Comments on the 2006 Test Run of the Rapu-rapu Polymetallic Project

I - Introduction

The 2006 Test Run of the Rapu-rapu Polymetallic Project was the government's answer to the conclusions and recommendations in the final report of the Rapu-rapu Fact-Finding Commission (RFFC). The main (and in reality, narrow) objective of the test run is to determine whether Lafayette Philippines, Inc. will be able to conduct an environmentally viable mining operation in Rapu-rapu Island.

Granting but not conceding the soundness of the government's decision, the test run should address the primary environmental issues raised by the RFFC. To quote:

> "On the issue of ***acid mine drainage*** (AMD), on the other hand, lies most of the worries of groups opposing mining in the island. For the RRFFC, the questions that must be answered: Is LPI able to control AMD? Or is the mining company in fact aggravating AMD and all its harsh effects?"
>
> "The RRFFC finds fault and inadequacy with the LPI's EIS, ECC and EPEP for failing to answer apprehensions relating to AMD…and the ***natural hazards of mining***...Consequently, environmental hazard prevention and mitigation strategies of LPI as contained in its Environmental Work Program and other guidelines are woefully lacking…"
>
> "Issue a moratorium on mining in Rapu-Rapu and a suspension of MPSAs in the island pending scientific and experts' favorable resolution of the issue of ***ecological conservation*** and the AMD problem in a fragile small island ecosystem" (Recommendation #8)

The test run objectives, as stated in the report, focuses on the optimization of the functions and operations of the various mine facilities. However, the issues of AMD, natural hazards and ecological conservation were not sufficiently addressed. The first two issues are discussed in the next sections while the last is discussed in a separate paper (see Dr. Regis' report).

II - On acid mine drainage

AMD was not mentioned in the main objectives. Instead, it has been reduced to one of the conditionalities of the Pollution Adjudication Board (PAB) to which the company must comply with during the test run. This and the fact that the independent study on AMD was conducted only during the test run's extension (after the 3rd stage) show the limited appreciation of the AMD problem by the company and the Technical Working Group (TWG). Such stance reduces AMD as just a mere byproduct of the mining and milling operations, de-emphasizing the other aspects of the phenomenon of acid drainage. Unsurprisingly, the test run and the independent study focused only on the short term monitoring and treatment of AMD (See Dr. Barril's report for a more detailed, chemistry-based critique of the test run).

From a hydrologic perspective, the AMD study conducted was not comprehensive. It did not characterize in detail the sources, paths and discharge zones of the acid drainage. First, it failed to emphasize or at least mention the mine pit as a source of AMD. Thus, there was no thorough study on the in situ acid generation potential of the mine pit. With a large surface area, the mine pit exposes large amounts of sulfide-rich materials to atmospheric oxygen and rain, and generates acid drainage. Blasting operations increase the permeability of the pit floors and walls, allowing for the immediate downward seepage of acidic fluids to the groundwater.

Second, there was no detailed description of subsurface transport. The major alteration of watershed configurations necessarily results to changes in the hydrogeologic regime. Absence of piezometric readings, well and tracer tests, geophysical surveys and numerical models precludes the determination of present hydraulic heads, flow paths, flow directions and flow rates. Analyses of physical and chemical properties of water from observation wells were not conducted. This limited information on factors affecting groundwater transport translates to a lack of understanding of the AMD processes (generation, transport and attenuation) in the subsurface.

Third, discharge zones were not mapped in detail. In the absence of an updated groundwater model, recharge and discharge zones need to be delineated in the field. Sampling was done only on major streams and a few identified springs. The possibility of submarine groundwater discharge was not investigated.

The lack of appreciation and understanding of the hydrologic (and chemical) framework of AMD explains the superficial view of AMD by the company and the TWG. This has negative implications to the environmental viability of the project. First, the company has limited capability to detect pathways and discharge sites of AMD. Second, the treatment of AMD necessarily involves significant uncertainties because the nature of AMD cannot be characterized until it reaches the treatment facilities. Such is true during precipitation events when the transient response of the hydrologic regime is highly unpredictable. All these lead to the conclusion that **contrary to the TWG report, Lafayette has yet to prove its capability to effectively manage acid mine drainage**.

III - On natural hazards

A. Water resource depletion

Although located in a climatic setting wherein there is high annual rainfall, natural factors intrinsic to small islands such as small drainage basins and low aquifer storage limit the freshwater resource of Rapu-rapu.

