STATE OF MICHIGAN

STATE OFFICE OF ADMINISTRATIVE HEARINGS AND RULES

In the matter of: The Petitions of the Keweenaw Bay Indian Community, Huron Mountain Club, National Wildlife Federation, and Yellow Dog Watershed Environmental Preserve, Inc., on permits issued to Kennecott Eagle Minerals Company. _____________________________/	File Nos.:	GW1810162 and MP 01 2007
	Part:	31, Groundwater Discharge 632, Nonferrous Metallic Mineral Mining
	Agency:	Department of Environmental Quality
	Case Type:	Water Bureau and Office of Geological Survey

DRAFT TRANSCRIPT

HEARING - VOLUME NO. XX (20)

BEFORE RICHARD A. PATTERSON, ADMINISTRATIVE LAW JUDGE

Constitution Hall, 525 West Allegan, Lansing, Michigan

Wednesday, May 28, 2008, 8:30 a.m.

APPEARANCES:

For the Petitioner Keweenaw Bay Indian Community:	MR. ERIC J. EGGAN (P32368) Honigman Miller Schwartz and Cohn LLP 222 North Washington Square, Suite 400 Lansing, Michigan 48933-1800 (517) 377-0726

For the Petitioner Huron Mountain Club:	WILLIAM J. STAPLETON (P38339) Hooper Hathaway Price Beuche & Wallace 126 S. Main Street Ann Arbor, Michigan 48104-1945 (734) 662-4426
For the Petitioners Yellow Dog Watershed Preserve and National Wildlife Federation:	JEFFREY K. HAYNES (P25140) Beier Howlett, PC 200 E. Long Lake Road, Ste. 110 Bloomfield Hills, Michigan 48304 (248) 645-9400 and F. MICHELLE HALLEY (P62637) National Wildlife Federation PO Box 914 Marquette, Michigan 49855 (906) 361-0520
For the Respondent Michigan Department of Environmental Quality:	ROBERT P. REICHEL (P31878) Assistant Attorney General Environment, Natural Resources and Agriculture Division 6th Floor, Williams Building 525 West Ottawa Street, PO Box 30755 Lansing, Michigan 48909 (517) 373-7540
For the Intervenor Kennecott Eagle Minerals Company:	RODRICK W. LEWIS (P43968) Warner Norcross & Judd LLP 2000 Town Center, Suite 2700 Southfield, Michigan 48075 (248) 784-5000
RECORDED BY:	Marcy A. Klingshirn, CER 6924 Certified Electronic Recorder Network Reporting Corporation 1-800-632-2720

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Lansing, Michigan

Wednesday, May 28, 2008 - 8:34 a.m.

JUDGE PATTERSON: Are you ready to go?

MR. LEWIS: Yes, your Honor. Intervenor Kennecott Eagle Minerals Company called Mark Logsdon.

REPORTER: Do you solemnly swear or affirm the testimony you're about to give will be the whole truth?

MR. LOGSDON: I do.

MARK J. LOGSDON

having been called by the Intervenor and sworn:

DIRECT EXAMINATION

BY MR. LEWIS:

Q Mr. Logsdon, would you state your full name and spell it for the record, please?

A My name is Mark, M-a-r-k, Joseph Logsdon. Last name is L-o-g-s-d-o-n.

Q Mr. Logsdon, you're a geochemist; is that right?

A Yes, sir.

Q And can you tell us how and where you're currently employed?

A I am the president and principal geochemist of a company in Aptos, California, called Geochimica, Incorporated, G-e-o-c-h-i-m-i-c-a.

Q And can you tell us about that company, what that company does?

A I formed the company in 1992 in order to provide consulting services to not only industry but also government and other entities offering analyses and advice and characterization programs dealing with the manner in which chemistry can be applied to natural resource issues.

Q And so you are the person -- you and your company did the geochemical work for the Kennecott Eagle Mine project; is that right?

A Yes. During the Phase I investigations, I used some of my colleagues at Golder Associates in Seattle, Washington, to assist with that work as well. And then at the end of Phase II, I was able to take over the work entirely from our firm.

Q And I've asked you to appear here to review and describe the geochemical testing that you did for the Kennecott Eagle project?

A That's what I understand.

Q Could you review your education for us, please, Mr. Logsdon?

A I received my bachelor's degree in geology with honors at Princeton in 1972, master's degree in geology with concentration in geochemistry at the University of New Mexico in 1981.

Q And specifically your degrees in geology, could you explain a little more about what that includes?

A The undergraduate degree is broad training in all aspects of physical geology and chemical geology. My research work at Princeton as both a junior and a senior, you have to do independent research work. My research work was in low temperature geochemistry in both of those cases. At the University of New Mexico, I had started working on a research project while I was still teaching school dealing with geothermal waters in the state of New Mexico and adapted that work for my master's thesis. I took courses in geochemistry, some of the traditional areas of geology and physical hydrology.

Q And your honors thesis was on what subject?

A My bachelor's honors thesis was an evaluation of the geochemical controls, copper mineralization at two orebodies and an unmineralized area of rock of the same general kind between the two to try to discern why there was copper mineralization at the two that there was and not at the intervening area. Those were in Arizona.

Q And your master's thesis?

A My master's thesis was an application of aqueous geochemistry; that is, the water chemistry; to understand the type of geothermal waters that were present in a particular valley in southwestern New Mexico understanding the origin of those waters, how the waters had interacted with rocks in the subsurface, where the most likely areas for exploration would be and how hot the temperature of the reservoir might be.

Q And were those theses published, Mr. Logsdon?

A The results of those were both published and presented in professional meetings.

Q And you conducted other research and published publications as a result of that research?

A Yes, sir, I have.

Q Are those listed in your CV, Mr. Logsdon?

A As far as I know, all of them are listed in the CV, although it's possible that a presentation I gave at the end of October of last year is not on the version that was submitted.

MR. LEWIS: And for the record, Mr. Logsdon's CV has been marked and admitted as Intervenor Exhibit Number 188.

Q Mr. Logsdon, on your CV you also have listed a number of professional organizations; Association of Applied Geochemists, Geochemical Society, Geological Society of America, Society of Economic Geologists and some others?

A Yes, sir.

Q And looking at your CV, you have a number of publications listed. And I see that you have broken them down into some categories. The first category of your publications you've titled, I believe, "Hydrogeochemical evaluations of mining projects, waste rock geochemistry"?

A Yeah. Those are not publications. Those are specific projects on which I've done work as a professional.

Q And you have a number listed there and then you have another number listed under "Mine closure and orphan mine projects"?

A Same situation. I've broken them down to projects by the type or general type of issue that we were working on.

Q What's an orphan mine?

A An orphan mine is a mine in which there is no active ownership and is now a public issue.

Q And you also have listed a number of projects under "Exploration and feasibility studies"?

A Yes, sir. Those would be projects which are either in consideration for development as mines or are in the advanced preparation stages as was Eagle when I was working on it.

Q And then you have also a listing under a heading called "Tailing and spent leach ore geochemistry"?

A Yes. That deals with the waste residues after ores have been extracted from the rock. It's not relevant to the mine plan that has been submitted at Eagle.

Q And you also have a section and several projects listed under the heading "Mine lakes, in situ mining and underground flooding." What's that work generally about?

A That work is an evaluation of what the potential chemistry of bodies of water would be after mining has been completed either in an open pit where it forms an open lake or in subsurface where underground workings would be flooded.

Q And you also have a number of peer reviewed articles listed in your CV, do you not?

A Yes, sir, I do.

Q Now, your CV lists a great number of projects, and it has a breakdown by the various topics we just talked about. But in general, how many different mining projects would you say you've worked on doing geochemical work in the United States and internationally?

A It's somewhere over 150.

Q And you've worked on the Eagle project since when?

A The last couple of months of 2003.

Q That's when you started, you mean?

A Yes, sir.

Q Beyond the college degrees that you discussed earlier, have you had additional continuing studies at universities?

A Yes. I've taken research projects in conjunction with universities and course work at a number of places. Let me see if I can recall them all. The University of New Mexico, New Mexico Tech, University of Waterloo in Ontario, professional training courses in statistics and probablistic risk assessment through the U.S. Nuclear Regulatory Commission at Sandia Laboratories. There may be something else still.

Q And we talked about your current -- the company, Geochimica. But could you review for us prior to the time you began work at Geochimica -- review your relevant work history as it relates to your professional career?

A Sure. From 1972 to 1979, I was teaching school, but I was also doing consulting work in the mining industry for mining exploration during summer holidays and other major breaks. And during the last three years in New Mexico, I was doing research on weekends and evenings that led up to my thesis work. Then I returned to school for a year to get my master's degree, took a position with the State Geological Survey of the State of New Mexico in Socorro, New Mexico.

Q Roughly what years would that have been?

A 1980 -- very end, December of 1980, until June or so of 1982. Then from '82 to the end of 1984, I was with the Division of Waste Management of the U.S. Nuclear Regulatory Commission in Washington, D.C. And then I moved out to Denver to start my consulting career in 1984 -- at the end of 1984. From 1984 to 1992, I worked with a small group of consultants who were organized as Adrian Brown Consultants in Denver, Colorado. And then in April of 1992, I established Geochimica.

Q And you currently live in California with your family?

A I do, in Aptos, California, near Santa Cruz.

Q Have you done work for Kennecott and its parent corporation Rio Tinto during your career?

A Yes, sir, I have.

Q Was that in addition to other mine companies that you've worked for?

A Oh, yes.

Q And have you done -- also done consulting work for projects which are not development-type projects?

A Yes, I have. A number of --

Q Can you give us some flavor for what that's been?

A Sure. I've done and routinely do reviews on behalf of governments and Indian tribes and non-governmental organizations, generally speaking, reviewing test work and project plans for mines or for the plans on how to remediate mining issues where incidents have already occurred and there are impacts to water resources that need to be remedied.

Q And have you worked for some governments as a consultant doing that kind of work?

A I have and am currently. Governments that I've worked for include the government of Indonesia, government of Papua New Guinea, the government of Philippines, the government of Canada and the United States of America.

Q What agency is that?

A U.S. Department of Justice and the Forest Service.

Q And have you consulted in geochemical fields -- in the geochemical field for a number of Native American tribes?

A I have.

Q And have you ever served on a committee of the National Academy of Sciences?

A Yes, sir, I have.

Q When was that?

A That was 2004. It was a review of the mineral sources program of the U.S. Geological Survey.

Q Now, during your career, we didn't go through all the various projects -- mining projects and other projects you have listed in your CV. But I understood from your discussion that you've been involved in doing geochemical work and consultation both in connection with pre-mining studies and also after mining, reclamation-type work; is that correct?

A Yes, sir, both of those.

Q And have you done the type of pre-mining, predictive work that you did on the Eagle project for other proposed mines in the U.S. and internationally?

A Yes, I have.

Q Can you give us a rough number of how many mines that you've been involved on the front end; in other words, before the mining project took place doing consultation and predictions as to potential water quality during the mining project?

A There are, I think, 13 projects in which I've done the kinds of calculations that I did for Eagle that were pre-mining projects.

Q And based on your experience on those projects, have there been any instances where there were -- it turned out that there were water quality problems which were related to imperfect or, let's say, unsound predictions of what the water quality would be?

A To the best of my knowledge, the predictions have all been somewhat over-conservative.

Q And on those mines specifically where you consulted and worked and did pre-mining water quality predictions, have there been any ARD problems that you're aware of?

A Not to my knowledge, sir.

Q Now, you know Dr. Ann Maest, don't you?

A Yes, I do.

Q And she does some work and does some publishing in the same general field that you are involved in professionally?

A Yes, she does.

Q And as you know, she testified perhaps a couple weeks ago now. And one of the papers she talked about -- one of the papers that she had published was marked as Petitioner's Exhibit 68. It was an article titled -- or it is an articled titled "Predicting water quality at hard rock mines." Are you familiar with that?

A Yes, sir, I am.

Q And were you, in fact -- did you, in fact, peer review that article for Dr. Maest?

A I did.

Q And what do you think about that paper, Dr. Logsdon?

A I think it's a very good compilation of the methods that are used for the characterization of materials at mining projects. It's appropriate for understanding the basis of -- on which predictions might be made or projections of further conditions might be made. I think it does a very good job of cataloging the methods that are available for doing predictions of water quality based on those characterization data. And I think it's a very sound piece of work.

Q And are the methods that Dr. Maest reviewed and discussed in there, in fact, methods that you use in your career?

A Yes, sir.

Q And methods that you used on the Eagle project?

A They are except that there are differences between the type of modeling that did and the type of modeling that Dr. Maest recommends doing.

Q Dr. Maest also discussed another paper that she's a co-author on. It was Petitioner's Exhibit Part 32 Exhibit 65 titled "Comparison of predicted and actual water quality at hard rock mines." Are you familiar with that paper as well, Mr. Logsdon?

A I have read the general version of the paper, yes.

Q And based on what's reported in that article, was that article peer reviewed by outside peer reviewer?

A All that I know is what's in the introduction to the paper which indicates that it was not given a formal outside peer review.

Q And in general, do you think there are limitations to the information or the conclusions reported by Dr. Maest in the comparison of predicted and actual water quality in hard rock mines paper?

A I think the way they organized the paper and set out their purpose indicates what some of those restrictions are and limitations are. It was focused specifically on mines that were permitted under NEPA, so it's directed towards the federal program and doesn't evaluate the kind of permitting and permit conditions that are applied today to mines that are permitted at least in part by state programs. It's limited to the information that was available in the initial NEPA documents and in the public records that they were able to review. And they discussed the limitations of their public record review in the paper. So there is not a full accounting of some matters such as background water quality or any of the characterization work that might have been done with respect to state issues. So it's quite clear in what it set out to do and the information that it used. But it's not necessarily the full body of information that one would have to consider specifically in looking at mines that have been organized and put into operation in the last five to ten years.

Q And again I wanted to ask you, Dr. Maest's premise in that paper and otherwise in her testimony seemed to be that the experience has shown that pre-mining water quality predictions generally are not reflected in the post-mining quality at least in the various mines -- some of the mines she reviewed in that paper. And just to be clear and again based on your experience that you've talked about earlier and based on the more mining history in this country and elsewhere, has that been your experience, Mr. Logsdon?

A I believe that in the last five to seven or maybe ten years out ability to evaluate the nature of water that will be generated in mining situations has improved very dramatically. And we now have long enough periods of performance for some mines where the more complete geochemical characterization work has been done and better information on mining methods and engineering controls have been put into place to show that the calculations that one can do today with the right kind of characterization work and the right kind of information from the mining company can, in fact, produce reliable estimates of what future water quality impacts will be.

Q And do you generally agree with Dr. Maest that the process of geochemical predictions remains as somewhat uncertain science?

A I agree. It has to be because we're dealing with the characterization of very large volumes and masses of material in the pre-mining condition always with a limited amount of information and therefore a certain amount of humility with respect to how closely we can understand the future is required.

Q And do you also then agree with Dr. Maest that it's important to have proper mitigation in place?

A Yes, it certainly is for those mines in which there is an expectation of geochemical impacts.

Q And is that the point of the geochemical predictions and calculations that you do?

A That's exactly the point of the calculations is to understand when and what kinds of active engineering controls would be required.

Q Now, if we could, I'd like to turn more specifically to the work you did for the Eagle project. Can you tell us first, in general, what your assignment was or, in general terms, what the work is that you did for the Eagle project?

A There were three fundamental assignments that I was given by Kennecott Eagle. The first was to develop and supervise a program for the geochemical characterization of the development rock. The second was to use that characterization information to evaluate the potential for acid rock drainage and leaching of metals from the development rock and also from the walls of the underground mine during and after mining. And then the third part of the assignment was to advise Kennecott Eagle on the need for and general types of engineering controls that would be required in order to protect water resources in the State of Michigan.

Q	Was it the aim or purpose of the work that you did to precisely predict the number of various constituents which would be in the water in the mine or the water collected from the temporary development rock storage area?

