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THE EFFECTS OF CLINO TOBERMORITE MINERAL FOR LIGHT WEIGHT CEMENT ON SIMULATOR CURING CHAMBER CONDITION

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ABSTRACT

The cement slurry to be set on bore hole wall arround of casing string, and so hardenner. On the bottom hole condition changers (based on simulator curing chamber), the characterization of cement such of changer strength, porosity, C/S ratio and caused mineralization. For the anticipated that conditions, the cement slurries to be added lightweight aditive (expanding and microsphere ceramics local), so results of characteristic cement is good (permeability, density, rheology, and strength). Results of the research are cement hardener good because any changes of mineralization tobermorite to clino tobermorite, by density 11-12 ppg (based on 15.8 ppg), thickening time 2 hours at 70-100 uc, so thats results can be applied on offshore oil and gas or geothermal fields

Keywards : The cement slurry, bore hole, expanding additive, strength retrogression additive, lightweight additive

ABSTRAK

Semen pemboran diset didasar lubang sumur antara pipa selubung dan dindang lubang bor. Semen tersebut kemudian mengeras dan mengalami beberapa perubahan karaterisasi sifat fisik seperti strength, permeability, porositas, C/S ratio dan mineralisasi akibat perubahan kondisi lubang bor yang disimulasikan pada simulator curing chamber. Untuk mengantisipasi perubahan tersebut diperlukan tambahan aditif pengembang yaitu expanding additive, aditif pencegah strength retrogression, dan aditif lightweight cement Parameter yang didapat adalah besarnya permeabilitas semen membatu, densitas semen slurry dan rheology, jenis mineral semen membatu, dan kekuatan gaya geser atau shearbond strength

Hasil penelitian ternyata adanya perubahan bentuk kristalisasi mineral pencegah strength retrogression dari tobermorite ke clino tobermorite, dan gradient tekanan yang terjadi berkisar 11-12 ppg, dibanding gradient yang umum digunakan sebesar 15.8 ppg, dengan thickening time sekitar 2 jam pada harga 70-100 uc. Hasil penelitian tersebut dapat digunakan pada daerah lapangan migas lepas pantai dan pada lapangan panasbumi

Kata kunci : Semen pemboran, lubang bor, aditif pengembang, aditif pencegah, aditif *lightweight*.

1. INTRODUCTION

The high temperature cementing is one of those problem, high temperature cementing consist of steam recovery wells, geothermal wells and ultra deep wells. The recent condition of reservoir is depletion pressure and almost reservoir trap found any fault and crack. Anticipated that used gradient pressure cement is low density and strong strength. Cementing is to isolate the annulus between the casing and wellbore in order to prevent communication between the various formation layers.

Besides its function as previously mentioned, cementing in the drilling operation may carry the following objectives :

1. Support the casing against the formation.
2. Protects the casing against underground environment effects, such as high pressure.
3. Prevent gas or high-pressure formation fluids movement into annulus casing-wellbore that may raise trouble at the surface.
4. Reduce gas-oil ratio, water oil ratio and water-gas ratio.

5. Minimize casing wear.

In order to achieve a good cementing job it requires accurate data obtained from the well bore, good cementing technique, proper cement suspension characteristics and cement quality.

This paper will discuss the effect of the addition of Expanding additive local from Wonosari and Tuban to performance of cement slurry and quality cement hardener on simulator curing chamber conditions (HTHP).

Nearly all cement slurry characteristics will affect the cement quality upon placement. A low cement slurry density will result in a low compressive strength, which may be caused by a high water cement ratio (WCR) used in the preparation of the cement slurry.

Cementing at high temperature requires a low cement density, impermeable and high cement strength by occurs formed mineralization, on first gel C-S-H, alpha diCa-S-H, Tobermorite etc. Because that, cement slurry has density is high, to reduce it to used ceramic powder. Meanwhile in order to increase the cement strength at high temperature can be attained by use of silica flour as special additive, and prevent shrinkaged by expanding additive.

2. REVIEW OF LITERATURES

Cement and additive if mixed with water results in a cement hydration process followed by a cement setting process. The definition of cement hydration process itself can be described as a chemical reaction between solids and liquids, in which mixtures eventually sets. On cement suspension, the hydration process happens between clinker, calcium sulfate and water, which causes the cement slurry to set.