The company's inability to effectively manage AMD remains a threat to the water quality in surrounding areas. Although the test run included some water quality monitoring, it **did not assess the short- and long-term effects of the mining and milling operations on the quantity of available freshwater resource**. Areas of concern include the drastic lowering of piezometric heads due to extraction of water at the mine pit and the diversions of surface drainage.

B. Geomorphic Hazards

Mining, as a catastrophic agent of geomorphic change, modifies ground conditions at high rates. Stripping of both land and vegetation, water extraction and diversion, and blasting have drastically displaced the landform equilibrium in terms of watershed configuration, slope stability and hydrology. Such disequilibrium has effects on the erosion rates, flooding and landslide potentials in the areas.

The test run included the evaluation of structural measures (mostly in the project site) to address erosion, flooding and landslides. However, **it did not conduct in depth hydrologic and geotechnical studies of areas surrounding the project site,** results of which should be published and disseminated in the form of reports and hazard maps of appropriate scales. Regular monitoring at strategic sites should have been in place by now.

Of particular concern is the effect of blasting operations on the slope stability of adjoining areas. Since the response to blasting of relatively fresh, unweathered rocks at the mine pit differs from that of the highly weathered surficial cover of slopes undisturbed by mining, geotechnical investigation should be extended to cover the latter.

IV- Conclusions

Review and assessment of the TWG Report shows that the test run, as the basis for the full resumption of Lafayette's operation, did not fully address the primary environmental issues of AMD and natural hazards. **Lafayette has yet to prove its capability to effectively manage acid mine drainage**. **It did not assess the effects of its operations on the freshwater resource. It did not conduct in depth hydrologic and geotechnical studies of areas surrounding the project site.** These are contrary to the final conclusions of the TWG, which eventually gave the go signal for Lafayette.

The formulation of the test run objectives, the actual conduct of the test run, and the drafting of the conclusions by the TWG exposes the **insufficiency of the government's standards for an environmentally viable mining operation and/or its bias for the mining company**. Either case proves the anti-people and anti-environment character of the current mining program being promoted by the government.

Detailed studies may be too exhaustive and expensive but it is a justified pre-requisite for mining in a small tropical island with a significant population depending on the island's limited resources.

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Comments on the "Evaluation Report of the Mines and Geosciences Bureau (MGB), on the Rapu-Rapu Polymetallic Project under the test run conditions" (dated Dec. 19, 2006)

A. General comments

1. Concerns are mostly on structural without linking the structure with the problems of AMD, seepage from the canals, tailings dam, etc.
2. No solution was given to what will happen to the heavy metals that will remain in the various ponds since these metals do not disappear even if the acid water has been neutralized
3. Arsenic (found to be very high in the area in the INECAR study of 2000-2001) will always volatilize from the dumping areas, from wastewater, and from open pit during sunny days. This will be brought down by rain and be dispersed into a wider area as well as into the sea
4. There is no clear explanation as to what will happen to the wastewater released from the milling, processing, and treatment areas and how the heavy metals from the wastewater will be prevented from being released into the surroundings towards water bodies such as rivers/creeks and the sea.
5. Even with ALD (anoxic lime drainage), heavy metals will still be present in the ponds, channel, dam, creeks/rivers.
6. All solutions are concerned only with structural stability and not linked much with the geophysico-chemical conditions of the island that worsen mining problems and cause AMD, as already explained by INECAR studies since year 2000 and proven in year 2005-2006.

B. Specific comments

1. Conclusion (page 5) – the monitoring the evaluation made by the DENR and the Multipartite Monitoring Team (MMT) were only concerned about water testing and leaks. Without including heavy metal contamination of soil/sediments that adsorb the contaminants, and biota that absorb heavy metals, **the assessment is very much inadequate to guarantee "safe" mining technology**.

   Acid remobilizes metals but clay particles adsorb the metals. Sulfur bacteria such as *Thiobacillus ferooxidans*, convert heavy metals into organic forms that can readily be taken up by living cells.

2. Environmental areas (page 10) – using a wetland area to trap heavy metals released from the polishing pond, does not guarantee that the metals will not anymore be released into the surroundings during heavy rains and typhoons which frequently occur in the area.