A	No, it was not, because I don't believe such predictions are possible.

Q	I believe that you in your work for the Kennecott project, you authored five various reports; is that right?

A	Yes, sir; that's correct.

Q	And the first two, I believe, you've referred to as the Phase I and Phase II characterization studies; is that --

A	That's correct. And the Phase II report is inclusive of the results of the Phase I investigations.

Q	And then, I think, you prepared three subsequent papers, which specifically looked at and discussed what the potential water quality would be in first the water collected under the temporary development rock storage area and a second, I think you called them, technical memoranda, the second one on the subject of the water quality in the mine during mining and a third technical memoranda discussing the potential water quality in the mine after mining; is that right?

A Yes, sir. Those are the additional memoranda.

Q Now, did you first as part of your analysis examine the geology relevant to the Eagle project?

A Yes, I did. If one doesn't under the minerals and the rock types that are present, one can hardly begin to understand what the interactions between water and those rocks would be. So one must begin with an understanding of the geology.

Q I think you prepared a slide. And could you tell us basically the gist of the geology and the examination of the geology that you did?

A Sure. The Eagle orebody is what's called a magmatic segregation type of ore. It's associated with igneous intrusive rocks that, in the magmatic stage, are anomalously high in metals. The metal sulfides begin to precipitate at relatively high temperatures while much of the rest of the magma is still fluid. And because their density is very much higher than the density of the remaining fluid, they tend to sink through the body and accumulate against some impediment in the system where part of the system has begun to crystallize. So you develop a segregated zone in which there is a concentration of the sulfide ores.

Q And is it the sulfide ores that contain the copper and the nickel and the deposits of interest?

A Yes, it is. And the principal sulfide minerals in this case are pyrrhotite, which is an iron sulfide that can contain some amount of nickel. The principal nickel ore pentlandite is a sulfide and chalcopyrite is a copper iron sulfide. The igneous intrusive itself is what's called an ultramafic rock, which means that it's high in minerals that contain iron and magnesium. It's an intrusive; that is, it has to have moved up into some preexisting formation. The principal minerals in the igneous intrusives that we're talking about at Eagle are olivine, pyroxene and feldspar. The country rock, which is the rock into which an intrusive is injected, are sandstones and siltstones that were preexisting the timing of this. They're made up primarily of quartz and feldspar and contain low concentrations of iron sulfides primarily as pyrite.

Q And in general, is the first category there on the slide -- is that generally what has been referred to as the ore itself and the target for the mining?

A Yes; yes. That's the type of deposit, magmatic segregation. But it's a nickel-copper orebody that is the target of the Kennecott Eagle project.

Q And is the second item -- bullet point, is that what's generally then referred in these proceedings so far as the peridotite?

A The peridotite is a type of rock which is high in olivine, then pyroxene and feldspar in different proportions, yes. The peridotite is the principal type of intrusive rock.

Q And does that generally surround the orebody; is that your understanding?

A Yes. The orebody nickel-copper concentrations are within a larger body of peridotitic intrusive rock.

Q And for purposes of the analysis and work that you did on this project, why was it important for you to know about the geology of this deposit?

A The potential for impact to the water resources is associated primarily with the metals that are present in the sulfide minerals. So one has to understand what the sulfide minerals are in order to know what kinds of metals one ought to be concerned about in this system. Also there's a substantial body of information that the geological-geochemical community have developed over many decades about the behavior of sulfide minerals. So if we know which sulfide minerals we're talking about, we have a better understanding of how they are apt to behave in the future.

The mineralogy of the intrusive and of the country rock is important because, if the sulfides oxidize and begin to generate sulfuric acid, that sulfuric acid will react with the other solids, the other minerals that are present in the system. And it's the ability of those minerals to attenuate the acidity, to neutralize the acidity, that prevents the system from becoming acidic rapidly. And so one needs to understand both the acid generating potential as a mineralogic matter and also the acid neutralizing potential as a mineralogic matter in order to understand what the behavior of the system is likely to be.

Q And I think you've also on the next side -- I think -- is it important again for your work for your analysis for this project to know some information about what the mining process will be?

A Yes, it is. Because the context in which the orebody will be developed and managed is critical to the potential behavior of the materials.

Q Can you summarize some of those important points on this slide?

A Sure. The first matter which is of very great importance is this would be developed as an underground mine, not as an open pit mine. And that's important because it limits the exposure of the rock to weathering processes during the time that mining is actually ongoing. Open pit mines have very large surface areas. They over-excavate material and gel are associated with low-grade orebodies, not high grade orebodies where it's possible to be much more specific about the target of the ore.

The second point which is critical to the entire organization of my characterization program -- our characterization program and also to the understanding of the behavior of the system in the long run is that ore will not be maintained at the site either as ore or as tailing after production of the concentrate but rather the ore will be shipped off directly and routinely and rapidly after it's excavated. So the material that will remain at the site for periods of months and years is going to be what we call the development rock; that is, the rock through which Kennecott must tunnel in order to reach the orebody and begin to develop the ore which will be remove quantitatively and rapidly from the system.

Q And what's the relevance there -- the distinction between the ore rock and the development rock and only the development rock being left above ground for some period of time?

A The development rock will have much more sulfide concentrations than the ore does. And therefore the potential reactivity of the ore is of very limited relevance to understanding the bulk behavior of the system in the long run on periods of years. The economically valuable ores are present in three types. There's a massive sulfide deposit in which much of the rock is made up of sulfide minerals.

Semi-massive ore, which is sometimes called net textured in which there is an intergrowth of the peridotite alumino-silicate minerals with high concentrations but only about a third as high as the massive sulfide of the sulfides and then more generally disseminated sulfides that surround that as the last bits of the crystallization of the orebody occurred.

Q How would you characterize what you're calling disseminated ore in relation to the massive and the semi-massive order?

A It's a lower grade material. It has --

Q What significance does it have in terms of sulfur content and metal content?

A The sulfur -- sorry. The surfer contents are very much lower than the semi-massive sulfide which is only a third of the massive sulfide. And so we're getting down to rocks where there is eventually a point at which there's not enough nickel to recover economically from the rock.

Q And does the mine plan include mining of what you call the disseminated ore as well?

A My understanding is that it does if the nickel content is high enough to be economic.

Q And the next point, Mr. Logsdon?

A Okay. After mining, essentially no ore remains underground. This is critical to my view of the material, but it's also critical to the mine plan for Kennecott Eagle. The value of the project is the ore grade materials, and therefore they have every reason and every intention of removing the ore from the system as completely as possible consistent with safe mining practice. Consequently there will be, as I understand the project, only small amounts of residual ore grade mineralization that are left in the subsurface. Quality control on mine grade and extraction of ores in modern mines especially over the last five years has progressed to the kind of quality control that one sees in industrial processes in many parts of industry where the goal is to approach the perfect target as closely as one can. The sixth signa approach is very common in industrial processes. And that's now being applied routinely in mining where one attempts to approach 99-plus percent recovery of the ore. And that will be the approach that they use at Kennecott Eagle.

The development rock will be stored temporarily in an engineered surface facility, and limestone will be added to that rock as it goes onto the pile in order to control the acid generation. Eventually all of that development rock is backfilled into the underground with additional limestone was needed in order to meet a target ratio that is intended to prevent acidification until the final stage of the overall engineering control, which is the re-flooding of the underground workings at which point there will no longer be oxygen available to generate acidity by the oxidation of the sulfides.

Q We talked about the formula for the oxidation process before, I believe, when Dr. Maest was here, Mr. Logsdon. But could you briefly review this process again?

A Yes. This is, I think, substantially the same information that Dr. Maest presented in her testimony. Because there's no dispute between her and me as to what that underlying process is. Sulfide minerals in the presence of molecular oxygen and water will oxidize. Dissolved metals will go into solution. Sulfate, which is the oxidized form of the sulfur that was in a reduced in the sulfide mineral, will go into solution. And through the breakdown of the water molecule that's involved in the reaction, there are hydrogen ions that go into solution as well. Hydrogen ions in solution are measured by the pH of the system. The more hydrogen ions there are, the lower the pH, therefore the more acidic the solution.

So the bottom line is the chemical formula that I think it probably the same one that Dr. Maest used, which shows what the proportions of pyrite used as the model for all of the sulfide minerals, oxygen and water are. And it's the relation of the number of moles, which are the chemical units of combination, that produce the iron-in solution, iron FE2+2 moles of sulfate plus two moles of hydrogen for each mole of pyrite that is oxidized.

Q And why have you highlighted the oxygen in that formula?

A Well, the overall reaction and the potential for the generation of acidity in the subsurface and the leaching of metals depends on the oxidation of the sulfides. If there's not an oxidant present in the system, the sulfide minerals will not oxidize. They will remain stable and there will be no acid generation or release of metals. So the entire process depends from a chemical point of view specifically on the presence of an oxidant. And, in fact, numerous studies in geochemistry show that ultimately that oxidant has to be oxygen.

Q And are you referring there to atmospheric or free oxygen?

A Free oxygen as the molecule $O2$, not the oxygen that's present in the water molecule itself. The oxygen in the water molecule is not available to oxidize sulfides or anything else.

Q So atmospheric oxygen must be present?

A Yes, molecular oxygen.

Q And the next side, I think you have some additional reaction formulas here. And would you explain briefly what these mean and the point of these formulas?

A The point of these formulas is to provide the rationale for the kind of geochemical characterization test work with which one begins the kind of the characterization program that we've used at Eagle and that, as far as I know, everyone in the mining industry today uses. I've taken another version of that same reaction and taken it to another step so that the full oxidization of the iron occurs in the system and there is yet additional release of hydrogen ions in the system. So instead of two hydrogen ions, there are now four hydrogen ions. And then I've written out in English the important point of this, which is that one mole of pyrite, if there is oxygen present in sufficient quantity, can produce two moles of sulfuric acid, which is the combination of that sulfate and these hydrogen ions. So two of those is four hydrogen ions, two sulfates in there. And what that means is that each mole of sulfur that's present in the sulfides is capable of producing one mole of sulfuric acid equivalent.

Now, acid generation is not the only thing that goes on geochemically in these systems either in the subsurface or in materials that have been placed in a stockpile at the surface. The hydrogen ions associated with the sulfuric acid which in water breaks down doesn't remain as H_2SO_4 -- it breaks to the hydrogen ions and the sulfate ions -- can combine with basic materials -- and basic materials are those that react with strong acids, a base. And calcite is one of those. I'll use that as the model as I used pyrite for the model of the acid generating material.

It does not have to be calcite.

Q Is that the $CaCO_3$?

A $CaCO_3$ is calcite. That's the principal component of limestone -- or the overwhelming component of limestone; 93, 95 percent of commercial limestone -- which breaks down to calcium and the carbonate ion. And the net reaction then is the sulfuric acid plus the base is neutralized and produces, since we're using a calcium base in here -- produced gypsum. And one mole of -- one chemical unit of calcite neutralizes one chemical unit of sulfuric acid. So one must understand the balance between the acid potential and the neutralizing potential of the materials in order to properly appreciate whether the materials will become acidic and have the potential to leach high concentrations of metals.

Q And do both of these types of reactions, the acid generation and the acid neutralization reactions, occur in nature?

A Yes, they both occur in nature and not only in mined rocks.

Q And would they both be expected to occur at some -- to some relative degree in the material within the mine and the material that's excavated from the mine?

A The acid generation reaction can be expected to occur when there is molecular oxygen available. The neutralization reactions are not dependent on the presence of oxygen. They will occur wherever an acid comes in contact with a base.

Q And to do appropriate and proper predictions as to the potential acidity of water in association with rock whether it's in the mine or in the development rock storage area, does one need to account for both the acid generating potential as well as the acid neutralization potential?

A Yes, you do. If you don't account for the neutralization, you will over-estimate the potential impacts of the system.

Q And we're going to take about this a little more. But just to preface that, in the reviews and re-calculations done by Dr. Maest and, I believe, John Coleman, did they account for the acid neutralization side of this story?

A They did not account for the acid neutralization associated with the limestone that the Kennecott plan includes.

Q I'd like to turn to your first two reports, Mr. Logsdon, which again you reference earlier as your Phase I and Phase II characterization studies, I believe. And could you describe for the court how you did this analysis, what you did in the Phase I and then what work you did and then what work you did in the Phase II?

A The kind of geochemical characterization work that we undertook for Eagle requires a substantial period of time to complete. Therefore it's incumbent to begin the work as quickly as possible and then to use your initial results to help you form judgments about additional work that needs to be done. When I joined the project in late 2003, the Kennecott exploration team had already collected a small suite, about 15 samples, that based on their prior experience including prior experience with me on a project in Canada, they had sent out for preliminary acid base accounting work. So we began the Phase I study by doing the geochemical characterization work on the samples that were already available while we compiled the underlying geologic information and mineralogic information on samples that had been collected since the suite that they had pulled from which we could determine an additional suite of samples for subsequent study. So the Phase I and Phase II studies have the same kinds of geochemical characterization work in them. Phase I begins earlier and with a small suite of samples. We expand the size of the samples both to give better spacial distribution to the samples and to more fully represent the nature of each of the rock types that are present in the orebody. But there are a continuum of tests between Phase I and Phase II. It was an arbitrary cutoff point in terms of scheduling and contracting.

Q What was the purpose of that testing, Mr. Logsdon?

A The purpose of that testing was to assemble the underlying geochemical characteristics of the rocks that one uses to reach judgments about the potential geochemical reactivity of the rocks and specifically the potential for acid generation and acid neutralization of the rocks and the leachability of metals from those in the course of weathering, by which I mean the reaction of air and water with the rock when such exposure occurs.

Q Could you explain the various types of testing that you did and try to make it understandable for the court?

A The general approach to geochemical characterization -- and this is the approach that Dr. Maest puts forward in her predictions paper as well -- is to use a simple suite of bounding tests which give you the general flavor of the likelihood of acid generation and metal leaching of the materials that can be accomplished quickly for a large number of samples. Based on the results of that work and your understanding of the mine plan and the underlying mineralogy of the rocks, one then selects a subset of the samples that you've already tested by simple methods and sets up a simulated weathering program in which you allow air to be exposed to the rock and occasionally apply some water as if it were rain or snow melt in order to remove reaction products that may have accumulated in the rock in the meantime and develop an analysis of the chemistry of the water that would be actually generated during a particular type of simulated weathering.

The types of tests that we begin with are the so-called static tests; that is, they take specific samples of rock and they're done at bench scale on subsets of material. They can be done rapidly at relatively limited cost. There are two general -- or a number of general types. Let me go through them. We had 103 independent samples, five of which we ran as replicates to see how closely sampling variation would be in those samples, for a total of 108 samples that were tested. We do a series of what are called acid-base accounts on this. The acid account determines what the acid generating potential would be by looking at the amount of sulfide sulfur that's present in the rock. Remember in the previous slide, the amount of sulfur is proportional to the amount of acidity that can be generated.

Q Does that assume then exposure to oxygen?

A Yes, it does assume exposure to oxygen. These are bounding calculations. It assumes that, if the sulfide could oxidize, how much acidity could possibly be generated by the rock.

Then the second subset of that same sample is tested to evaluate how much acidity it can neutralize. And one does that as a separate test in the EPA style testing, the Sobek test that we use for this procedure in here. One takes the rock, crushes it up, adds a known amount of acid to that. The rock reacts with as much acid as it is capable of reacting with. And then one adds again by titration a known amount of a strong base, sodium hydroxide, to determine how much the acid was consumed. And that calculation identifies to you the capacity of the rock to neutralize acidity were acidity generated.

Q And does that relate back to what you talked about earlier? It depends on the content of the rock of things like calcium carbonate, which would be a base-type element?

A Yes, it does. And it's not -- the number that is reported is reported in a conventional unit that references calcium carbonate. But the test is not specific to calcium carbonate. The rock neutralizes the acid or the rock does not neutralize the acid. And one can express the capacity in terms of an equivalent amount of calcium carbonate whether all of that capacity is due to calcium carbonate or some is due to other minerals that are present in the rock.