The hydration of Portland cement is a sequence of overlapping chemical reactions between clinker components, calcium sulfate and water, leading to continuous cement slurry thickening time and hardening. Although the hydration of C_3S is often used as a model for the hydration of Portland cement, it must be kept in mind that many additional parameters are involved.

The hydration of Portland cement is a complex process of crushing/settling. Unlike in the pure single phase, the various multi component hydration reaction works at different rates. It influences between phases for example : the C_3A hydration modified by the presence of C_3S in which the formation of calcium hydroxide will reduce the C_3A by gypsum. The clinker contains certain impurities, this depends on the composition of its raw material in which within each composition contains different oxides.

As a consequence of the impurities the hydration also becomes impure, in which C-S-H gel tends to bond with aluminate, iron oxide and sulphur, meanwhile ettringite and monosulpho-aluminate contains silica. Calcium hydroxide in this case also contains certain amount of other ions.

2.1. Hydration Processes

Hydration is a chemical reaction between solids and liquids, in which mixtures of both will eventually sets into solid. In the cement slurry used in the cementing job, the hydration taking place is between clinker, calcium sulfate and water, which results in a set cement at the end of the process.

Among the main factors affecting the hydration process of Portland cement is formation temperature. High temperature may accelerate the rate of hydration, but in the other hand it can affects the cement stability and change the cement component morfology. The hydration phenomenon of Portland cement based on temperatures can be classified into two categories, that is : low temperature and high temperature hydration.

At low temperature hydration, the components of Portland cement is anhydrous, which means when it comes in contact with water the cement components breaks apart and hydrates in which eventually turns to set cement. Meanwhile at high temperature hydration above 110^{0}C, the process begins with the formation of Alpha Dicalcium Silicate Hydrate (α-C_2SH) which changes the cement components.

Composition that can affect the cement strength usually known as Strength Retrogression (introduced by Swayze 1954). Strength retrogression is overcomed by addition of silica flour as special additive into the cement prior of mixing it with water.

C-S-H gel is a material with excellent binding characteristics especially at temperatures up to 230°F (110°C). At higher temperature, C-S-H gel is subject to metamorphosis, which usually results in a decreased compressive strength and increase in permeability of the set cement. This process known as Strength Retrogression was first reported by Swayze (1954).

C-S-H gel often converts into a phase known as alpha dicalcium silicate hydrate (α-C_2SH), which is highly crystalline and much denser than C-S-H gel. As a result, it affects the compressive strength and permeability of set cement at a temperature of 230°F (110°C).

The strength retrogression can be prevented by adding silica flour into the cement prior of mixing with water. The main purpose is to approximate a C/S ratio of 1.0. It must be noted that commercial cement has a C/S ratio around 1.5, therefore the amount of silica needed to reach the desired C/S ratio value is 35% (Menzel, Klousek, Carter and Smith).

1.2. Light weight and Expanding Additives

Light weight additive is extender additive used in reducing the density of cement therefore it is applicable in formation that easily collapse. Microsphere is an extender having a specific gravity of 0.4 to 0.6, and as cementing technology adavances, use of microsphere becomes more common.

There are two types of microsphere, glass microsphere and ceramic microsphere. This research uses ceramic microsphere. Preparation of cement slurry using microsphere is developed in order to give certain values of cement slurry static pressure having a low density which may influence the strength-density ratio of the cement. Microsphere owes some advantages and disadvantages, the higher the composition of microsphere tends to reduce the density of cement but it reduces the compressive strength and shear bond strength as well.

Expanding additive of cements means that expanding of cement relative volume due to cement bulk expansion (Danjuschewskij, 1983). It is caused by:

1. Chemical contraction that formed another hydrated product on liquid phase condition, i.e. crystallizing of dissolved salt at high temperature.
2. The presence of expanding materials in cement slurry before hardened condition, i.e. lime, periclase, $CaSO_4$, etc.
3. The presence of electrolyte around the cement bulk after the hardened condition.

The part 2 is merit condition that might bring to increase the shear bond strength, and also the expansion effect could be controlled by arranging the burning temperature and surface area of the expanding materials.

During the interim, a number of expanding additives have become available from the service industry; most of these are patented and therefore unknown composition and efficacy.

Under borehole conditions, many of the known additives, such as powdered aluminium or ettringite-forming products, present problems with respect to affectivity or controllability, or both, because of the expansion mechanism involved. Even under atmospheric conditions, several cements do not exhibit any expansion at all, but merely a decrease in volumetric shrinkage.