3. Other concerns (page 15):

   a) *Dead marine organisms found along the shore during the test run – collected in the afternoon of July 20, 2006 until the morning of the following day, the solution was only to monitor heavy metals in water until the condition became normal (within DENR standards).*

      This was achieved by lime dosing (David and Romero report, 2006). Lime dosing of water only neutralizes the acidity but does not cause heavy metals to disappear. They are merely precipitated by the alkaline condition and will always be carried by rainwater and runoff during heavy rainfall and typhoons towards the sea and/or dispersed overland onto and into the soil where they cause poisoning of the land for many years, some even for hundreds of years. Groundwater in this case will also be contaminated.

      Using silt fences and gabions to control silt (which is most likely polluted with heavy metals) does not solve the problem. Thus, *the concern of MGB regarding maintenance of the silt fence and gabions to control the silt materials from going into the sea* shows the incapability of MGB personnel to understand that heavy metals carried by water will be adsorb by clay particles in silt. Under this condition, heavy metals become concentrated in this area and when rains and typhoons come, the metals will be released into the sea and poison marine organisms. **Hence, it will not be surprising in the future if dead marine organisms will be found near the area from time to time**.

      In addition, the polluted silt will kill marine organisms not only due to heavy metals but also through the effects of silt on the gills of fishes. Studies show that silt particles injure the gill tissues of fishes through their abrasive action (Department of Fisheries and Oceans, http://www.dfo-mpo.gc.ca/regions/CENTRAL/pub/fact-fait/tl_e.html).

   b) The **death of marine organisms can be attributed to the mining operation** because mining includes tailings and waste rock dump that are acid forming and releases heavy metals continuously. Even if the acid has been neutralized in the receiving ponds, the heavy metals already released from the source will always be present. Many studies all over the world by scientists of high caliber have already ascertained that copper brought down by water and silt causes death to marine organisms.

      Moreover, the report of the DENR – Pollution Adjudication Board (DENR-PAB) dated January 9, 2006, shows very high level of cyanide that was measured during the spill; ranging from 0.0651 to 31.65 mg/L which is equivalent to 30 – 63,200 % exceeding the DENR standards (0.05 mg/L). Attached in a copy of the report from the Pollution Adjudication Board.

      Such report definitely shows that fish-kill could not be in the amount reported by Mines and Geosciences Bureau (MGB) of some 2 – 15 kilos only. Fishes and other

marine organisms were killed while at sea and floated with the surface waves driven by the northeast monsoon or *amihan* towards Sorsogon. Along the way, cyanide continue to kill other fishes because cyanide do not volatilize into the air when there is rain, or clouds and alkaline water (seawater) causes cyanide to precipitate.

4. Chromium (page 29) – there are two types of chromium commonly found in the environment – Cr III (trivalent) and Cr VI (hexavalent) and both are toxic with the latter, very toxic (US-EPA, 2000 and 2006). Although the level of chromium in water during the test run is within DENR standards, it must be understood that hexavalent chromium is very soluble, so that it can easily be taken up by living organisms due to the fact that it is an essential element in the body in minute amount but toxic in large doses. Thus, it can move through the food chain and accumulate in living cells, although eventually, some are also released by the body naturally. It is dangerous to assume that because the level is low, it is safe.

   Hexavalent, more toxic chromium occurs in groundwater and although it is eventually transformed into the less soluble, less toxic trivalent form as it moves towards the upper soil layers (Shanker et al., 2005) . Its immediate movement to the surface by mining activities allow the hexavalent form to enter living plants readily, thus, it is able to disrupt the plant's metabolic activities. This is how productivity of plants and associated animals are also affected.

C. Final comments

If AMD remediation in Pagcolbon area has not been successful, will it be successful in remediating the current AMD in 3 other areas (Alma Creek, Hollowstone Creek and Ungay Creek)? These creeks have been affected only during the Lafayette mining operations.

It is but proper that Lafayette mining company remediates first the AMD already occurring in the 3 additional acidic creeks that resulted from its mining operations.

There is a very urgent need for the DENR and the MGB personnel responsible in making assessments to study further and improve their capability in understanding mining problems especially on Acid Mine Drainage. Without this expertise, these government agencies do not have the competence to assess and make decisions regarding mining problems, remediation, and give permission to operate.