Q What are some examples of some other minerals that may be present that would have the same effect as calcium carbonate in terms of neutralizing acidity?

A A very important one for our particular purposes is that the ultramafic mineral olivine has a very substantial -- not as high as calcite -- but a very substantial capacity to neutralize acid as does the breakdown products during natural weathering of olivine that are the serpentine minerals. So there are other minerals that are present in here and we know they're present in here because of the very detailed mineralogical analysis that Dr. Jambor did for us in here. So we understand that we have both carbonate minerals and highly reactive alumino-silicates in the form of olivine and the serpentine in the system. So we understand what the mineralogic basis and those -- that mineralogic basis is consistent with the sorts of numbers that we measure in terms of the neutralization potential of the samples.

In addition to those acid-base account tests that we do, we dissolve the rock in a specific combination of acids that are intended to dissolve essentially all of the rock and then analyze the solution that's generated from that in order to understand what the chemical composition of the rock is including the trace metal content. The presence of trace metal in the solid rock does not indicate the extent to which the trace metal would be released during weathering. But it does identify to us the trace metals that are present in anomalous concentrations in the rock and therefore the track metals about which one might be concerned in terms of potential impacts if there were weathering.

Q So that part of the testing is not about looking at the potential for acidification or the potential for neutralization but is it directly to look at the specific content, the relative amounts of different types of materials in the rock?

A Yes, it is, for example, to determine that the rock is anomalous in nickel and anomalous in copper, whereas it may not be anomalous in aluminum content.

Q Now, you used the term "weathering" before. Does that mean exposure to oxygen or does it mean something else?

A Exposure to oxygen and water; that is, the sort of process that occurs near the surface of the earth when rain falls on soil, it's present. That's the weathering process and, from a chemical point of view, involves very similar processes to the ones that we're studying in terms of mining issues.

Q In general, if potentially acid generating rocks are contained within the earth and are not exposed to the surface, do they have the potential without exposure to the surface of generating acidity, ARD-type conditions?

A No, they won't generate acidity, because we would have no sulfide orebodies to mine if oxidation occurred absent the presence of oxygen.

Q Why would that be true?

A Because if oxygen can't get to the sulfides, if the sulfides are isolated either within a solid rock mass or because the rock mass is saturated with water, the pore space is filled with water, then oxygen can't get to the sulfides and the sulfides will remain in place with no oxidation and no generation of acidity.

Q So water alone cannot cause degeneration of this acidic-producing reaction?

A H2O by itself will not cause the process to occur. There must be dissolved oxygen or molecular oxygen, free air, present in the system. It doesn't have to be free air. There does have to be molecular oxygen.

Q As opposed to H2O?

A Yes.

Q And could you continue with the description of the next type of testing that you performed in the characterization phase of your study?

A During the phase two study I asked that we add a second type of screening test for acid generation to the Sobek test that we were running. So it's not instead of, it's in addition to the Sobek test. And it's a test that was developed initially in Australia and has been applied very widely in Australia and the Western Pacific and increasingly is used in mine studies in North America in conjunction with the Sobek-type test that we're routinely familiar with in North America.

Q Who developed that test?

A That test was developed by Dr. Stuart Miller at the company called Environmental Geochemistry International in Balmaine, New South Wales, Australia. The purpose of this test, it's actually a pretty neat idea. What we really want to know, the Sobek-type acid potential and neutralization potential tests are done on separate splits of the rock and the rock's treated differently in the two tests and then one does an arithmetic comparison of the two values.

Q Meaning the acid part and the base part is done separately?

A Yes. The test is done separately, and each produces a different number. And the potential for net acid generation or net neutralization depends then on the magnitude of those two numbers. What we really want to know is how the rock itself would behave. If oxidation of the sulfides began to occur, would the rock around the oxidizing sulfides be capable of neutralizing the acidity on its own right. We don't want to add acid to it. We want to know what would actually happen in here. So the net acid generation test takes a sample of rock, crushes it to a particular specification so that there's lots of opportunity for reaction to occur, adds a strong oxidant called hydrogen peroxide, which is a stronger oxidant than molecular oxygen but does not persist in the natural environment, so that there is the maximum potential to oxidize the sulfide in the rock. And then one waits a period of time, four hours to 24 hours, depending on how you set up the test, to see how the rock will react with the amount of acidity that is generated by the oxidation of the sulfides. And one looks at the net acid generation. Either the pH stays high and there remains alkalinity being released by the system, or the pH falls below four and a half and there is no measurable alkalinity in the system. So it's acid generating or nonacid-forming in those two cases.

And when one does that test in conjunction with the Sobek acid-based accounting test that we use in the United States, the two independent measures of the performance of the system and by using them together you can have a much higher confidence in your conclusions about which materials are going to be acid generating and which materials are not going to be acid generating. It's now a standard part of my characterization program at projects all over the world.

Q Now, you indicate on the slide here that in addition to the 103 or 108 with the five replicate samples for acid-base and whole-rock chemistry that you did the net acid generation testing on 68 samples?

A Those were from the phase two work.

Q Okay. And are those samples meant to be or were they representative of the various types of rock that you talked about earlier on the one slide, the ore-type rocks and the country rocks and the peridotite-type rocks?

A Our concentration was primarily on the development rocks, not on the ores. But we did test multiple samples of semi-massive and massive sulfide ores, as well as a range of sulfide concentrations in the intrusive rocks.

Q Why was your focus on the development rock?

A Because as I said before, that's the rock that will remain at the Eagle site, the management of which is important to being able to control the environmental conditions at the site. The ores are going to be removed by direct shipment to another processing location, and won't remain at the site for more than short periods of time while trains are being loaded or trucks, whatever -- how ever it's transported.

Q Okay. And what was the next type of testing that you did?

A During the phase one test we ran a series of short-term leach tests on ten of the 15 samples that were available. It's a test originally designed by contractors to the U.S. Environmental Protection Agency called the synthetic precipitation leaching procedure in which one takes distilled water, adds small amounts of sulfuric nitric acid to the water in order to simulate an acid rain, and then reacts a given quantity 20 times the mass of the solid is the mass of the liquid and looks at what the amount of leachable material from those would be.

Q I missed -- your putting that fluid around the rock samples?

A Yeah. You take the rock sample, you crush it up, you stick it in a -- it's not a plastic bottle you stick it into, but a reagent container in there. You add 20 times the mass of the rock solid in there, you shake it back and forth for 24 hours, separate the solids from the liquids and measure the liquid concentrations.

Q And that's why it's called short-term? It's a 24-hour?

A It's a 24-hour test, and it's a static test because it occurs in the short-term. In my judgment, in this case as in essentially all cases where I've tried to do this, it's not a very illuminating test. Because the concern that we have is not the leachability of the rock as it comes out of a core from the ground. It's the leachability of the rock after it's been exposed at the surface for some number of months or years or in subsurface for some number of months or years. It's the amount of leachability that's associated with that acid generation process that we're interested in trying to evaluation. The short-term test is done on fresh rock samples from core. And there has not been sufficient oxidation of that material to simulate the problem that we're actually looking at. In addition, the EPA protocol calling for 20 times as much water as there is solid means that you have a huge dilution of whatever leachability there is in the process, and you -- essentially in all cases that I can think of for fresh core, you end up with detection level values for the samples because you simply got more water in there than you can identify the presence of the dissolved constituents in. So it's not providing information. We can run the test and spend the money and produce tables full of numbers that are all extremely low. But it's not actually providing any information that we can use for decision making because the test is poorly posed with respect to the problem that we're trying to evaluate.

So after doing the ten samples in phase one and seeing the expected outcome that we didn't see leachability in there, my judgment was that it was not a worthwhile test to continue doing, because we were going to go to another type of geochemical test that would in fact evaluate what happens when the rock materials are weathered in the presence of oxygen and water. So we terminated it after phase one.

Over the course of phase one plus phase two, we selected 30 samples out of the 103 independent samples that we had for detail and mineralogical examination. I used the person I believe is the most qualified mineralogist in the world with respect to mine waste, Dr. John Jambor, who very unfortunately died in January; spent 40 years for the Canadian Geological Survey and the government of Canada looking at the mineralogy of mine waste; absolute world class leader in research in this field. And John prepared I think it's four reports for us, all of which are attachments to the phase two report that describe aspects of the mineralogy of the rocks. He did that work using optical microscopy, using a microscope in order to look at samples and take pictures of them to look at their relation, identify what the minerals are, look at the relationships of texture between the way the sulfide minerals present themselves and the way the neutralizing minerals present themselves. He looked specifically at the compositions of both the sulfides and the neutralizing phases using scanning electron microscopy with energy dispersive analysis and x-ray defraction techniques in order to quantify the proportions of the different minerals that are present. And the information that this generated is indispensable to Kennecott Eagle's understanding of the nature of the materials and the interpretations that we make of the geochemical test work of bulk solids; that is, that geochemical test work because it's on the bulk material includes the effects of both sulfides and the silicates in the rock. Knowing what the specific mineralogy of those samples is allows us to understand why we see the behavior in bulk that we actually see. It's a critical part of our study.

Finally, during both phase one and phase two we initiated what are called kinetic leach tests. We began this in phase one. The kinetic leach tests need to run for substantial periods of time. And if one waits until after all of the static work is done to select samples for testing, it defers the information that can be generated from these tests until after you would really like to have it. So we selected five samples from the suite of samples in the phase one test work and began the kinetic testing on those early. And then when we had selected the -- and done the initial acid-base accounting on the phase two samples, we selected an additional ten samples to represent a wider range in both space and composition than we had been able to achieve with the small data set available in phase one.

Q Now, you've described earlier what the acid-base and whole-rock chemistry testing is, and then that acid generation and the short-term static leaching, but you have not yet described what this long-term kinetic leaching testing is. Could you please do that?

A Yes. The purpose of the long-term leaching test is to expose crushed samples of rock to oxygen and water and evaluate what the chemistry is of the water that moves down through a column of this material. We did the tests as columns; PVC columns, filled them with crushed rock. We know the particle size distribution because we measure it after we've crushed the rock before placing it in the column. Then on weekly cycles one takes a period of three days and blows dry air upward through the column. And you do dry air so that you'll dry out whatever moisture is present in the system. And because we're using high flows of air, we'll deliver as much oxygen to the materials as it's possible to do; very high flows of oxygen compared to what would be present if you stuck a rock on the surface of the table in here. And then for a period of three more days, we add moisture to that water and put moisture back into the system so that there is water present during the reaction phase.

And on the seventh day, you take a measured quantity of water and we pour it in at the surface over a dispersal plate so that we get a nice even flow of water moving down through the column. That water moves down through the column, drains under gravity. We collect the water on a weekly basis. And that water is analyzed chemically in a certified laboratory. And then we repeat the cycle. And the cycling goes on for how ever long it goes on. And one sees the evolution of the chemistry of solutions, if there is reaction between oxygen and water and the rock that's present in the column. If we filled the column up with glass beads and ran the experiment, there would be no reaction coming out the bottom. It would be a small amount of silica coming out from the water in the glass, but there would be no acidity associated with it, there would be no nickel, there would be no copper.

What we're looking for in this is a simulation of our conceptualization that the weathering process involves the exposure of the sulfide minerals to oxygen in the presence of sufficient water to permit the reaction to proceed. And then there is an infiltration period which occurs whenever it occurs, steadily or incrementally associated with rain events if you're on a surface system, that flushes down through that system and delivers reaction products at the base. And the rate at which mass is moved from the solids to the water is considered in the analysis to be related to the rate at which solids would be delivered to water in an actual mine waste system once we work out how to scale the difference between the test that we're doing and the behavior that would occur at the field scale problem.

Q What kind of parameters, then, are tested for or quantified from this long-term kinetic leaching testing?

A Each week it measures the pH and about 40 dissolved constituents in the -- in the water, something like 32 metals plus components like sulfate and nitrate and chloride and fluoride and things that are not metals but may in fact go into solution. We calculate the total undissolved solids of the system. We look at the alkalinity or the acidity; that is, the measure of whether it's a basic water or an acidic water in the system. It's a very large suite of analyses that's done for each of these columns each week that it's run.

Q Is the purpose of this testing to provide some information as to what the longer-term behavior of the various types of rock in the field might be when exposed to oxygen and water?

A That's exactly what we're trying to do is a simulation of the weathering process over the long run rather than the short-term characterizations on the subsets of the system that we can do with a larger number of static tests.

Q And does this testing in fact accelerate that process?

A There are arguments in favor of the acceleration, particularly the crushing of the rock that goes into the formation of the sample that will be tested produces more surface area than one would expect to see in the rock that's present due to mining. And that accelerates the rate of removal of mass from the system. The regular flushing accelerates the rate at which we see the production of the effluents in the system, because we're doing it routinely week by week, whereas there might be dry periods in which essentially no water is flowing through the system in the field or in wintertime the portions of the system may be frozen. There may be no water moving through the system at all.

The underlying reactions that occur at the surfaces of the minerals are set primarily by the details of the physical chemistry of the minerals, and those cannot readily be accelerated for a given set of reactives. But the overall reaction is believed by essentially all geochemists to be accelerated with respect to the behavior that would be seen for full-scale mine materials.

Q Now, these long-term kinetic leaching test results, you used those results, for instance, in something we're going to talk about later, to calculate the predicted water chemistry for the development rock, the water under the temporary development rock storage area?

A Yes. That was the use of the test work. The test also can be used to confirm the judgments on acid generation that come from the static tests. So if we predict it to be acid generating, then during the simulated weathering does it become acid generating. And if so, does that happen quickly or does that happen after some extended period of time in which it remains neutral.

Q Has that long-term kinetic leach testing continued?

A Yes, it has. It continues to date.

MR. LEWIS: I'd like to look at, if we could, Exhibit 595, please. This is what's been marked as Intervenor's Exhibit 595.

Q Are these the long-term kinetic leach test results data, Mr. Logsdon?

A These are the first 26 weeks for the parameters that are shown on that table of the long-term test work.

Q And subsequent pages reflect continuing weeks of data?

A Yes, they do. They're numbered consecutively by week from zero up to this one I think goes to 196 or something like that.

Q And do you recall without looking approximately how many weeks of testing have now taken place on the samples that you originally started doing this testing on?

A The last time I looked at the numbers comprehensively, they were at about 196. And that was a couple of months ago, so we're over 200 weeks.

Q Over 200 weeks on at least the original samples that you started doing --

A I think that's over 200 weeks on all 15 of the samples at this stage.

Q And this is the results that were done by the certified laboratory that you referred to earlier?

A Yes, in Vancouver, Canada.

Q And have you reviewed their procedures and how they do their testing?

A I have. And I've been to their laboratory to look at the columns and the manner in which they run the columns. I've worked with this laboratory on this type of testing for more than ten years.

Q And this data, then, in the form we're looking at here in Exhibit 595, is that what is sent to you from the laboratory?

A Yes. They have a routine reporting period. Once a month they send me an update of the data. And it comes in Excel spreadsheets that produce tables that look like this.

Q And do you review that data, then?

A I review it every month.

Q Now, this -- for instance, this page says, "Draft Only -- Subject to Change." Why does it say that?

A The laboratory sends it to me in that form because I've asked them to send me the results as soon as they are updated. That way I can look at the time series behavior of the materials and identify whether there are any numbers that look problematic in which I wish them to re-analyze the samples. If I report back to them that everything is in order, then they produce a final document with the same date. And that is delivered to Kennecott Eagle, because they're the client and they're paying the bill. I get the draft information and work with that for my analysis.

Q And have you now reviewed this data that's represented in Exhibit 595?

A Yes, I have.

Q And have you determined that to be final?

A Yes, it is.

Q And I believe we heard Dr. Maest refer to this exhibit and talk about this data earlier. Do you recall that testimony?