Danjuschewskij in 1980 proposed lime and periclase as expanding additives to create expanding cement. He found the expansion effect more than 1% and up to 25% in specific condition. Several other investigations also had been conducted on the effectivity of expanding cements based on these calcium and magnesium oxide additives. Both materials are characterized by the capability of influencing the reactivity and thus the swelling behavior by way of the manufacturing process.

Industrially, lime and periclase are usually manufactured by calcining of calcium and magnesium carbonates (liberation of CO_2, deacidification). In contrast to other expanding additives, lime and periclase provide two possibilities of influencing the reactivity (hydration activity) by means of the manufacturing process.

Decreasing the reactivity by increasing the calcining temperature during manufacture of the swelling additive, as well as, Increasing the reactivity by augmenting the specific surface area of fineness during grinding of the swelling additive.

3.DESIGN EXPERIMENTS

3.1. *Design Simulator Curing Chamber*

The specification was designed a physical simulator model as a modification of pressure curing chamber that could be operated under 350ºC operating temperature and 3000 psi operating pressure, see Figure 4. The advantages of the simulator, besides could handle large amount of sample (30 samples), it was designed that could be operated using formation water both from oil-gas field or geothermal field. It was also equipped with CO_2 and H_2S injection appliance.

The main parts of simulator are listed below:

1. Simulator tubes were equipped with heater and thermocouple.
2. Maximator pump, pressure source that could supply hydraulic pressure up to 6500 psi.
3. Safety valves and rupture disc.
4. Formation fluid injector
5. Automatic thermo controller.
6. Gas injection flow meter.
7. Outlet exchanger and reservoir chamber.
8. Manometer and in/out simulator liquid gas regulator valves.

The test required 3 types of specimen molds as cement slurry chamber that should be treated during hardening. The specimen molds describe as referred to below:

Cubic type, with dimensions 2" x 2" x 2", to determine the tensile and compressive strength of the cement

Cylindrical type, with 1" diameter and 2" height to determine the shear bond strength between cement-casing and also to measure cement casing-permeability. The specimen mold needs chamber caps when it is placed into simulator.

Cylindrical type, with 1" diameter and 2,5" height. This specimen mold contains 6 cement chambers. The cement specimens are used to determine both cement permeability and the compressive strength.

All those specimen molds are designed that could be run simultaneously in the simulator at given well condition.

Compressive strength value is calculated with the following formula:

CS=k.P.(A1/A2) (1)

where,

CS : compressive strength, psi

P : maximum load, psi

A1 : hydraulic mortar's bearing block cross section area, in^2

A2 : cement core's cross section area, in^2

k : correction constant, function of height (t) and diameter (d) ratio, see Table1.

Shear bond strength is calculated using the following formula:

SBS=P.(A1/π D.h) (2)

Where, SBS: shear bond strength, psi ;

P : strain maximum load, psi

A : cement core's cross section area, in^2

H : cement core's height, in

D : diameter core, in

Table 1. Relations of constanta and h/d

h/d	Konstanta (k)
2,00	1,00
1,75	0,98
1,50	0,96
1,25	0,93
1,00	0,87

3.2. Design of Laboratories Works

Figure 1. Sampling Additive Local (pericalse)