Will the DENR Secretary (currently Secretary Angelo Reyes) who issued the Permanent Lifting Order (PLO) accept responsibility and be liable for the damages and disasters that will happen in the present mining area after the issuance of said order to Lafayette Philippines, Inc. and its associate companies (RRPI, etc.)? This area has already been predicted by studies and assessments by scientists and various groups (academe and associated groups) to result in mining pollution and other disasters if mining is allowed in the area. **Will Lafayette Mining Ltd of Australia, the real owner of the mining project in Rapu-Rapu, accept the same responsibility and liability as stated above, under the principle of command responsibility?**

There must be a government agency especially intended for protecting the environment. The Department of Environment and Natural Resources (DENR) is a government agency that has conflicting interests: **protection of the environment** and **exploitation of natural resources**. This is probably one of the major reasons why there are so many environmental problems in the Philippines.

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COMMENTS ON THE FINAL REPORT OF
CARLOS PRIMO C. DAVID AND RUSTICA G. ROMERO ON
"THE EVALUATION OF RRPI'S ACID MINE DRAINAGE (AMD) ABATEMENT AND CONTROL STRATEGIES"

I. GENERAL COMMENTS

The purpose of this review of the final report of Dr. David and his partner was to determine whether the study was conducted in a scientific manner considering the objective, scope and methodology, reporting and interpretation of the results, conclusion and recommendations. Based on this review, to know whether the final report served as a valid basis for the lifting of the suspension order.
The commentary given here is entirely based on the technical quality and scientific soundness of the report and is not intended to malign the characters of the authors.

Title and Purpose of the study.

The study purports "to evaluate the AMD abatement and control strategies of the Rapu-Rapu Polymetallic Project, Inc. (RRPI) in Rapu-Rapu Island."

To effectively evaluate these strategies, it is important to know what are these strategies, first of all, including their advantages and disadvantages and whether they are appropriate or applicable to the case at hand. However, the report contains no description and evaluation of the effectiveness and applicability of AMD abatement and control strategies being employed by RRPI. For this reason alone, the study may be considered grossly inadequate and technically invalid.

Scope and methodology of the study.

The way the study was done, there is much to be desired in terms of study design, coverage and technical quality. At the minimum, it should have covered the following topics:

Principle and chemistry of AMD production.
Factors that affect AMD production
AMD Prediction
- Characterisation of the rock material
- Sampling plan
- Static and kinetic tests for evaluating potential for acid formation.
- Classification of geologic units as acid or non-acid forming, etc.

Control and mitigation technologies for AMD
Evaluation of control and mitigations strategies of RRPI.
Findings and observations
Conclusions and Recommendations

Principle and chemistry of AMD production.

The chemistry of AMD should have been included since this is basic to the problem. Without this important information, the report suffers from lack of technical quality because we do not know whether the study team fully understands the chemical reaction involved and the factors that affect it. Without the clear understanding of these matters, control and abatement of AMD would at best be guesswork.

Factors that affect AMD production.

While the report mentions the primary and secondary factors that affect AMD production, it neglected the tertiary factors which are equally important. Some of the tertiary factors affecting acid drainage are the physical characteristics of the material, how acid generating and acid neutralizing materials are placed, waste, and the hydrologic regime in the vicinity. **We do not know the reason why tertiary factors were omitted: was it just an oversight on the part of the study team or was it because it would make RRPI's case untenable, especially if the issue concerning the hydrologic regime in the vicinity is considered.**

AMD Prediction.

In principle, the objectives of AMD predictive testing are to: (1) determine if a discrete volume of mining waste will generate acid and (2) predict the quality of the drainage based on the rate of acid formation measured (California Mining Association 1991).

These objectives, however, were never mentioned in the study notwithstanding the fact that it focused on AMD prediction. **If we compare the study design used by Dr. David and his partner with the typical steps in AMD prediction given below, we can see that the study was done haphazardly and superficially giving unreliable results and misleading conclusions.**

The typical steps in predicting the acid forming potential, as described in summary documents on the subject, are listed below (California Mining Association 1991, British Columbia AMD Task Force 1989):

a) Define the geologic (or lithologic) units that will be encountered during mining. Describe the geology and mineralogy of these units in detail.

b) Develop a sampling plan based on understanding of geology (rock mass, etc.). Collect samples to represent ranges of compositional variation within a rock unit.

c) Select static or kinetic tests and evaluate potential for acid formation.

d) Evaluate sampling criteria and conduct additional kinetic tests as required.

e) Develop a model as appropriate.

f) Based on findings, classify geologic (lithologic) units as acid, non-acid forming, or uncertain.