A I read the testimony.

MR. LEWIS: Your Honor, I'd like to offer this exhibit at this time, Intervenor Number 595.

MR. REICHEL: No objection.

MR. EGGAN: Do I understand that Exhibit 595 -- Intervenor 595 will remove the "Draft Only -- Subject to Change" language, or are we just offering it as is?

MR. LEWIS: I think the record reflects that he has reviewed it and it is finalized. I submit that's sufficient. We don't need to change the document, I don't think, Mr. Eggan.

MR. EGGAN: I don't think so either. I just didn't know. I don't have an objection.

MR; HAYNES: Your Honor, I which has one brief bit of voir dire for the witness.

JUDGE PATTERSON: Okay.

VOIR DIRE EXAMINATION

BY MR. HAYNES:

Q Mr. Logsdon, is it your testimony that the final document based upon the draft that's Exhibit 595 has been submitted to Kennecott with no changes?

A I don't know that it has been submitted. When it is submitted, it will have no changes compared to this. There are no changes to the data required.

MR; HAYNES: All right. With that understanding, I have no objection, Your Honor.

JUDGE PATTERSON: Okay. Being no objection, it will be entered.

(Intervenor's Exhibit 595 received)

DIRECT EXAMINATION

BY MR. LEWIS: (continued)

Q Mr. Logsdon, I'd like to turn next, if we may, there was some discussion by Dr. Maest I recall. I think she took issue with whether the samples you had selected for this various testing were as representative as they ought to be perhaps both in space and by rock type. And I think you've prepared a slide here to illustrate in fact the spatial representation of the various samples on which you did the testing that you've just described. Could you explain please what this figure shows?

A Okay. This is Figure 2-2 from the phase two characterization report, which is Attachment D-2 to the mine permit application. So this is in part of the record for some substantial period of time. This is a cross-section, so we're standing on the south looking towards the north with the entryway for the mining coming in from the east down a ramp towards the Eagle orebody. Each of the points that's shown on here is a spatial projection onto the cross-section. So ground surface is up here (indicating). Ground surface is up here, depth is down this direction. Zero is a reference elevation. It has no particular meaning. These are the projections from both behind this plane and in front of this plane onto this plane of the sample locations. And the purpose of this is to show how the Eagle geologists and I selected the spatial distribution of samples so that we would have a fair representation of the distribution of materials across the whole of the spatial domain that will be mined by Kennecott Eagle. It's very important to have that so that we're not, for example, doing a whole bunch of test work on something that's located up here or just down here in some corner. We need to have the full three-dimensional distribution of the samples. This isn't a three-dimensional figure. It's a projection of the three-dimensional material. And you'll note that it includes the green symbols are country rock, those are the sandstones and siltstones that were present in the system prior to the intrusion; blues are intrusive rocks; that is, the peridotites that exist within the Eagle intrusion; the brown and red zone in here is the ore zone that is the target of the Eagle mining project. And the locations in here include samples of country rock that are on this side of Eagle and on the other side of Eagle, so they're all compressed into a single system. Note particularly that we have samples that are located all the way from below the orebody to above the orebody, including across the elevations that would remain in a crown pillar under both the conditions that I understood when I did my work and under the expanded crown pillar that is now the permitted requirement for the system. And we have all degrees of direction laterally as well as vertically covered by the samples. The essence of the kind of testing that we're doing is that it is the nature of the rock type that determines its behavior, not its specific location. But we want the locations from which we test the rocks to represent the entire range in space and, therefore, the entire mining history of the operation so that we would understand whether and when in the mining sequence we could expect to see changes in behavior.

Q And if we could next, I want to -- I think Dr. Maest also presented some discussion as to whether you had properly represented the sulfur content characteristics of the rock for the testing purposes and predictive purposes. And I believe you've prepared a slide here to explain the representation of sulfur, have you, Mr. Logsdon?

A Yes, I have. The data are from the exhibit that you just introduced. Well, not from that. It's from the database that was provided by Kennecott. You better identify it. I'm sorry, Rod.

MR. LEWIS: Yes. For the record, that's Intervenor Exhibit 309 that was admitted through Andrew Ware earlier in the case.

Q And does this figure show the actual distribution of sulfur by rock type and the range of sulfur content?

A It's not by rock type. This is the total range of sulfur for all rocks that has been drawn by Kennecott Eagle project.

Q Can you explain what the figure shows?

A Sure. It's important to understand that this represents the result of sulfur concentrations in 6,348 samples that have been tested by Kennecott Eagle.

Q Is that the blue line on the figure?

A The blue line. Each point on here represents a single analysis of a single sample in the Kennecott database. So this is the entire database for sulfur for the whole project. It includes country rock, it includes intrusive rocks that are in the development rock category, it includes ores both semi-massive and massive sulfide. This is the entire representation of the orebody on which all of their mine plans and economic evaluations as well as our test work is based.

Q This is, you said, 6,348 samples?

A That's the count.

Q Okay. What else does the figure show, then?

A Okay. The vertical axis represents the sulfur concentration for specific samples that are identified in blue over here. Those samples are arranged by their sulfur rank from the lowest sulfur concentration to the highest sulfur concentration so that each sample is assigned a specific number from one to 6,348 in here. So a sample that falls here (indicating) is the 2,000th sample in the system, and it has a sulfur concentration of about 2 percent. Okay. Now, the critical features of this diagram with respect to the sulfur distribution -- I'll come back to the red figures, which are where our column test samples lie in this distribution in just a moment -- are that the nature of the curve is not -- it's not straight line. If it were a straight line, it would just continue off in this direction and we'd have no sulfur concentrations that were higher than about 15 percent.

So the fact that there are changes in the slope and angle of the line indicates that there are fundamental changes in the nature of the sulfur that's present in the rock and, therefore, fundamentally different types of rock that need to be considered. First, there's a range of samples that come up to about a sulfur of 3 percent. And that's a nice linear trend up to about 3 percent. At about 3 percent to about 15 percent there's a change in the slope of the rank order distribution of the sulfur, and that's indicates that we've entered a new type of rock with respect to its sulfur. From about 15 percent to about 32 or 33 percent, there are very few samples. The number -- rank order number does not increase. It goes up vertically, so there are in fact samples between those, but it's a very small proportion, a fraction of a percent of the total rock that's present has concentrations between 15 percent and 30 percent. Then we have at 32 or 33 percent we have another change in slope of this, a change in orientation. It's called an inflection point. And that goes up to very high concentrations. These (indicating) are the massive sulfide ores. These are the rest of the ores, the semi-massive and the high sulfur concentration disseminated ores in here. There's a transition between semi-massive and massive, which is just a textural relationship between them in there. And then down below 3 percent we're in the low sulfur end of the system, and this is where the development rock lies, both country rock and intrusive, low sulfur materials with concentrations less than about 3 percent.

Q Is 3 percent roughly the breakoff between material that would be mined for economic reasons and the material that will be so-called development rock?

A That is my expectation based on the nickel concentrations that go along with the sulfur in this, as I understand that information. So this is the development rock, and this is the rock on which we were focusing our characterization work, because that's the rock that will remain at the site for long periods of time, potentially subject to weathering and, therefore generating potential impacts to water quality. We did sample some materials for long-term kinetic tests. One sample in the massive sulfide, two samples in the semi-massive sulfide for completeness, and so that we could address at some level the impacts for residual ores were they to be present in the subsurface.

Q So now you're talking about the red dots?

A The red dots are --

Q And those represent --

A The red dots are the sulfur concentrations for the 15-column test that we've conducted.

Q And so you indicated you did one for the massive sulfide and two for the -- what is that area?

A The semi-massive sulfide.

Q Okay.

A And then the rest of them are in the range of the country rock -- of the development rock. Because this is a straight line or essentially a straight line from the lowest sulfur concentrations to about 3 percent, there's an expectation of about half that material being on the high sulfur end and about half that material being on the low sulfur end, because it's a straight line.

Q And based on what you -- we looked at the prior slide as far as the distribution of the various samples in and around the orebody. And then this slide we've now just looked at as far as the representation of the sulfur testing and so forth, do you believe that you have adequately represented the samples for purposes of predicting the potential for ARD development for this project?

A Yes, I believe so. I believe the spatial distribution is entirely adequate, and I believe that looking at the full set of 108 measurements of static acid-based accounting we have the basis across a wide range of samples as well as a representative subset of those to use in the kinetic test.

Q And could we turn to the next slide? And I believe you have a quotation there from your -- I believe it would be your Appendix D-2 report as far as what was the conclusion of your phase one and phase two characterization studies.

A The conclusion of the phase one and phase two studies was that there are sufficient sulfide minerals present in the development rock and the concentrations of trace metals are sufficiently high that active management of all rock units in the mine, not only the ores but also the development rock, will be required in order to have a modern environmental program for a mine.

MR. LEWIS: Your Honor, I'd like to identify for the record and offer the first two reports which we've now talked about by Mr. Logsdon. And the first one is in Intervenor Exhibit 3. It's also referred to as Volume 1B, Appendix D-1 of the mine permit application. And the Bates range for the Appendix D-1 report in Intervenor Exhibit 3 is 102577-103162. The second report which Mr. Logsdon referred to as the phase two report is in Intervenor Exhibit 4, also referenced as being in Volume 1C of the mine permit application, Appendix D-2, and identified by Bates range 103163-103616. And I'd offer those now.

MR. EGGAN: Can you say the numbers of the exhibits again, Counsel?

MR. LEWIS: The Bates range?

MR. EGGAN: No. One was Exhibit 4, I think, and the other was --

MR. LEWIS: Yes. The first one is within our Exhibit 3 and the Bates range I gave you.

MR. EGGAN: Yeah.

MR. LEWIS: And the second one is within our Exhibit 4 within the Bates range I gave you.

MR. HAYNES: Your Honor, as to Appendix D-1, which is also identified as DEQ Exhibit 27, this is the phase one Eagle project geochemistry study. I assume it was authored by Mr. Logsdon; is that right?

THE WITNESS: It was written by me in conjunction with my colleagues at Golder Associates. I was responsible for the report. But specific wording at various points was provided to me in draft by the people at Golder who were working under my direct supervision.

MR; HAYNES: Right. As to that exhibit, I don't have an objection. As to Exhibit -- as to Appendix D-2, which is called -- which is also DEQ Exhibit 28, the phase two Eagle project geochemistry study, that study includes the mineralogy -- as the witness testified, the mineralogy reports prepared by --

THE WITNESS: Dr. John Jambor.

MR; HAYNES: -- Dr. Jambor, who apparently is now deceased. And so we won't have a chance to cross-examine him unfortunately. Those studies, which are entitled Environmental Mineralogy of Samples from the Eagle Deposit Michigan Part One April 2004 and Environmental Mineralogy of Samples from the Eagle Deposit Michigan Part Two, comprise, oh, say more than a hundred pages of pretty detailed work here. And we don't have a witness to authenticate those, so I object to those portions of D-2 being admitted. Otherwise, I have no objection to Appendix D-2.

MR. EGGAN: I agree, Judge. The problem, of course, is that we have a witness who is deceased who is not present to testify about them. I would add that a similar objection was raised by Kennecott with respect to one of Ann Maest's reports; that it contained materials that had been prepared by others who either are not going to be called or are not available. And the Court sustained the objection, so I have to object, too.

MR. LEWIS: This has come up before. Mr. Eggan has responded that way, and I responded this way. And I'll clarify once again, as to the attempt to introduce through

Ann Maest the conclusions of another expert -- and as I think the Court probably recalls, the problem there was that the attachment to that exhibit that was being offered was the conclusions of someone who had done some groundwater studies, as I recall. There was no showing that that work by this other group in another discipline, another subject matter area for which Dr. Maest was not qualified, there was no showing that Ann Maest even relied on that for any of her testimony, for any of the subject matter that was within the report that was actually authored by her. And we went through that. We asked more questions. And it was plainly apparent that that was the case. This is a different situation. This is a situation where Mr. Logsdon has in fact relied on the work done by this now deceased geologist; has testified that he reviewed that work and I think participated in that process. So it is very much a horse of a different color in that respect. And I think that in that respect that the general rule that's applied in this forum and I believe has been applied before in this case to the effect that an agency may admit and give probative effect to have evidence of the type commonly relied upon by reasonably prudent men in the conduct of their affairs ought to govern the decision on the admissibility of this particular report.

MR. REICHEL: Your Honor, I have no objection. And I would also note that this witness' testimony is that he was very familiar with the work of Mr. Jambor and is familiar with the quality of his work, his reputation in the field. And I understand his testimony to be that as a part of his involvement in this he relied upon the information compiled by Mr. Jambor and did so in a reasonable manner.

MR; HAYNES: Well, Your Honor, the reliance is irrelevant. The witness can rely on all sorts of things. But if they're not admissible in evidence, just because he relies on it, doesn't make it admissible. So that criterion cannot be the -- cannot govern the admissibility of the mineralogy reports.

JUDGE PATTERSON: I'm going to overrule the objection. I think there's been -- it's been established that he, if I can use the term commissioned, that work and relied on it and utilized it in his conclusions. So I will admit both documents as proffered.

(Intervenor's Exhibit 3, Vol. 1B, App. D-1 received)

(Intervenor's Exhibit 4, Vol. 1C, App. D-2 received)

MR. LEWIS: Okay. Thank you, Your Honor.

JUDGE PATTERSON: Can we take a break before you start again?

MR. LEWIS: Yes.

(Off the record)

JUDGE PATTERSON: Whenever you're ready.

MR. LEWIS: Thank you, Your Honor.

Q Mr. Logsdon, we talked earlier about the fact that what you called the kinetic testing, the longer-term testing, has continued. And I can't remember. How many weeks roughly has it continued at this point?

A Something over 200 weeks.

Q And have you -- and that was in reference to Exhibit 595 that we introduced earlier. Have you shown graphically or prepared a graphic representation of what that long-term kinetic test data shows?

A I have.

Q And could we look at that next, please? Is this the figure that you prepared?

A Yes, it is.

Q And could you explain what this shows in terms of the kinetic testing results?

A This is the time of time series presentation of kinetic test data that we use standardly in this kind of analysis. In this graph the vertical axis is the concentration of nickel and it's in a logarithmic scale because we go from very low concentrations to substantial concentrations. The horizontal scale is the number of weeks of the test as of the reporting period for the data. These data are through the beginning of November of last year, so the longest term ones are 196 weeks. Those were tests that were begun in phase one. The phase two tests lag that by about 40 weeks.

Q Have you chosen nickel just as an example of some of the leaching products that you actually test for here?

A Yes, both as an example and because nickel -- this being a nickel mine is a parameter of particular concern if it were to leach in the water.

Q And does it reflect, then, the long-term test conditions of the other metals as well?

A Yes. The specific concentrations would be different for parameter to parameter, but the patterns are consistent.

Q Okay. Continue with your explanation of what this figure shows, please.

A Well, it has each of the humidity cells -- not humidity cells -- the column tests up here (indicating). The nickel indicates that we're dealing with nickel. The first number is whether it's phase one or phase two. The second number is the column associated with phase one or phase two so that one can identify these by their pattern to the specific tests that were conducted. And it shows that there is a group of the country rock samples -- of the development rock samples involving both country rock and intrusives in which there is essentially no incremental leaching of nickel. We have the same range of concentrations over the full 196 weeks of testing up to this time period.

Q If we could back up just a minute, please? Does each line on this graph represent an individual sample?

A Yes. It represents an individual sample.

Q And its behavior over time?

A Its behavior over time from a specific column. For example, these triangles here are phase one column number three. And if I went to a table that identified that, I would know what its sample number was. I don't have that off the top of my head.

Q And what do the various colors on the lines represent?

A Green are the country rock samples; blue are intrusives, and red are the semi-massive and massive sulfides.

Q Okay. And could you continue your explanation, then, of what this shows us?