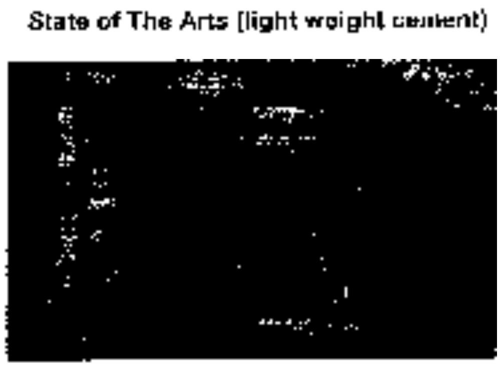

Figure 2. Design of Light Weight Cement

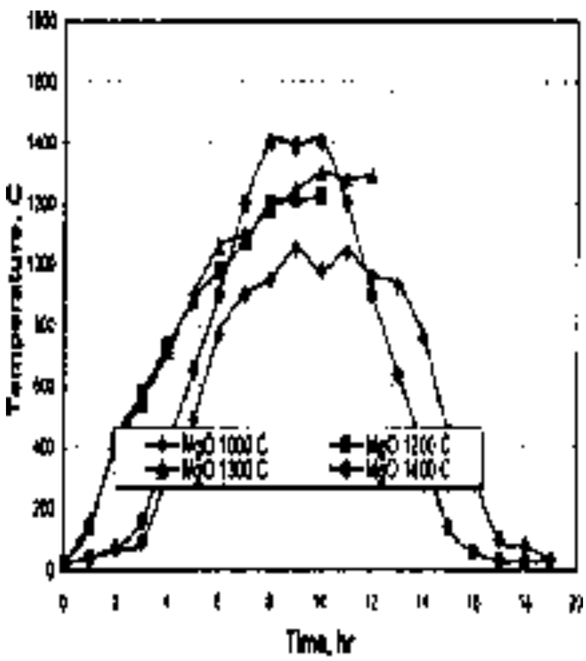

Figure 3. Based of Berned Additives

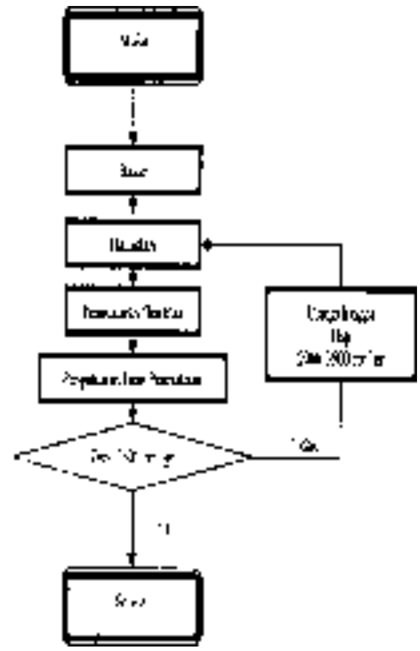

Figure 4. Activasion Process

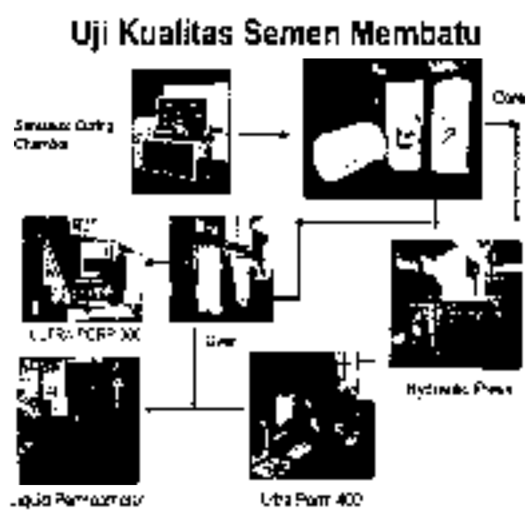

Figure 5. Laboratories Experiment

4. RESULTS AND DISCUSSIONS

For the experiment laboratories, that cement slurries and hardener saw followed on Table 2 and Appendix.

For Table 2, The API spec or ASTM spec has been based of value of finnenes a powder great than 2500 cm^2/gr from test bein permeameter, the strengths of hardener cement is good bonding and the powder is finnenes great that value.. From Appendix 1 up 5, the density of based cement is 15.9 ppg and after added silica flour changes 15,3 ppg, so on the light weight cement is 11.7 ppg. that's value up compare with Figure 2,. The strength such upper 500 psi.. it is limited based value compressive strength, the results see on Appendix 4.. The thickening time from measured by atmospheric consistometer 70-100 Uc are between 75-105 minutes on expanding additives is add CaO 3 % concentration, and 95-125 minutes after added MgO 3%. On limited value is up 120 minutes strength up 500 psi. The value of permeability is 0.195 md, it mean is the siimilary than silica cement is a good if compare based of cement (see Appendix 3). The effect of LWA additive and microsphere is to be changer mineral tobermorite 11 A to clyno tobermorite, see Appendix 5.

Table 2. The finneness of local additives

Powder of Materials	Finenes (cm^2/gr)
Based Cement	2517
Silica Flour	3150
Lime Local	[illegible]
Periclase Local	[illegible]

5. CONCLUSIONS

For results and discussions can be take of several conclusions :

1. The effect of light weight additive (LWA) periclase (local) to caused reducing of density and strength.
2. The hardener of cement is best because impermeable, thickening time is reliable on based range 75 -125 minutes, and create mineral clyno tobermorite.