Considering the above steps, the prediction of acid forming potential as carried out by Dr. David and his partner was done haphazardly and superficially for the following reasons: a) there was no geological and mineralogical characterization of the rock materials; b) the sampling plan was limited and not based on understanding of geological or lithological characteristics; c) the static and kinetic tests and evaluation of acid production potential made were limited; d) there was no evaluation of sampling criteria and no additional kinetic tests conducted; and e) based on findings, there was no classification of geologic units as acid, non-acid forming, etc.

The report also failed to include a calculation of the APP based on the static and kinetic studies and how the massive AMD that can potentially be produced from PAF, NAF and other materials can be managed.

Evaluation of control and mitigation strategies of RRPI.

Being the title and main objective of the study, the identitification and description of the AMD control and abatement or mitigation strategies of RRPI should have been included in the report. But no clear description of any control or mitigating techniques was included. All that was mentioned was the so-called "environmental ponds" as the main abatement measures to control AMD. But what do these environmental ponds do and what are their limitations was not mentioned. Liming was also mentioned as a means of neutralizing AMD and yet at the end of the report, lime dosing was recommended not to be included in the AMD management system because it is costly. Likewise, limestone drain as a neutralizing system was not recommended to be used as a primary treatment method. **What then would remain as the AMD control and abatement techniques in RRPI? Would this be adequate to contain and manage the AMD that will be produced during and after the mining operations? This very important issue was not considered in the report, while the study team seemingly is more concerned with cost saving rather than controlling and managing the AMD problem.**

Control and mitigation technologies for AMD

Related to the evaluation of control and abatement strategies applied by RRPI must be a discussion of the advantages (and disadvantages) and effectiveness of each technique that has been employed in AMD management. This aspect should have been included in the report. **But since no description of any adopted control technologies was made, the report sadly lacks such important and useful information for a better understanding of the effectiveness and applicability of the technology adopted by RRPI.**

II. SPECIFIC COMMENTS

Acid Generation Prediction tests.

a) **In terms of methodology, the tests were done haphazardly and indiscriminately.** For example, the procedure for the static tests was too general, lacking enough details and using

terminology that is misleading such as "maximum potential acidity" (MPA) which should properly be "maximum acid production potential" (AP or APP). Also, the procedure for the determination of the neutralization potential (NP) was mentioned as the Modified Lapakko experiment but no reference or description was given. **Without giving specific and clear procedures, the results obtained would be confusing and meaningless.**

b) **Reporting of results is confusing and misleading**. The results for the static tests given in **Table 3** are too confusing to make any sense. Most of the column headings are not clearly defined or use wrong factors. Also the authors failed to determine the net neutralizing potential (NNP) whether as a difference or a ratio. Another column should have been added in **Table 3** for the NNP and interpret its values properly. **Thus, Table 3 as presented cannot be considered worthy of a technical report. It is not only very confusing and misleading but also fails to include the main objective of predictive testing, i.e. the NNP or net AP. Thus, any conclusion or recommendation based on this study is misleading and unreliable.**

Similarly, in the kinetic tests, the results are doubtful because the length of the tests were too short. **Thus again, we consider the results of the kinetic tests as unreliable, patchy and inconclusive.**

c) Failure to predict acid generation potential for the RRPI.

The biggest omission of the study was its failure to 1**) determine if a discrete volume of mining waste will generate acid and (2) predict the quality of the drainage based on the rate of acid formation measured.**

- **Based on the static tests, it should have determined the total NNP per type of rock materials (PAF, NAF, other wastes) and their respective volume to be generated during the entire mining operation. BUT THIS WAS NOT DONE!**
- **Based on the kinetic tests, it should have determined the quality of the drainage from each type of rock materials (PAF, NAF) generated and thereby determined if the AMD abatement and control strategies adopted by RRPI are adequate to contain and neutralize the AMD. AGAIN, THIS WAS NOT DONE!**

IN THE LIGHT OF THE ABOVE OBSERVATIONS, WE CONSIDER THE AMD PREDICTION EXPERIMENTS AS GROSSLY INADEQUATE AND LACKING IN TECHNICAL MERIT AND QUALITY WHOSE RESULTS ARE DOUBTFUL AND UNRELIABLE.