A So there's a proportion of the rock in which there is no incremental change, no increase in nickel leaching over time associated with the samples. They bounce back and forth very close to the limit of analytical indetection in the samples, which is why they appear noisy in here. But there's no upward trend in the data. There's another group associated with development rock, primarily in the country rock, but including some samples of the intrusive in which there is a lag period of some number of weeks, about 25, 26 weeks, and then the concentrations begin to increase up to time periods around 70 or 80 weeks and then the samples leach in a consistent rate following that. The ores in one sample of the high sulfide intrusive rock rise after a lag period for the intrusive and a lag period for the semi-massive samples. They rise rapidly to concentrations above ten milligrams per liter, but less than a hundred milligrams per liter. The single semi-massive sulfide sample started out at very high concentrations around -- 200, 300, 400 -- 500 milligrams per liter and then rapidly fell down to concentrations that are about at the same level as the semi-massive sulfides rise to. Because this is on a downward trend, we elected to discontinue the metals analysis of the massive sulfide sample because we had all of the information including the maximum value that was observed in the system. We continue to monitor the pH and the electrical conductance on that all the way out through time. And those do not change. They have steadied out, so we're confident that there's been no change in the nickel concentrations either.

Q And do these results depicted on this graph generally indicate that there's been sufficient time that you've reached what we might call a steady state condition or --

A I believe that's exactly what we see. Beyond 100 weeks in the samples there are steady concentrations that are present for the samples. And we would not expect to see new spikes occur. There's no process by which that would occur given the known mineralogy of the samples.

Q Now, when you did your reporting and your various analyses, and some of which we'll talk about later, your predictions for the water quality and the water under the TDRSA, in the mine, during mining and in the mine after mining, did you use these long-term kinetic test results?

A At the time I prepared those calculations, we had data only up to about week 50. We had week 70 for some samples, as little as week 26 for others.

Q And we heard earlier from Dr. Maest and -- both Dr. Maest and Mr. Coleman at the time they looked at this data, information further out in time, test data further out for subsequent week 70, week 90, weeks I don't recall what's available to them, and as part of their recalculations they used that longer-term test data; do you recall that testimony?

A I do.

Q And in that time frame, in the time frame between the time you did your report and the time frame that Dr. Maest and Mr. Coleman looked at the updated data, had there been some increased rate of leaching of metals as shown by these results?

A Yes. The time period that they're talking about is this time period in here around 50 to 70 weeks. And you can see that there are increasing concentrations in some but not all of the samples.

Q And does that explain in part why they recalculated numbers in terms of predicted concentrations of metals and so forth that were higher than the numbers you had in your report?

A Yes. They used the highest value and I did not, because I was using earlier times.

Q And in terms of your final conclusions in the various reports, and we looked at on a prior slide your conclusion as to phase one and phase two, that that being that there will be a need for active management of all rock types, does the fact that longer-term leach test results would show a higher calculated concentration of metals in the water change that conclusion?

A Not at all.

Q Why is that?

A Well, because the impacts that I calculate from the values that were available to me when I did the calculations, which are lower values than some of those in later time, already showed the need for active engineering management. And I had made that recommendation based on the earlier data. The longer-term data also indicate the need for active engineering management. And the change in concentrations are not of a magnitude which would change the type of active engineering controls that Eagle was considering.

Q Now, as we discussed earlier, that long-term kinetic testing has continued. Why is that being continued?

A Well, there are two principle reasons. The fundamental reason is that in the Kennecott companies there is a standard procedure to continue this type of testing well out into the future until at least there's been a determination that steady state concentrations have been achieved so that one can update understanding of the significance of the increasing data set as time goes on and consider whether that requests any reconsideration of the contingent decisions that were based on earlier time.

Q And in your opinion, based on the results we just looked at in this figure and based on the analysis and work that you have done, do you think it's likely that there will be sufficient change in that picture that changes or modifications to the planned mitigation programs will need to be made?

A I do not expect that requirement.

Q Is it your understanding, Mr. Logsdon, that the continuing testing is required by the DEQ and that Kennecott is required to report that information to the DEQ?

A In my understanding from direct conversations with managers at Eagle is that it's a permit requirement and they intend to make the updated report with the first annual report next month.

Q Now I'd like to turn to the lateral three reports that you prepared, Mr. Logsdon. And just to review for the Court's benefit, there were three of them, and we'll identify them by exhibit number as we go. But the three are -- one addressed what would be the water quality in the water in the temporary development rock storage area, one -- another one, Appendix D-4 -- the first being Appendix D-3. Appendix D-4 you address the water quality in the mine during mining, and then the third one, Appendix D-5, you address the water quality at the end of mining in the mine with all of the backfill back in the mine.

A That's correct.

Q And if we could go to the next slide, please? Could you explain what was the purpose of preparing these reports and these analyses of the potential conditions in the water in the TDRSA, the mine during mining and the mine after mining?

A The purpose is related to the third of the three tasks that Kennecott had assigned me. And the purpose is to use the information that's available at the time an assessment is made to provide the support that's necessary for me to advise my client, in this case, Kennecott Eagle Mining, on the need for and the general types of engineering controls that would be required for the site-specific materials that they have in order to protect water quality.

Q Did you use what we should properly refer to as geochemical models in doing these three analyses and predictions?

A I used geochemical models in one of the three main ways that scientists use the term "models."

Q Can you explain that, please?

A Sure. The first way that scientists use the term "model" is that of what we sometimes call a conceptual model or a qualitative description of a system, a semi-quantitative perhaps description of the system. For example, in elementary physics, one considers incline planes as if they were frictionless; places a marble on the incline plane, tracks its movement as a function of time down the slope, sees that there is an acceleration and produces an analysis that that acceleration is due to the force of gravity. That's a simple qualitative, semi-quantitative model.

At the other extreme is the sort of detailed numerical analysis that one uses when there is a great deal of data available to describe a well constrained system; for example, the kind of model that an engineer would use in designing the wings of an airplane where we have 100 years of information on the behavior or how airfoils behave. And we have detailed information on the materials that are going to go into the wing, the way the flaps behave in the system and whatnot. We know that it's for a 767 or a 737, so we can describe the length of the wing with respect to the performance that's needed. When there are well defined deterministic systems with a great deal of information available, then one can, in fact, do a detailed prediction of the behavior of that system.

Q Is that the kind of prediction that people in your field do for mining application and the kind of application that you did for this project?

A No, it's not.

Q What kind of -- how would you characterize the type of modeling that you did here?

A The kind of modeling that we do -- and this is a general principle that's used throughout science where modeling is used at all -- is that the nature of the model needs to be commensurate with the information that's available and the questions that have to be answered by the model. So rather than a deterministic model of the sort of -- the next return of Halley's comet, what we're looking at here is what the science philosopher Naomi Oreskes calls heuristic modeling. They're models where we're investigating the general behavior of a type of system so that we can investigate future questions that come to our mind. It's an exploratory type of modeling for the purposes of answering simple questions about the directions that materials are going to go in a system, not making firm predictions of specific details that would exist sometime in the future before we've ever gone underground in the mine and done any mining whatsoever.

Q And does that distinction -- Mr. Logsdon, does that characterize the distinction, perhaps, in the philosophy that Dr. Maest has expressed in her testimony and papers versus the philosophy and methodology that you and other people that work in this field apply to this question?

A I believe that it does. I think Dr. Maest places a higher regard on the capability of numerical calculations for details that are relevant to specific future cases than I think is justified by the kind of information and problem solving that we're actually looking at.

Q And should a mining company try to generate a worst-case model, as Dr. Maest suggests?

A I think it's almost always a bad idea to produce worst-case models, particularly if they rely on assumptions that do not represent the future conditions that you're trying to understand.

Q What do you mean by that?

A Well, for example, in her calculations of the water quality associated with the TDRSA, Dr. Maest assumes that there would be up to 5 weight percent semi-massive sulfide ore that reports to the development rock stockpile. A 5 percent mistake in allocation of high-grade ore is simply out of the bounds of quality control that modern mining uses. Modern mining allocates its rock and does its entire economic and operational model on the assumption that they can achieve fractions of 1 percent precision, maybe 1/100 of 1 percent precision. If 1 in 100 trucks at a modern mine mis-allocates its load, that's an unsatisfactory performance and major reorganization of the procedures are required. So assuming 5 percent is simply an unrealistic assumption. It's beyond worst case. It's simply not plausible.

Another example would be failing to account for the flooding as a control of oxidation in terms of the long-term acid generation potential and water quality in the subsurface. One can do the calculation and do it arithmetically correctly, but it produces a number that instead of being worst case, represents a system that will not exist and therefore is irrelevant.

Q Would another example on that same point be the omission of any effect of amending the development rock with limestone by both Dr. Maest and Mr. Coleman?

A Yes. It's clear that the mine plans and the permit requirements for Eagle are for the addition of limestone. And it has a particular design purpose in there that will, therefore, be part of the future underground situation and of the development rock and the TDRSA. And therefore it needs to be incorporated into a model if what you're trying to do is predict the actual future behavior.

Q Now, I'd like to turn next to a discussion about the general methodology that you followed in doing the water quality predictions in these three scenarios represented in the mine permit application reports we referred to earlier of the Appendices D-3, D-4 and D-5. And I think you have a slide here that summarizes the methodology that you used. So could you please explain that methodology?

A This is a consistent methodology that was used for all three sorts of calculations, the same general approach to the calculations.

THE WITNESS: And I apologize for the very busy slide, your Honor, but there's a number of steps to this, and it's important that they all be expressed.

Q He's seen worse already, I can tell you.

A The first step in the process is -- since we're going to base the calculations on the kinetic column test, is to compile the underlying information that's related to the columns; what type of rock is in each column, what the mass of each rock is, what the particle size distribution is, the dimensions, the rates of which the water are being applied, the fundamental experimental design descriptors of each of the columns that one is going to consider. Then one takes the data that are available at the time that the calculation is being done and compile those data for whatever that period of record is and make a judgment as to where in the history of the outcomes one is going to use the data for the calculations.

Because we're interested in long-term behavior, it's reasonable to take values that are at the longer end of the available data. And I believe it's reasonable to average them over some period of time rather than to take a point measurement so that we have a representation of the average behavior of the water that's going to be coming along because, again, extreme precision in the calculations is simply not available. Well, it then goes through a series of arithmetic calculations that convert the observed concentrations in the effluents which have been analyzed by the certified laboratory in Vancouver, to release rates; that is, how many milligrams or kilograms of some component like calcium or nickel has been released from the rock for the surface area of the crushed rock that's present, 'cause it's based on the particle size distribution, and a unit time like per week or per year or per day, whatever unit time you wish to do. As long as you're consistent in your calculations, it's okay.

Q At this point you're still talking about the so-called column testings with the crushed rock and --

A Yes. These are all -- these are the underlying data that are going to go into the calculation of the large-scale system that we wish to evaluate. Then we make a calculation of the surface area of the rock in the stockpile. And I use a method based on particle size of the rock in the stockpile that's conditions by the requirement that what we're really interested in is not the particle size distribution of specific rocks, but how we would take the results of the column test and work out what the appropriate scaling factor would be when we apply it to the full-scale system.

Q What do you mean by that?

A Well, if I look at the behaviors -- imagine this were a well designed car model -- I can run engineering tests that are associated with this, but I'm actually interested in the behavior in a crash of a Mercedes Benz. So I have to work out what the difference in the scale of my experiment is with respect to the forces that would be applied if 2,000 or 2500 pounds of Mercedes Benz came crashing into the wall. So the experiment is not the same thing as the portion of the system we wish to analyze. And we need to consider whether the way we have done our experiment affects the outcome so that we can make good judgments about how to apply our experimental data to the problem that we actually wish to consider. And that's not a simple arithmetic matter.

Q Are you talking about moving from the particle size of the crushed rock used in the column test to the particle size that might be present in the TDRSA rock?

A That's part of it. But the other part of it is that there are other matters that affect the leachability in the full-scale system that have to be considered, including the access of oxygen to the system, the preferential flow paths that occur in heterogeneous materials. What we want is a good representation of the kind of water we would expect to see if we were dealing with large volumes and large surface areas of material given that we can only test small volumes and small surface areas of material.

Q What was the next step in the process?

A Then we calculate taking our unit times and assuming them to be applied over a full year, so our unit release rate per day or per week -- per day we'd multiple by 365 to get per year, and by week we'd multiply by 52. And the reason we're going to do that is that we're going to calculate an average concentration over a long period of time like a year. The release rates that we get in the laboratory are a function of the specific way we conduct the test. It's the mass of material we have in the column, the specific grind that we apply to that material, how much water we applied compared to how much water there is in the column test samples. Well, all of those matters plus more that are associated from the uncertainty that arises from heterogeneous material at large come into play, and we have to -- we have to look at a way of estimating the concentrations not as if they occurred at 11:00 in one particular morning, but rather over a period of time about which judgments can be made.

So we try to work out or I try to work out the equivalent of an average annual concentration understanding that there will be variations around that associated with the details of the behavior in a particular year, and from year to year those numbers will change. But it's an estimate that we use. So we do it on a full-year basis, and we calculate the amount of infiltration that's expected over that same time period. How much water would infiltrate across the footprint of the TDRSA in a year? And we --

Q   Where do you get that information?

A   Oh, we get that information from -- in part from the climatic database for the site that represents what the average annual precipitation is and then from a professional judgment about how much of the water that falls as annual precipitation actually moves as infiltration through the rock pile.

Q   And for your other predictions as to the water quality in the mine during and after mining, do you also there assume some amount of water infiltration?

A   I assumed in those cases a water infiltration number that was provided by the hydrogeologist for the project.

Q   Do you want to explain the next step in the methodology?

A   So the mass that's released in a year divided by the amount of water that's in a year has the units of concentration, mass per unit volume in there. So we calculate an average annual concentration by the total mass that would be released divided by the total amount of water that comes in contact with the rock that's doing that release, and that's the estimate of the concentration.

Now, up to this point, this is the calculation process that's called a mass balance analysis because it tracks the mass of constituents of concern, nickel, copper, cobalt, sulfate, whatever it is that we wish to track in here. We track those all the way through and we assume that they are preserved in the universe and they move from one spot to another in the system. There's been no loss of mass. There's been no gain of mass in the total system. What was in solids is now in liquids, but the total mass remains balanced.

What one often finds is that when you do this calculation for the kind of data that is generated by these tests and you calculate all those numbers and make the projections by scale upward in the numbers, you wind up with very high concentrations, concentrations that, in fact, are so high that the geochemistry of the solution, particularly for the pH of the solution that you have calculated, would not permit all of that mass to remain in solution. So an essential step in doing these kinds of calculations is to consider whether you need to apply a geochemical solubility control model to those mass balance calculations in order to account for the effect that the solution chemistry has on how much metal can actually remain in solution.

Q Why is that important?

A Well, if you don't apply it, then you end up with over estimating concentrations of metals that would be present in the water that will not actually have iron concentrations or sulfate concentrations or copper concentrations that are as high as the mass balance yields because you have not considered the effect of the pH and the rest of the dissolved ion interactions on how minerals precipitate from solution.

Q And is that what Dr. Maest and Mr. Coleman failed to do in their recalculations?

A They did not do the calculation of pH, and therefore they could not do the solubility control. So neither of their calculations accounts for solubility control in the calculations.

Q Now, I believe both of those witnesses said that you did not account for solubility controls and that was their rationale for their own omission for adjusting for solubility controls. First point, is it true that you did not account in your own calculations for what you've described as these solubility controls?

A No, that's not correct.

Q Please explain that.

A For both my model of the TDRSA and for my model of the underground mine during operations, I specifically applied the geochemical reaction model called REACT as explained in the Phase 2 report in order to adjust the concentrations of solubility controls of well-known minerals that precipitate in mining environments with acid drainage under the pH conditions that my model, which did track pH, controls.

Q What about the scenario for the water quality in the mine after mining? What did you do there?