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Appendix

Appendix 1. The Density of cement slurries and local additives

No.	Composition Models	Density (ppg)
01	Based Cement Powder	24.99
02	Silica Flour Powder	22.24
03.	Lime Powder Local (CaO)	21.32
04.	Periclase Powder Local (MgO)	29.16
05.	Based of Cement Slurry (BC)	15.9
06.	Silica Cement Slurry (SC)	[illegible]
07.	SC + Periclase Local 3%	15.60
08.	SC + Periclase Local 5%	15.61
09.	SC + Lime Local 3%	15.55
10.	SC + Lime Local 5%	15.55
11.	SC Microsphere + Periclase Local 3%	11.75
12.	SC Microsphere + Periclase Local 5%	11.75
13.	SC Microsphere + Lime Local 3%	11.70
14.	SC Microsphere + Lime Local 5%	11.75

Appendix 2. Thickening times

Data Ultra Permeabilitas Test

Core Lab Instruments (www.coreinst.com)

Note: This report can be opened in Microsoft Excel for editing

Ultraperm Report			
Company	ITB	Operator	P. Yoe
Job	P [illegible]	Details	[illegible]

[illegible]	Length (cm)	[illegible]	Temp ©	Back Pres (psig)	Conf Pres	[illegible]	[illegible]	P1 (Pas)	P2 (Pas)	[illegible]	[illegible]	[illegible]
som c5%	3.610	2.535	24.5	690.0	300	1.46	1.32	14.72	13.26	0.023	0.207	13.990
som m5%	3.725	2.505	24.5	693.0	300	1.46	1.32	14.72	13.26	0.024	0.287	13.000
som c3%	3.600	2.530	24.5	687.0	300	1.47	1.32	14.72	13.26	0.022	0.204	13.000
som m3%	3.500	2.425	24.5	680.0	300	1.46	1.32	14.72	13.26	0.021	0.186	13.900
sc	3.275	2.537	24.5	690.0	300	1.46	1.32	14.72	13.26	0.023	0.195	13.990

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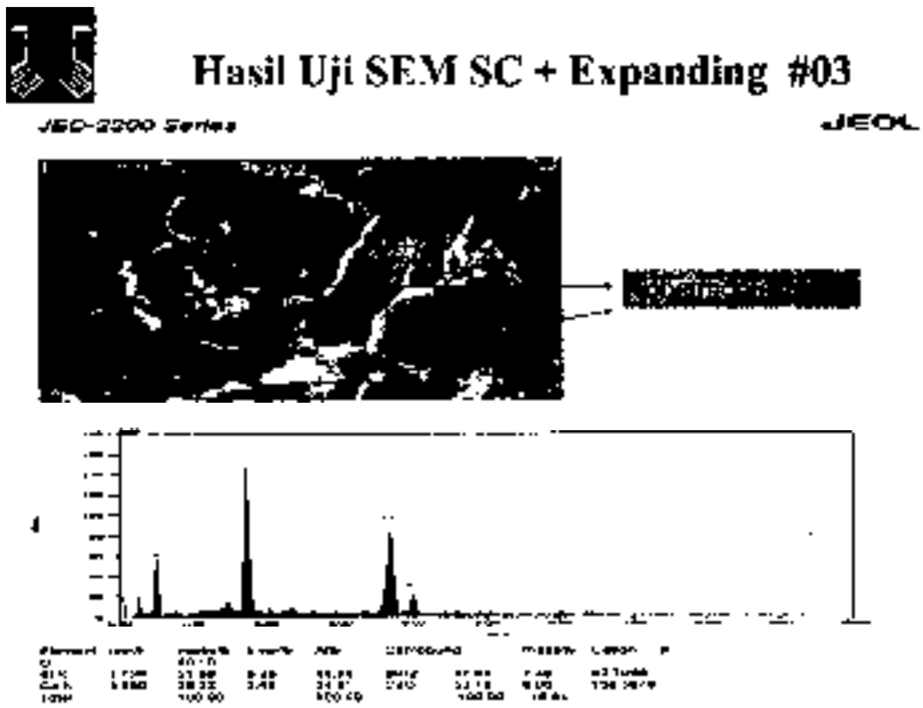
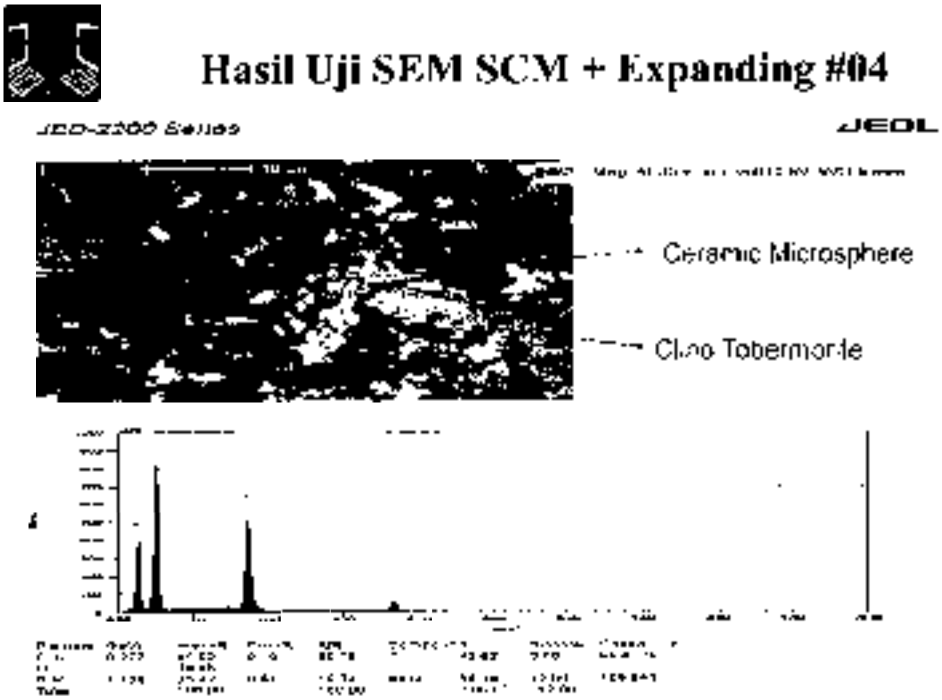
Appendix 3. Permeability test