"In-situ measurements"

The conduct of in-situ measurements was also done haphazardly and superficially. A few days or even a week of observation is not enough to make a credible assessment of the effectiveness of the AMD abatement systems.
Thus, we find the report on observed values of parameters patchy, confusing and misleading.

On "Monitoring"

The monitoring data generated in the time period Sept. 1 to Oct. 15, 2006 is too limited to make any credible conclusions on the adequacy of the AMD abatement system. The mining operation has barely started and the AMD abatement system is newly established. It is a fact, that AMD generation starts slowly, but the moment it gains momentum its rate will accelerate rapidly, especially when iron oxidizing bacteria have acclimatized. We do not know yet how the AMD abatement system will react to this and how effective it will be in the long run.

So, the very short time of monitoring study cannot therefore generate any meaningful results. What is needed is a carefully planned monitoring program that includes the results of AMD prediction studies on both static and kinetic tests and how the massive amounts of AMD that will be generated from both PAF and NAF materials and other materials can be managed.

On the "Discussion"

The sweeping statement made by the authors that "**the environmental ponds are effective in treating the wastewater"** is not consistent with the results and observations of the study. As shown in Table 2, only the wetlands, ALD 1 and ALD 2 which are lime-dosed have pH value above 6.5; all the others have pH values lower than 6.5 and therefore are not compliant with DENR standards. As mentioned above, the limited observation time and patchy results of the study are not enough to make such a sweeping statement.

From our point of view, the authors do not seem to know how to conduct a scientific study, much less to interpret its results.

In fact,one notable result of the study that should have been considered before making the above conclusion was the observation that non-acid forming (NAF) materials generate as much AMD as the PAF materials. **This is highly significant and disturbing because the NAF materials have been used to mitigate AMD and are therefore emplaced as if they are resistant to AMD generation.** APPARENTLY THERE WAS A MISTAKE IN THE WAY THE ROCKS WERE CLASSIFIED. THIS SHOULD BE INVESTIGATED AND RECTIFIED RIGHT AWAY BEFORE IT IS TOO LATE. BETTER STILL, THE MINING OPERATIONS SHOULD BE STOPPED UNTIL ALL THE DIFFERENT ROCK TYPES HAVE BEEN PROPERLY CLASSIFIED.

Another very important issue that the study failed to consider is how the **AMD in the open pit** would be managed and contained during and after the mining operations. As the pyritic materials are alternately exposed to air and water in the open pit, AMD will be generated containing acid and toxic heavy metals which will seep into groundwater through the cracks that blasting and shaking of the ground will create. Likewise, the report failed to consider the significance of toxic heavy metals generated by the AMD. Toxic heavy metals such as arsenic, cadmium, copper, silver, and zinc pose health hazards and are of greater concern than the acidity in environmental terms.

On the "Recommendations"

Again, Dr. David and his partner made a sweeping statement that is premature and not consistent with the results, so limited as they are, of the study. **To say that "Currently, RRPI is able to manage the AMD generated in the site" is too hasty and premature and reflects bias in favor of RRPI if not lack of technical competence of the study group.**
How can this conclusion be made in the light of the data shown in Table 2 where the pH levels of most of the AMD abatement system are not compliant with the DENR standards? As mentioned throughout this commentary, the study made by Dr. David and his partner was done haphazardly and superficially and fraught with technical loopholes and shortcomings, so much so, that the results generated are not only so limited but also of doubtful and unreliable quality. Thus, no conclusive statement is yet possible.

Regarding the six recommendations of the study, all of them may be considered tentative and of little significance as they are based on very limited and unreliable data set and insufficient monitoring studies. In fact, some of the recommendations are ill-advised, impractical and do not have sound basis. These include recommendations nos. 2 and 4.

Recommendation no. 2 pertains to the exclusion of lime dosing in the AMD management system, while no. 4 recommends not to use open limestone drain as a primary treatment method. Both of these recommendations reflect lack of in-depth understanding and appreciation of the magnitude of the AMD problem.
Based on the results of the static tests (Table 3), each ton of high grade Cu ore alone can potentially generate **1,022 kg of acid** (i.e. AP = 31.25 * %S or 31.25 x 32.7 = 1022 kg/ton). Considering that millions of tons of Cu ore wil be milled every year, this means million of tons of acid can be potentially generated. If you add other sources of AMD like the tailings, the PAF and NAF,etc. then the AMD problem becomes even more formidable. **How can the huge amount of acid that might be generated be neutralized without using lime or any similar materials should be explained in the report in support of the two recommendations. Otherwise, the two recommendations are premature and ill-advised.**

On the other hand, recommendations nos. 5 and 6 border on the irrelevant, inconsequential and banality.