A I considered solubility control and the need to exert it in that case. But the concentrations that I had calculated were sufficiently low, and the pH was near neutral. And my judgment was based on 30 years of experience at doing these calculations by hand as well as with a computer that the reduction in concentration associated with solubility control for that third case and that third case alone would be sufficiently small that it wasn't justified to use the computer model. But I did consider the solubility controls, and I did have the pH data to make that judgment reliably.

Q Is that a conservative assumption then on your part as to that scenario?

A Yes, slightly conservative.

Q And as to that scenario, in turning back to the recalculations by Dr. Maest and John Coleman wherein they represented much higher concentrations than reflected in your reports, in that situation is it, in fact, required that this so-called solubility control adjustment be made?

A If you wish to have a representation of what you believe the water chemistry will actually be for the model that you're putting forward, you must do the solubility calculation to show that you've considered the actual solution chemistry.

Q And do you need to have the pH of that water as a starting point?

A Yes, you do specifically for systems in which you're interested in metals.

Q And you reported -- you said near neutral pH in your calculation of water quality in the mine after mining?

A With the backfill.

Q Did either John Coleman or Ann Maest with their recalculated much higher numbers record a pH corresponding with those concentrations?

A No, they did not.

Q Were they unable, therefore, to even begin to calculate a proper adjustment to a solubility control you've just been talking about?

A There would be no way to do that calculation without the pH.

Q Now, the steps we've just reviewed here apply to all -- generally to all three of the scenarios you looked at, the TDRSA, mine water during mining and mine water after mining?

A Yes. It's the same general approach to the computations.

Q I'd like to turn to, then, if we may, to look more specifically at how you did your calculations and predictions of the water quality in the temporary development rock storage area which is reflected in the Appendix D-3 report. Could you explain what's shown on this diagram in reference to how you did this analysis?

A This is what an earth scientist refers to as an illustration of a conceptual model, in this case, for the development rock stockpile. The upper drawing is a plan view. It's as if we were in space, staring down at the TDRSA as it would ultimately be developed. And based on the information that was available to me at the time, I understood that the outer perimeter was 202 meters by 114 meters, twice that for the perimeter, with a given surface area in there. Then if we imagine a cross-section, we're standing down, say, on this (indicating) side and looking up at this, and we could cut it in half and look at what the interior of this would be. There's a generally flat upper surface, sloping sides and a base.

There's precipitation that falls on the TDRSA across the whole of the footprint. There's some evaporation that comes back off from that. There can be runoff down the banks of this. How much runoff depends on how it's constructed, and in particular, on things like putting an artificial liner on the surface which would greatly increase the runoff from the material. The difference between what comes in, what evaporates and what runs off is the net infiltration through the material. I made an assumption for the purpose of these calculations that about 20 percent of the average annual precipitation would report to the base as infiltration.

Q What's that assumption based on?

A That assumption is based on many years of looking at detailed water balance calculations that my engineering colleagues have done on projects that I've been associated with. And in the sort of latitude that we've looked at for Eagle, about 20 percent of annual precipitation is routinely observed when you look at the water balance for the mine operations. The rest of it disappears as evaporation or runoff or is tied up permanently in storage in the wetting of the rock within the rock pile.

Q Does your assumption in that regard in your calculations here take into account the fact that Kennecott will be using a cover over the TDRSA?

A No, it does not.

Q Would the expected infiltration amount of water infiltrating into the stockpile be reduced based on using a cover over the rock pile?

A Very much so.

Q And would that be expected to have some beneficial effect in reducing the leaching of metals into the water collecting in the TDRSA?

MR. EGGAN: Your Honor, could we have non-leading questions in this line of questioning?

Q Would that have some effect on the predicted concentrations of metals which might be leachable into the water under the TDRSA?

A Because we're dividing a release rate by an amount of water, it would affect the predicted concentration. More importantly, it reduces the load, how many total milligrams or kilograms of metal have to be managed by the water treatment system. In fact, it might slightly increase the concentrations, but only slightly, if there's a solubility control considered. But it would certainly reduce the mass flux that has to be managed.

Q What assumptions did you make about the relative quantities of different types of rocks which would report to the TDRSA?

A My assumption in the model is that all of the rock that reports to the TDRSA is development rock; that is, it's produced during the development of the mine, and that that would be an approximately equal split between intrusive rock and country rock and that each of those would further be approximately equally split between high sulfur and low sulfur types as measured in our test.

Q And is that a reasonable assumption based on what you know about both the testing and the mining plans?

A I discussed the issues with the Eagle geologists and with the mine planners, and their belief, based at the time that I asked the questions in preparing the calculations, was that those were reasonable estimates to make given that no one had produced any development rock at this stage.

Q Now, I heard testimony again from both Dr. Maest and, I think, John Coleman as to the assumption for the size of the rock you used in your calculations here, that being 10 centimeters. And I think we saw or Dr. Maest or perhaps Mr. Coleman were shown a chart of a table from some reference paper wherein, as I recall, there were some information or data about particle size for -- I think four mines were represented on that chart. And they testified based on that in part that they disagreed with your selection of a 10 centimeter particle size for these calculations, believing that you should have selected some smaller size, therefore resulting in a greater surface area. Do you agree with their criticisms and comments about your selection of the 10 centimeter particle size here?

A No, I don't.

Q Why not?

A Well, the reason is that what I'm trying to do is not produce an estimate of a particle size distribution in a rock pile before any such rock as been produced, but rather to use a number that allows me to scale my test results to my expectation of the behavior of the full-scale pile that I want to evaluate. I do that calculation arithmetically through the use of a particle size for the development rock. But in choosing that value, I'm trying for the purposes of scaling, to choose a number that will produce the kinds of results for equivalent leaching that I have observed in many such calculations in many such mines around the world which requires that only a fraction of the rock actually participates in the reactions and the leaching at any given time because both the airflow through the system and the water flow through the system does not contact all of the materials equally. Because the materials are heterogeneous, the fluids distribute themselves differentially through the rock. And if you place too fine a particle size on the material, you produce numbers which are, again, arithmetically correct.

They're done in the Excel spreadsheet, and there's nothing wrong with the calculation with the numbers. But they do not reflect the way the full-scale system actually behaves. What we need to do is to come up with an estimate of that scalability. And after looking at and talking with the mine engineers and staff at Kennecott about the range of particle sizes that they might expect to see, I selected as an average value 10 centimeters or about 4 inches as a number that I could use in these calculations in order to estimate what I believe to be a reliable representation of the kind of water quality that would actually be observed.

Q And again, given what both you and Dr. Maest have said about the uncertainty, the limitations of these kinds of calculations and predictions and what you've testified about as far as your view of what the purpose of this is not being a deterministic exercise, does it really make any difference to your conclusions if we use 10 centimeters versus the assumptions that Dr. Maest and Mr. Coleman used; I think it was 90 percent, 10 centimeter, and 10 percent, 1 centimeter? Does it really make any difference to your conclusions that you came to and reported to Kennecott?

A If I used the numbers that Dr. Maest had used, I would have exactly the same advice to Kennecott. It would make no difference whatsoever.

Q And then could we turn to -- could you summarize the results of the analysis that you did on the water quality for the development rock stockpile, Mr. Logsdon?

A Sure. The principle results, the ones that are fundamental to my formation of advice to Kennecott Eagle in this matter, were that the pH would be near neutral. There would be elevated sulfate concentrations. There would be elevated total dissolved solids in the water. There would be distinctly elevated nickel and zinc and some other metals, concentrations above a milligram per liter. And based on those water quality outcomes, my conclusion and the advice that I gave to Eagle is that active water management would be required. And I believe they acted on that advice. I know they did.

Q Now, I want to ask you, Mr. Logsdon, we know now that Kennecott is going to, and, in fact, it's required that they amend the development rock -- all the development rock with limestone at a specified rate. Do you recall what that rate is?

A 20 kilograms per ton.

Q However, you did not in your -- well, did you in your analyses of these three scenarios, water quality in the TDRSA, water quality in the mine during mining and water quality in the mine after mining, consider and make any adjustments whatsoever for that addition of limestone?

A No, I did not.

Q Why didn't you do that?

A Because my purpose in the calculations was to advise Kennecott on the need for a mitigation program. The addition of limestone was their -- was part of their response to my advice that we needed a program of active control that's associated with the system. Other parts that they've added are the cover for the TDRSA, the leachate collection systems, the water treatment plant. All of those matters are in response to the underlying advice that active engineering controls and active water management would be required. And that advice was based on what would happen if you did not involve these interventions in the system. So there was no point in putting in a partial intervention.

Q Now, as we've discussed, both Dr. Maest and Mr. Coleman purported to change various assumptions in your calculations and presented recalculated numbers substantially higher than yours. But if the purpose here was to actually talk about what the expected water quality might be in the mine or in the TDRSA, would one need to account for the limestone addition?

A Absolutely, because that is the condition that they purport to analyze.

Q And what effect is the limestone addition expected to have on the water quality?

A The addition of the limestone will provide additional available base to the system so that the pH will be better buffered; that is, the pH will remain near neutral for a longer period of time. This increases, maybe for very substantial periods of time, what's called the lag period, the time over which the system is not acid generating some distance off in the future, probably some number of years, and it decreases the amount of total leaching that would occur by neutralizing that acid and therefore eliminating the secondary leaching of metals that's associated with the acid production system.

Q And is that a proven and generally accepted practice in the modern mining industry, Mr. Logsdon?

A It is very widely used. And where it is used under careful controls and with appropriate monitoring, it is effective.

Q And if one really wanted to look at what might be the actual predicted water quality parameters under the mining plan as required in the permit, would either the numbers that you calculated or the numbers that Dr. Maest and Mr. Coleman calculated need to be revised if we took limestone into account?

A Yes. You would have to account for limestone in the calculations.

MR. LEWIS: Your Honor, at this time I want to offer this report as an exhibit. And it's within Intervenor Exhibit 4, and it's also referenced as being in the Mine Permit Application, Volume IC, Appendix D-3, Bates range 103618-103629.

MR. EGGAN: Counsel, can you just give me that series again? It's Intervenor's Exhibit 4, but it's also?

MR. LEWIS: It's identified in the Mine Permit Application as Volume IC, Appendix D-3. Do you want --

MR. EGGAN: D-3? Okay.

MR. REICHEL: Your Honor, we have no objection. I would note that the document Counsel has just referred to is also part of DEQ Exhibit 29 which is Appendices D-3 to D-5, the Mining Permit.

MR. HAYNES: Your Honor, I don't have an objection.

MR. EGGAN: Not do I, your Honor.

JUDGE PATTERSON: Okay. Thank you. No objections, it will be entered.

(Intervenor's Exhibit 4, Vol. 1C, App. D-3 received)

Q Mr. Logsdon, before -- I want to move on to the next of these three water quality predictions scenarios, that being the water quality in the mine during mining, but before we move to that I want to clarify the discussion you and I just had about the omission of any adjustment for the fact that limestone will be amended to all this development rock. Does what you said about that omission hold true for all three of these scenarios, the TDRSA, the water quality in the mine during mining and the water quality in the mine after mining?

A It applies to the TDRSA and the memo on water quality at the end of mining in which the backfill is included and therefore has limestone. There is no consideration of backfill involved in my operational evaluation.

Q And that's the second scenario, the water quality in the mine during mining, that we're now going to turn to that you're talking about?

A Yes.

Q Okay. And we'll get to that in a minute, but could you first explain the conceptual model that you used for this analysis?

A Okay. The --

Q By the way, this figure is in your report?

A Yes, it is. Each of the reports has the conceptual model figures in it. In this conceptual model we imagined the mine workings to be an equivalent cylindrical tunnel or a portion of the mine workings to be an equivalent cylindrical tunnel. And the reason we do that is, if we unzip this down some line and open it up, we can see that the surface area is very easily calculated for that. The reason we're interested is that, in order to scale from the kinetic tests to the underground workings, I need to account in the way that I do the calculations for the surface area of the underground rock. And the surface area of the underground rock is not just the planar surface area because the rock when it's blasted will be rough, and rough materials have more surface area than smooth materials. And the rock walls will be fractured. There will be both natural fractures that existed before the mining and there will be additional fracturing that occurs as a result of the use of explosives on the rock, and there may be some additional fracturing that's associated with stress relief after the blasting has been completed. So the observation in underground mines is that the total surface area that is exposed to oxygen and water in actual underground mine walls is very much greater than the geometric planar surface area of the equivalent wall surface area.

Now, there is a detailed study, as far as I know, the only one that's been done of this, looking at all of the available data in English and much of what's available in Russian, by two Canadian geochemists named Kevin Morin and Nora Hutt. And based on measurements that they made over some number of dozens of mines, they found that the fracture adjustments ranged from about 20 to about 120 times the geometric surface area. It's 20 times in very clean, hard rock. It can be above 100 times in rock that's extremely weak or that has been very badly damaged by over blasting.

So in order to be reasonably conservative in our calculations, although our rock is strong and therefore unlikely to be at the very crumbly end of rock that Dr. Morin and Dr. Hutt looked at in this, I took 100 times the geometric surface area as the basis for being sure that we had a large accommodation for surface area available in the walls of the mine. Then we had to decide what the actual surface area was. And I went back to Kennecott Eagle, and I said, "I need an estimate from your mining engineers of what the full exposed surface area of the mine would be, and because we want to look at the high end of the outcomes, let's do it for the full life of mine; that is, the maximum development, the maximum amount of surface area of mine rock that would be exposed over the whole life of the mine." Okay?

There will always be less than that up until the last day of blasting in the system. And their mining engineers came back to me with a number on what that surface area of exposed rock would be. And they do this by having a design for how high the stopes would be and how wide they would be and the distance between the primary and secondary stopes and all of the things that go into calculating an underground mine plan.

So I took the surface area that we would use in the calculations then to be 100 times the maximum geometric area that the mining engineers had planned because I was using this projection factor from Morin and Hutt of 100 times the geometric. So that's how I come up with the amount of surface area that would be exposed to oxygen and water in the calculations.

Q And then did you apply the same methodology you talked about earlier for all three of these scenarios, that general methodology that's based on the column leach test results and so forth?

A Yes. I used the same general methodology. In this case I made the assumption -- and this was after the discussion with Kennecott Eagle. What they were interested in was understanding what kind of water they might have to handle during the operational phase of the mining. And during the operational phase of the mining it's clear that there would, in fact, be ore exposed in some of the rock faces because, wherever they are, they're there for the reasons of ore. So I took 50 percent of the total area of the underground mine to be ore. And I, in fact, used the massive-sulfide ore, which is the highest sulfur, highest metal, most reactive, as you saw on the time series data for the system, and used the massive-sulfide ore as 50 percent of the total surface area and assumed that the rest of the surface area was a mixture of country rock and intrusive in the high sulfur and low sulfur split.

Q What assumption, then, did you use -- we talked about the TDRSA, and you -- as part of your calculations you had to use an amount of water based on weather data which could be expected to fall in the TDRSA and then an infiltration rate. Here also did you have to assume some amount of water that would report to the mine that would be a part of this -- of these formulas in these calculations?

A Yes. In order to do the calculation of a mass divided by volume, I had to have a volume of water that would be used for the calculation.

Q And what volume did you use for that?

A 180 gallons a minute.

Q And what was the source of that number?

A I went to Kennecott Eagle and I asked them to provide me with the best available estimate from their hydrogeologist of what the long-term inflow to the mine would be. And the number they came back with was 180 gallons a minute.

Q Now, we heard -- the court heard testimony from Dr. Maest earlier that apparently after that -- at some point in time after that, Golder issued a report wherein it had -- they reported a base case mine inflow number -- expected mine inflow number of 75 gallons per minute. Was that information in that report available at the time you were given the 180 gpm assumption?

A No, sir, it was not.

Q Both Dr. Maest and perhaps Mr. Coleman talked about, again, one of the things they did in the recalculations which resulted in higher numbers was that they suggested you should have used, if you had the number available at least, the 75 gpm as opposed to the 180 that you did use. And I think they indicated that that would drive their recalculated numbers up by something over twofold. Would it, in fact, have that kind of effect on the calculated concentration?