Composition Models	Conditioning Time (hours)	*Compresssive strength (psi)*	*Shearbond strength (psi)*
Silica Microsphere Cement (SMC) + Periclase 3% BWOS	24	2615	1087
	72	3050	1027
	168	3627	1294
Silica Microsphere Cement (SMC)+ Periclase 5% BWOS	24	2744	1179
	72	3020	992
	168	3506	1236
Silica Microsphere Cement (SMC) + Lime 3% BWOS	24	689	873
	72	891	427
	168	3796	1216
Silica Microsphere Cement SMC) + Lime 5% BWOS	24	3506	402
	72	3541	665
	168	3595	1038

Appendix 4. Result of Strengths on Composition Models Cement



Appendix 5. Create of Mineral Clyno Tobermorite



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Language: All manuscripts must be written in Indonesian or in English.

Format: Manuscripts should be typewritten with Microsoft Word, Times New Roman at 10 font size, single-spaced on one face of A4 size sheets, with a 2,5 cm top and bottom, and 2,5 cm from left, and 1,5 cm right margin. The full length of paper is of 6 to 15 printed pages. Papers should be submitted both in a black and white hard copy and in a disk.

Organization of manuscripts: The manuscript should be organized under suitable order such as Abstract, Introduction, Methods, Results, Discussion, Conclusions, and References.

Title page and authorship: The title page should contain: title of article, no more than 2 rows (40 characters). Put the full name of author, name(s) of institution(s), address and email of author on the next row bellow the title directly.

Abstract and keywords: Limits abstract 200 words, one paragraph, and should comprise informative essence of the entire content of the article. Abstract as well as keywords should be prepared in Indonesian and English. Select 3-5 keywords and put them below the abstract directly. Both of abstract and keywords should be typewritten in Times New Roman at 8-font size and single-spaced.

Table: Title of tables and all necessary remarks should be typewritten either in Indonesian or English. Table should be numbered. The uses of comma (,) and point (.) in all figures in the table indicate a decimal fraction, and a thousand multiplications, respectively.

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Photograph: Photograph submitted should have high contrast, and should be supplied with necessary information as for line drawing.

Reference: Reference should be listed in alphabetical order of authors name with the year of publication, such as the following example:

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Walling, D.E. 1983. The sediment delivery problem, *Journal of Hydrology* 65(1), p.209-237.

Buku:

Diessel C.F.K. 1992. *Coal bearing depositional systems*, Springer-Verlag Berlin Heidenberg, 721 p.

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