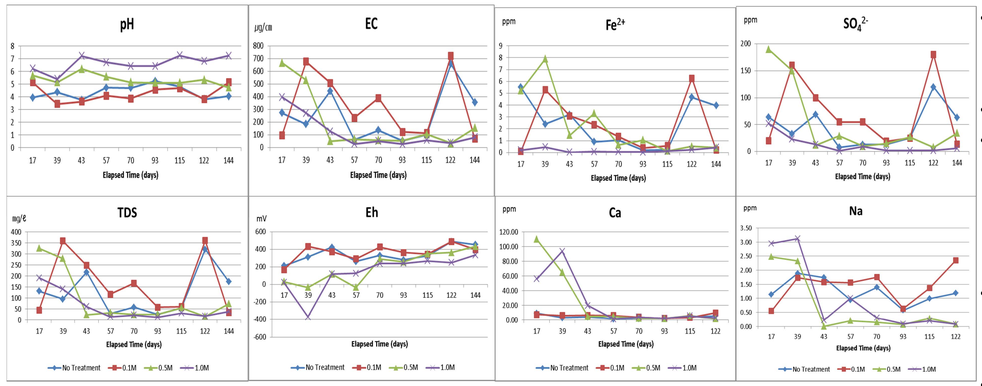
1M = 232g(CaSiO3) + 2000g(water) + 50(silica sol)
0.5M = 116g(CaSiO3) + 2000g(water) + 50(silica sol)
0.1M = 23g(CaSiO3) + 2000g(water) + 50(silica sol)



- For the source control, from the results of rice meter tests for applying calcium silicate as encapsulation liquid, specimens from 4 other zones maintain the encapsulation effects after 3 months (Most specimen of calcium silicate 1M and 0.5M increase from pH3 to pH6-7.).
- Increasing effects of pH have been confirmed through encapsulation, and encapsulation effects based on proper particle size were increased.



- Liquid using calcium silicate has been developed as the encapsulation liquid to suppress the acid mine drainage development and process which applies this liquid to mine cavities and mine waste dumps has been established.
- Also, from encapsulations, pH increasing effects and decreasing of Fe and sulphate were confirmed.
- From these results, it is judged that 1M (mole) of liquid is the liquid which can be applied to the mine cavity and mine waste dump.



- measurement results of on the surface encapsulated water quality monitoring at Road cut slopes :
  - non-treated area is measured to the pH4
  - treat area(1M) is measured to the pH7 although 5 months have passed.
- EC value becomes the leaching up a lot at first stage and is stabilized after 50 days
- Result of chemical analysis
  - leaching is minimized in Ca value after 50 days
  - ferrous was analyzed except a 0.1M area so that it was very low
  - Na value was leaching to the minimum after 60 days
  - Al and Sulphate ion value were analyzed for small value compared with a non-treat area
- If results constructed in the site were reviewed, it is confirmed that Ca contents were generated continuously. Also, tiny quantities of Fe, Al, Mn and Na were generated, but there were no decreases of contamination and secondary environmental contamination.
- Through securing more long-term data, the evaluation of encapsulation capabilities are needed.

This research was supported by the Research Project of the Korea Institute of Geoscience and Mineral Resources (KIGAM) funded by the Ministry of knowledge Economy.

Ministry of Knowledge Economy