A Yes, it would. It would have an effect of about 2.4.

Q Now, again, would that be, Mr. Logsdon, before the solubility controls are taken into account, as we discussed earlier?

A Yes. That's on a strictly mass balance basis without consideration of the geochemical control.

Q And if, in fact, the numbers were adjusted to use the 75 gpm versus 180 and assuming, I guess for the sake of argument now, that we don't do the solubility controls, which you indicated earlier would be required with their numbers, would there nevertheless be any effect, any change in your bottom line conclusions in your reporting to Kennecott?

A If my numbers had been a factor of 2.4 higher, my advice would have been exactly the same.

Q And does that reflect to some extent the level of uncertainty in these types of calculations and the purpose that you've describe earlier; that being, it's not a deterministic exercise but more of a qualitative exercise?

A Yes, it's that, but it's also that raising it is asymmetric. It's only on the side of larger impact, and therefore more importance needing to be attached to the need for active water management.

Q Now, let's turn, if we may, I think, to the next slide and discuss the results of your analysis of the mine water quality during mining that you just talked about. And first, before we talk about the results, I wanted to ask you, Dr. Maest and perhaps Mr. Coleman as well -- I do recall Dr. Maest specifically also took issue with this calculation. She indicated that you had assumed year three of mining for this calculation and prediction of water quality during mining and pointed out that that would be before backfill had been put back into the mine according to the schedule in the mine permit application. And she suggested that, instead, she used two different numbers, year 4 and year 7, as periods of time in which there would be more backfill in the mine. And the reason she did and the result of that was she was able to increase the surface area of rock within the mine, which, as you know, drove higher numbers with her calculations. So I wanted to ask you first of all, why did you in your analysis choose year 3 rather than some later year for this particular scenario?

A Well, I didn't actually choose year 3. The surface area that I use for the mine is for the full life of mine. So it's 8 years into the mine. It's the last moment of the calculation. I believe that her assumption that it was year 3 is related to the fact that this model does not include backfill. But there was a reason for that. And the reason was I was looking at what the impacts of the mine walls would be on water quality. I was simplifying the system for the purpose of understanding a partial behavior and providing information that would be useful to my client in their planning.

Q And the -- just forecasting, in your final scenario, the water quality in the mine after mining, what did you assume there as far as backfill in the mine?

A I assumed 379,000 tons of backfill without limestone amendment.

Q Now, could you discuss the results of this analysis of water quality the mine during mining?

A Okay. The results of this analysis are driven primarily by the assumption of the large amount of massive-sulfide ore that would be exposed in the calculation that I did. I don't actually believe that 50 percent of the walls of the mine are ever going to have massive-sulfide exposed in them at one time. But it was for the purposes of doing a calculation. And the result is a very low pH with elevated sulfate, TDS, high concentrations of iron and extremely high concentrations of nickel. And, of course, these derive from the massive-sulfide ore that's in there. From this I derive the conclusion that the water would be acidic with high dissolved metals and certainly would need active management. That was my advice to Kennecott.

MR. LEWIS: I'd like offer at this time the next exhibit in this series, and that again is in Intervenor

Exhibit 4. It's referenced in the Mine Permit Application as Volume IC, Appendix D-4. And it's in Bates range 103631-103637.

MR. REICHEL: No objection.

MR. HAYNES: Your Honor, I understand that this exhibit is also contained in DEQ Exhibit 29 starting on page 13, and I have no objection to its admission.

MR. EGGAN: No objection.

JUDGE PATTERSON: No objection, it will be entered.

(Intervenor's Exhibit 4, Vol. 1C, App. D-4 received)

Q Let's turn next, Mr. Logsdon, to the final scenario wherein you calculated and reported on the predicted water quality results in the mine after completion of mining. Did you follow the same methodology you described earlier, the same general methodology?

A I did.

Q And is this analysis did you assume the same volume of water input, the 180 gallons per minute?

A Yes, I did.

Q And did you assume in this analysis that the backfill, at least 300-some-thousand tons, had been returned to the mine?

A Yes, I did.

Q Now, another -- I wanted to ask you about a couple of things also that Dr. Maest had to say about this calculation. One was she said as to this and probably the previous scenario as well, that you ought to have accounted for some incremental increase in metals in the water coming into the mine through the bedrock above the mine by virtue of the fact that that water would encounter ore-type material on its way to the mine. Have you reviewed that portion of her testimony?

A Yes, I did.

Q And do you agree with her on that point that some adjustment should have been made that would make any difference here?

A I think the probability of elevated concentrations of metals in that water coming through the crown pillar is actually quite small.

Q Why is that?

A Well, because the crown pillar, if it's going to yield water, must be under a saturation state that is close to fully saturated. Otherwise the water wouldn't move through it. It would vapor lock against a zone that was unsaturated.

Q You're referring to the potential cracks and fissures --

A The cracks and fissures between the surface where the recharge would occur and the discharge into the roof, what miners call the back of the mine. If there's water flowing through there, there must be flow paths that are continuous down through that system.

Q And just for point of reference, you're understanding we're talking about and 87.5-meter-thick crown pillar in bedrock?

A Yes.

Q Okay. And you described earlier, is some level of atmospheric oxygen required for this oxidation process to occur?

A Without atmospheric oxygen, the process will not begin.

Q And in your opinion, is that kind of atmospheric oxygen going to be available for this process to occur as water circulates through that bedrock?

A I think that it will be very low and probably negligible concentrations of dissolved oxygen in most of that water by the time it reaches the bottom part of the crown pillar.

Q And another point of discussion by Dr. Maest and, I think, Mr. Coleman on this scenario as well, is they suggested that you did not use and account for the full tonnage of backfill material which would ultimately remain in the mine. And are they correct on that point generally?

A They are correct on that point.

Q What number did you use?

A 379,000.

Q And what's the total tonnage of backfill including the part that never comes out of the mine and the part that's placed on the TDRSA? What's the total tonnage?

A 669,000.

Q And what's the reason that you did not use the 600-and-some-thousand number rather than the 300-some-thousand number?

A This was a miscommunication between me and the mine planning team. I understood that all of the development rock would go to the stockpile and then be returned to the underground. And I did not understand the way they actually intended to manage all of the development rock.

Q And in terms of the effect of that difference, I think that Dr. Maest and/or Mr. Coleman suggested that that would result, in effect, in the doubling of the calculated concentrations of metals. Do you agree with that?

A No, that's not correct.

Q Can you explain why that's not correct?

A When we did the calculations using the 379,000 tons, I showed in the memorandum that the backfill accounted for about 22 percent of the total mass that would be released into the mine water. If one doubled the amount of backfill, one would have approximately that same incremental mass. So we'd go from my predicted considerations of 20 percent mine wall impact and 20 -- 80 percent mine wall impact -- excuse me -- and 20 percent backfill to 60 percent mine wall impact and 40 percent backfill. So that would be an increase of under 50 percent, not a factor of 2.

Q And once again, given what we've already talked about in terms of the purpose of this kind of analysis, would it make any difference if we corrected for that for your numbers to your conclusions and recommendations?

A No, it would not. I'd still recommend that it requires monitoring in the capability of management.

Q And just to be clear, again, for this calculation you did not assume and account for any beneficial affect of the limestone amendment?

A I did not.

Q Nor did either Dr. Coleman -- or Dr. Maest or Mr. Coleman?

A They did not either.

Q And in addition -- and you explained the reasons you did not include that, but I wanted to ask you, as to the point that's been discussed here, the fact that the mine permit application and the permits now require that the mine after mining be rapidly re-flooded and if we look at the calculations that you made for the post mining water quality or that Dr. Maest and Mr. Coleman presented for that, do any of those take into account the effect of the re-flooding of the mine?

A No, they do not.

Q And in terms of the fact that there is going to be re-flooding, and I guess particularly in the context that there is going to be limestone amendment to all this backfill in the mine first and the effect that will have, as you described earlier in terms of delaying the lag period and then with the second part of this that we're going to have accelerated re-flooding of the mine, what would be the expected outcome of the concentrations of these metals that either you or Dr. Maest or Mr. Coleman have calculated?

A If you accounted for both of those, it would have to be lower concentrations predicted.

Q Because of dilution?

A In part because of dilution, in part because of the effect of the limestone buffering the system and increasing the lag period before the onset of oxidation before the re-flooding would occur.

Q And based on your experience, is re-flooding also a proven and generally accepted technology in the modern mining industry?

A Yes, sir, it is.

MR. LEWIS: I wanted to offer, your Honor, the final report in this series, and it is also in Intervenor Exhibit Number 4. It's referenced in the Mine Permit Application as Volume IC, Appendix D-5, Bates range 103639-103647.

MR. REICHEL: Your Honor, that's also part of DEQ Exhibit 29. We have no objection.

MR. HAYNES: No objection, your Honor.

MR. EGGAN: No objection, your Honor.

JUDGE PATTERSON: Thank you. No objection, it will be entered.

(Intervenor's Exhibit 4, Vol. 1C, App. D-5 received)

Q Mr. Logsdon, based on your -- I think you said I think 30-some years experience in this field -- is that right? --

A Yes, sir.

Q -- and our further discussion about your experience in many mines doing this kind of geochemical characterization and your knowledge and understanding about modern mining methods, in your opinion is the Kennecott geochemical characterization program and management program designed to minimize impacts on the environment and to be protective of the environment?

A Yes, it is designed to minimize those impacts and be protective.

MR. LEWIS: Thank you. That's all I have for my direct examination, your Honor.

MR. REICHEL: I have no questions at this time, but I reserve the right to ask the witness questions following cross-examination by the other parties.

JUDGE PATTERSON: Counsel, do you want to break before you do your -- who is going to do the cross?

MR. EGGAN: I'll probably do the first cross, Judge. A break would be fine.

JUDGE PATTERSON: It's ten to 12:00, so why don't we break 'til 1:00 o'clock?

(Off the record)

MR. LEWIS: Your Honor, if I may, I was reminded during the break that I should offer to the court as a demonstrative exhibit for whatever you may make of it the slides that Mr. Logsdon reviewed. I believe you have a copy up there; they're marked as Intervenor 630.

JUDGE PATTERSON: I do have that.

MR. HAYNES: With the understanding that the slides are demonstrative only, I have no objection.

MR. EGGAN: Well, your Honor, I've expressed my concern about this in the past.

JUDGE PATTERSON: Yeah, I know.

MR. EGGAN: And you overruled it in the past, so --

JUDGE PATTERSON: And I'm about to do that again.

MR. EGGAN: You really know how to hurt a guy. I understand. I understand, Judge. I'm just concerned that they are not evidence in the case.

JUDGE PATTERSON: Right.

MR. EGGAN: And as long as you are going to look at them from that perspective,

JUDGE PATTERSON: I'm just going to use it as basically an outline of his testimony.

MR. REICHEL: No objection, Judge.

JUDGE PATTERSON: Just so you know, I have to break briefly at 1:30 for a phone conference. Probably take all of five minutes.

MR. EGGAN: Okay. Mr. Logsdon, I will begin cross-examination and then I suspect my colleague, Mr. Haynes, will have some questions for you also. So bear with us while we go through some questions about your testimony and about the work that you did.

CROSS-EXAMINATION

BY MR. EGGAN:

Q   Initially, I wrote down -- I wrote down some quotes during your direct examination. I just want to make sure that I wrote them down correctly and that I understand them. You indicated that because the volumes that we're dealing with here in terms of core and development rock, waste rock as you call it, are so great and because we are really in a premining mode at this time, I think you said that a certain amount of humility is required in terms of the analysis of what this water quality is going to look like; a certain amount of humility?

A   That was the word I used and it's specifically with respect to numerical predictions.

Q   Understood. And I think you also said that you really cannot precisely predict the che3mistry of the effluent that is going to be going into, say, the wastewater treatment plant?

A I believe that to be true.

Q Okay. And I think you also said that your modeling does not intend to make firm predictions; is that true?

A Of the numeric sort.

Q Okay. Now, one of the things that I wanted to ask you about; in your conclusions you say that -- and this is the conclusions that you reach principle results usually during operation with 50 percent MSU and wall rock. The conclusion that you reached is that the water would be acidic with high dissolved metals and certainly would need active management. Now, I assume that when you make the reference to "active management" in your conclusions, active management is something that someone else decides; in other words, you're here to tell us about what the water is going to look like, but how Kennecott handles that water in terms of the design of the wastewater treatment plant, that's someone else's bailiwick?

A Yes, sir.

Q Okay. So you didn't make any specific design recommendations with respect to the design of the wastewater treatment plant, the design of the TWIS, the design of the TDRSA; those were someone else's bailiwick?

A That is correct.

Q Okay. Just out of curiosity, you talked about characterization of the rock and the importance of the geology. Is there any part of the analysis that you do that takes into consideration the environmental sensitivity of a given site?

A Absolutely. I mean, I take into consideration as part of my general background the nature of the environment as I understand it from reading and talking with people and making observations if I've been there.

Q In this case -- in this case I assume it was talking to people from Kennecott or Kennecott's engineers about where this mine was going to be located and the sensitivity of the area as a result of those discussions?

A I had discussions with them and also with citizens in Marquette during public meetings.

Q Okay. Well, that was going to be one of my questions. It sounds to me like you were present during the public meetings?

A I was present during a presentation to the community advisory committee or -- that may not be the proper name of that. And I was also in Marquette for the day-long public meetings in March 2006; I think it was 2006.

Q Okay. Those would have been the local public meetings then?

A Yes, sir.

Q Okay. There were some public meetings conducted by the Department of Environmental Quality in, I think, September or October; you didn't participate in those?

A No.

Q Now, you indicated that you have done some work for Rio Tinto in the past. What work have you done with Rio Tinto in the past on mining projects?

A Rio Tinto is a large company that has -- I don't know right now -- probably 65 operating mines around the world, each of which is operationally an independent corporation that has an ownership relationship with Rio Tinto. Rio Tinto has a program of environmental overview of its projects and I'm part of the review team that is tasked with going to these projects when they designate us to go to a specific one.

Q How many times have you been designated to go to a specific project?

A As part of that ARD review for Rio Tinto I believe it's 16. There are also operating companies of Rio Tinto with whom I've worked directly, like Kennecott Eagle.

Q Okay. So you have conducted an ARD evaluation of 16 mines?

A Yes.

Q But you've also had other relationships with Rio Tinto; because of their ongoing mining operations they've asked you to look at some of those sites also?

A Their specific operating companies like Kennecott Eagle retained me directly; I wasn't retained by Rio Tinto in this case.

Q How many times have you been retained by Rio Tinto related companies?

A Including those 16 reviews, I don't -- 25 to 30.

Q Okay. So we've got the 16; it sounds like maybe another --

A Another 15.

Q -- 14, 15, something like that?

A Yeah.

Q How about Kennecott; how many -- have you had other relationships with Kennecott related mines?

A I'm including Kennecott in the Rio Tinto group of companies.

Q Oh. How many times do you think that you've worked on Kennecott related projects?

A Well, there are more than one project at specific sites, so probably eight of those 15 or 16 are Kennecott sites.

Q Okay. I want to ask you also about the material to be mined at Kennecott.

MR. EGGAN: Your Honor, this is an exhibit that has been admitted in this matter. It is Petitioner's Part 31 Exhibit 28-B. It was admitted through Ann Maest.

Q Mr. Logsdon, this is a summary of the geochemical characteristics and the testing of the deposit at the Kennecott mine site. What I want to ask you is to look at the ore itself and I think what we're talking about is --

are samples that were taken and the acid generation potential summary there in column two. It looks like when we're talking about the massive sulfide unit, the MSU, it looks like three out of three of the samples that you took in the massive sulfide unit were acid generating; is that right?

A That's what it says.

Q Okay. And you would agree with that?

A That seems perfectly reasonable.