III. SUMMARY AND OVER ALL ASSESSMENT OF THE REPORT

The final report of Dr. David and his partner was reviewed in terms of the objective, study design and the way the study was carried out, reported, discussed and interpreted.
Based on this review, it can be said that the study failed to make a systematic, thorough and credible evaluation of the AMD abatement and control systems of RRPI.

Technically, we find the study made by Dr. David and his partner as unscientific, carried out haphazardly and superficially, and fraught with technical loopholes and shortcomings, so much so, that the results generated are not only very limited, but also of doubtful and unreliable quality. Among its shortcomings and deficiencies are:

1. **Objective and study design**. While the objective of the study was clear, no mention of the study design or how to carry out the study was made. This resulted in a very limited coverage, haphazard approach and patchy methodology.

2. **Lack of basic principles.** The report did not include important basic and technical principles such as the chemistry of AMD generation and the factors that affect it that are so essential in understanding the AMD problem and how effectively it can be solved.

3. **No description of AMD control strategies**. Glaringly, the report failed to present even a brief description of what kind of AMD abatement and control strategies are currently being employed by RRPI and how they would be able to control AMD generation in the different areas of operation, both in the short and long term.

4. **No evaluation of AMD control strategies**. The study did not include the evaluation of the advantages and disadvantages of different AMD control and mitigation technologies in relation to the AMD strategies currently employed by RRPI.

5. **AMD prediction study.** This was done haphazardly and indiscriminately and not according to standard procedures. For example, a) there was no geological and mineralogical characterization of the rock materials; b) the sampling plan was limited and not based on understanding of geological characteristics; c) the static and kinetic tests were patchy and limited and the results were very confusing and unreliable. In fact, there was no result reported on the net neutralizing potential or NNP of the different samples tested!

6. **No calculation of the acid producing potential (APP).** The report failed to include a calculation of the APP based on the static and kinetic studies and how the massive AMD that can potentially be produced from PAF, NAF and other materials can be managed.

7. **In-situ measurements**. Reporting of results of in-situ measurements was confusing and misleading.

8. **Monitoring**. Monitoring study was very short and results are very limited and not convincing enough.

9. **AMD in the open pit**. It also failed to consider how the AMD in the open pit would be managed and contained during and after the mining operations, considering its size and potential for contaminating the groundwater.

10. **Health hazards from heavy metals**. The report also failed to consider the health significance of toxic heavy metals generated by the AMD. Toxic heavy metals such as arsenic, cadmium, copper, silver, and zinc pose health hazards and are of greater concern than the acidity in environmental terms.

For the above reasons and overall unreliability of the results of the study, **we do not agree** to the conclusion and recommendations, particularly with respect to the sweeping statements that **"the environmental ponds are effective in treating the wastewater"** (made in the Discussion portion) and that **"Currently, RRPI is able to manage the AMD generated in the site"** (made in the Conclusion portion). **Both of these statements are not consistent**

with the results of the study and are based on very limited, patchy experiments and insufficient monitoring studies.

In fact,one notable result of the study that should have been considered before making the above conclusion was the observation that non-acid forming (NAF) materials generate as much AMD as the PAF materials. **This is highly significant and disturbing because the NAF materials have been used to mitigate AMD and are therefore emplaced as if they are resistant to AMD generation. Apparently there was a mistake in the way the rocks were classified. This should be investigated and rectified right away before it is too late. Better still, the mining operations should be stopped until all the different rock types have been properly classified and a thorough assessment of the AMD management system is made.**

BASED ON THE ABOVE OBSERVATIONS, THEREFORE, WE FIND THE RESULTS OF THE STUDY VERY LIMITED, INCONCLUSIVE AND UNRELIABLE, AND SHOULD NOT HAVE BEEN USED AS THE BASIS FOR LIFTING THE SUSPENSION ORDER.

THUS, WE RECOMMEND A REPEAT OF THE ABOVE STUDY EMPLOYING A TECHNICALLY COMPETENT STUDY TEAM FOR A THOROUGH, SYSTEMATIC AND SCIENTIFIC APPROACH TO THE PROBLEM.

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