Q Okay. And in the semi-massive sulfide unit three out of three of the Phase I samples that you took were acid generating; isn't that right?

A Yes.

Q Okay. And in the sedimentary units -- I guess we're going back up to the top now on the left-hand side, the sedimentary units. And that, according to the data you provided, was siltstone, sandstone and hornfels. Sixty-nine percent of that rock has acid-generating potential; isn't that right?

A Yes.

Q And you would agree with that reference as 69 percent?

A It seems reasonable. I don't believe I produced that table, but it seems the right sort of number.

Q Okay. And with respect to the peridotite, which is the second set of -- the first column, the second paragraph here, it looks like there was 61 percent of those materials were acid generating in the test * 1:18:53 that you did?

A Yes.

Q Okay. And with respect to the development rock, your own testing showed that three-quarters of all the waste rock -- of all the waste rock generated at this site has to be managed as special handling to avoid acid rock drainage and material -- and metals leaching; isn't that right?

A That was my conclusion.

Q Okay. That was the conclusion that you reached in your Phase II study, acid rock drainage characterization study. And I'm going to read you the quote -- we don't have to show it if you agree with it. It says,

> "Therefore, based on two independent lines of testing more than three-quarters of all the rocks tested which we and KMC consider to be a representative suite of both intrusive and country rock lithology as across the spatial domain of the project must be managed as special handling waste rock in order to manage risk of ARD and metals leaching."

So three-quarters of that rock needs to be special handled because of the potential for acid rock drainage?

A That was my conclusion.

Q And metals leaching?

A Yes.

Q Now, would you amend that conclusion based on the time between writing this report and now?

A No.

Q Would you agree that it should perhaps be more than three-quarters?

A If it's three-quarters they're effectively going to handle all of the waste rock in the same manner.

Q Okay. So it may be more than three-quarters but to you it doesn't make any difference?

A It might be 80 percent.

Q Okay. Now, in terms of the sulfide testing that you did -- again, this is the chart -- in the massive sulfide unit -- in the massive sulfide unit there, which is the third -- the first column on the left-hand side, the third reference, "massive sulfide unit," you're showing that there was a greater than 80 percent level of sulfide in that rock; am I right?

A Yes, that would be about 80 percent.

Q Okay. And in some of the samples you took there was actually a hundred percent sulfide in the massive sulfide unit?

A Oh, I don't know that we had 50 percent sulfur in anything. I think the 36.1 percent for the massive sulfide was the highest sulfide that we tested.

Q I'm looking at the 50-100 percent sulfide there and under the massive sulfide unit here (indicating). Do you disagree with that number?

A There may be portions of the rock, particular volumes of the rock that run as high as a hundred percent sulfide. Yeah, that could be the case.

Q Okay. And in the semi-massive sulfide unit 30 to 50 percent of the rock was sulfide?

A That seems reasonable based on the mineralogy.

Q Okay. How do these levels of sulfide compare to other mines that you've seen? Higher or lower?

A Well, there are magnetic segregation deposits around the world that are comparable to these. There are other kinds of massive sulfide deposits that are mined around the world that have the same range as the upper end of these materials. There are also many mines that have lower concentrations of sulfide. So it's --

Q I guess what I'm getting at is this is probably one of the highest you've seen.

A It's at the high end of the sulfide content when one looks at the ore.

Q Understood. My question would be, this particular deposit has been described as a world class sulfide deposit. Would you agree with that?

A That's my understanding.

Q Okay. Now, with respect to metals leaching, we have to agree that the rock here has a very high potential for metals leaching; am I right?

A If it's allowed to become acidic.

Q Okay. And those metals are going to have the highest potential for metals -- I'm sorry. That rock is going to have the highest potential for metals leaching when mining is occurring; am I right? During mining operations.

A I think most people's experience is that the maximum leachability occurs when rock is stored at the surface for long periods of time after it has been mined.

Q Okay. And when we talk about the leaching and the metals we could be talking about in this case nickel?

A Yes.

Q Copper?

A Yes.

Q What else?

A There's cobalt in the rock. There's iron. Zinc.

Q All of these -- all of these metals, high potential for leaching as a result of this particular site because of the characteristics of this particular site?

A If one were concentrating specifically on the ore grade material there would be a high potential if those were permitted to weather at the surface.

Q But again, we do agree that three-quarters of the rock that is going to be development rock, the rock that's going to be stored in the TDRSA, for example, that too has a very high potential for leaching; leaching metals?

A It has a potential for leaching metals if it is permitted to oxidize and that is not neutralized by the addition of limestone before the rock can be reflooded after it's been backfilled.

Q Well, let me ask you about that very issue, this limestone issue. You understand that there's this concept called "armoring" I take it?

A Yes.

Q And that has to do with a coating that develops around rock because of iron and it develops a coating, and that could inhibit the impact or the favorable impact of the limestone, could it?

A If it actually occurred it could slow down the rate at which the limestone is available. It does not occur instantaneously. It does not necessarily close off the neutralization potential of the limestone. It's a detailed matter depending on the specifics of the site.

Q But we can agree that armoring could limit the effectiveness of limestone at this site, couldn't we?

A And that is why when I did the calculations for Kennecott Eagle of how much --

Q Sir, just -- the question is this: we can agree, can't we, that armoring could impact the effectiveness of the addition of limestone at this site?

A Yes, it could.

Q All right. And we can also agree that limestone isn't going to decrease the concentrations of certain contaminants; am I right?

A It will have a limited effect on decreasing the concentrations of some contaminants.

Q Okay. It's going to have a limited -- it's going to have a limited effect on decreasing the concentrations of sodium?

A No, it won't affect sodium.

Q Limestone will not affect sodium?

A No.

Q Okay. Zinc?

A It will have some affect on zinc in terms of the release.

Q Well, let me see if I can show you a chart. What I want to do, Mr. Logsdon, is to show you your chart. This is -- these are charts that I believe you created. These are from -- let me make sure I've got the reference for everybody here. This is from the groundwater discharge permit application and it is from a chart F-2. It is page 5 of 11 and then it goes over to page 8 of 11. And what I'm doing is I'm comparing two charts side by side and these are charts that you created; am I right?

A Yes.

Q Okay. And on the left we have expected concentrations without the addition of limestone; is that right?

A Yes.

Q And on the right we have those same identical constituents with the addition of limestone; correct?

A Yes.

Q Okay. And as I look through this list it looks to me like cadmium stays the same with or without limestone?

A The way I did the calculations that's correct.

Q Okay. Cobalt stays the same with or without limestone?

A Yes.

Q Lead stays the same with or without limestone?

A Because it's present at such a low concentration.

Q Sir, lead stays the same with or without limestone?

A Yes.

Q Manganese stays the same with or without limestone?

A Yes.

Q Molybdenum stays the same with or without limestone?

A Yes.

Q Nickel stays the same with or without limestone, doesn't it?

A Yes.

Q So all of those particular constituents -- all of those constituents are unaffected by the addition of limestone?

A To a solution.

Q Well, in your chart.

A In my chart, yes.

JUDGE PATTERSON: I'm sorry. I have to break for about five minutes.

MR. EGGAN: Very good. Thank you.

(Off the record)

Q Now, Mr. Logsdon, just a question for you with respect to the study that Maest and Kuipers did, that Comparison of Predicted and Actual Water Quality at Hard Rock Mines and that was a report in -- of 2006. You indicated that you read it, I take it?

A Yes, I did.

Q Okay. You are aware, aren't you, that in that report Maest and Kuipers found that 75 percent of the hard rock mines that they evaluated caused exceedences of water quality standards? That was one of their conclusions.

A I understand that to be one of their conclusions.

Q Okay. And I think what you said is that modern mines, you know, just don't have that problem. My question would be, have you done a study of so-called modern mines? And those modern mines are apparently from your perspective within the last five years. Have you done a study to determine whether or not those hard rock mines have had exceedences?

A I can speak only to the ones that I've worked at; I've not done a systematic study.

Q Okay. And with respect to the so-called modern mines, those are in that five-year period from 2003 to 2008 I take it?

A They might be as much as ten years old for some of them. Again, systematically I haven't done --

Q Well, I think you said -- I think you said five years before.

A Okay. Within five years, that would be the time frame then.

Q Okay. And coincidentally, you began working on this particular project in 2003; on the Kennecott project in the last two months of 2003?

A That is when I began.

Q Okay. So coincidentally you think modern mining is a period that begins about five years ago just about the time you began working on this particular project?

A Well, I think "coincidentally" is your characterization rather than my opinion.

Q Maybe it isn't coincidental. If it isn't coincidental you tell us.

A 2003 was also the time frame in which Rio Tinto organized its systematic review with outside specialists looking at ARD, so I think 2003 is a time frame in which the Rio Tinto companies in particular, including Kennecott, significantly altered the manner in which they considered acid rock drainage and metal leaching at their mines and it is my experience with those programs that they have in fact changed their way of doing business: their way of doing the evaluations, their way of doing their engineering.

Q Is it only Rio Tinto or is it the whole mining industry that has suddenly come up with this change of heart? Unstudied, by the way.

A I wouldn't say that the entire mining industry has undertaken the level of commitment to this that the Rio Tinto companies have done.

Q Are you aware, sir, that among the conclusions reached by Kuipers and Maest were that mines that had a high ability to produce acid mine and to leach metals -- which sounds a lot like this mine -- and which are close to water resources had a higher rate of exceedences and poor water quality, almost 85 to 90 percent?

A I'm aware that that's their conclusion.

Q Okay. And over the last five years there have been these changes that have somehow altered that?

A My experience is my experience. Now I believe they're doing the better job.

Q Okay. Now, for the group that had exceedences 64 percent of the exceedences were due to failed mitigations. Would you agree with that? That's the conclusion that they reached.

A That's the conclusion they reached.

Q Okay. Based on their study and based on their analysis of mines?

A That's my understanding.

Q Okay. Bottom line is with the kind of area that we're dealing with in the Upper Peninsula of Michigan and with the kind of rock that we're dealing with at this particular site, it's very important to get this right, isn't it?

A It's very important to meet the performance requirements that have been set by the State.

Q Exactly. And to get it right and to protect the resources of Michigan. We've got to get this right, don't we?

A I'm sure we all agree.

Q Okay. In looking at your résumé I noted that you don't -- you show that you are a membership in -- a member in some professional organizations, but are you a member of any environmental groups, like the Sierra Club?

A No, I'm not.

Q Okay. Would the fact that you don't belong to one of those groups suggest that you don't care about the environment?

A I don't believe so.

Q Would the fact that somebody else might belong to one of those groups suggest that they somehow are anti-mining and don't favor progress?

A I wouldn't draw that conclusion necessarily.

Q No; of course not. Just to clarify this issue about volume. The volume of the ore here in this particular site is something like 4.05 million tons?

A I don't know that number.

Q Okay. You don't. What about the volume of the waste rock?

A The development rock?

Q Yes.

A The total volume is apparently 669,000 tons.

Q Okay. Very good. I had a lower number in one of your reports, but you clarified that this morning, the 379,000 tons or --

A The 379,000 tons is the total to be delivered to the TDRSA.

Q Okay. My question is, does a large volume of ore and waste rock -- or "development rock" as we call it -- does that make it more difficult to characterize in terms of an accurate characterization?

A Sampling from large volumes is harder to do than sampling from small volumes, but by mining standards these are not large volumes of rock.

Q Now, you're aware, aren't you, of mines that have had water quality problems associated with the stockpiling of development rock?

A I'm aware of mines that have had water quality problems with the stockpiling of waste rock.

Q Okay. Well, in your view is the rock that is going to be stored in the temporary development rock storage area -- is that called waste rock or is it called development rock, or can we use them interchangeably?

A Well, it is the material that is not going to be put to productive economic use from this mine, but it doesn't have the same origin as large piles of rock from open pit mines do where the waste is intimately commingled with the ore.

Q I understand. Okay. But getting back to my question. Are you are of mines that have had water quality problems associated with the stockpiling of development rock?

A I can't provide a specific example, but it was not surprise me if there were.

Q Okay. Are you aware that the temporary development rock storage area, the TDRSA, is going to be used as an overflow area in case the contact water basins overflow?

A I did not know that.

Q What is your thought in terms of using the temporary development rock storage area as a water overflow area for the contact water basins; good idea or a bad idea?

A It's an engineering decision that's based on a variety of risks that are -- including things that are outside geochemistry. I have no basis for making a judgment.

Q So you don't have any opinion as to whether or not it's a good idea to mix water with the temporary development rock stockpile area, storage area?

A If that water is collected and actively managed including treated, I can't see that there's an issue with it.

Q Now, as they put rock into that TDRSA area there isn't any plan that you're aware of that would separate, say, the more acid-generating rock from the less acid-generating rock?

A That's not the plan as I understand it.

Q Okay. And in fact it would be almost impossible to do that at this site?

A I don't know that to be true.

Q Okay. Now, I want to talk to you for a minute about some of your -- the major findings that you reached in the Phase II studies and make certain that there has been no change in that analysis. And this is from your report of June 30th of '05, page 44. Do you recognize this as being page 44 of your Phase II Acid Rock Drainage Characterization Study?

A I can just make out the header and footer and that appears to be the case.

Q Okay. I just want to make sure I'm -- we're going to confirm these together. Okay? What you say is, "Up to 80 percent of the development rock that is produced should be expected to be potentially acid generating." Still agree with that?

A Yes, I do.

Q Okay. Now, with respect to the time periods for acid generation, in that same paragraph you say, "There may be variable lag periods to the onset of net acidification, but sulfate and nickel leaching can begin quite early in the leaching process." Do you agree with that conclusion still?

A Yes.

Q Okay. When you say "quite early," what does that mean?

A On the matter of something like 20 or 26 weeks.

Q Okay. So relatively quickly after the development rock is placed in the TDRSA it has at least the potential to begin leaching?

A About a half a year if there were no additional limestone added.

Q Okay. And it can begin leaching sulfate and nickel during that time period?

A Based on the mineralogy that's a reasonable expectation.

Q Okay. Bullet 2 says that, "High-sulfur intrusive and country rocks can react quickly in 10 to 20 weeks of column leaching." So your study showed that high-sulfur intrusive and country rock, which is the kind of rock that's going to be in that temporary development rock storage area -- that can begin to react quickly and to create acid quickly in ten to twenty weeks?

A That's not quite what the bullet says.

Q Well, tell us what it says.

A Firstly, only a portion of the rock that is in the TDRSA is the high sulfur category.

Q Understood.

A Secondly, the ten to twenty weeks refers to the column leaching and the method for the column leaching of forcing high fluxes of oxygen past the rock accelerates the acidification, the oxidation process and, therefore, the onset.

Q As does the addition of water?

A No, the addition of water itself -- there's plenty of water available in humid air for this to occur. It's not dependent on the water. The water is there to continue to provide the humidity and to leak -- and to rinse the reaction products through the test. But the rate at which something reacts in a column test is not the same as necessarily the rate at which it occurs in the field condition because they're two different tests.

Q All right. Well, then let's talk about the field condition when it's out there. "High-sulfur intrusive and country rocks can react quickly." How quickly will they react when they are there in the TDRSA?

A My expectation would be that they're going to react on the order of a half a year to a couple of years.

Q Certainly well within the time that it's going to be stored there in that area?

A Yes.

Q Very good. Now, the third bullet: "When the leach rates of the high-sulfur country rock and intrusives are considered effluent chemistry for the development rock stockpile may contain elevated levels of sulfate approximately 2,000 milligrams per liter, TDS" -- what's TDS?

A Total dissolved solids.

Q Okay -- "approximately 3,000 milligrams per liter. And some metals and metalalloids that" -- did I say that right, "metal" --

A Metalloids.

Q -- "metalloids that are not solubility controlled by calcium neutral pH."

A "By circum-neutral."

Q -- "circum-neutral pH. The solubility of aqueous sulfate is enhanced in effluents by substantial concentrates of dissolved MG." That's manganese?

A Magnesium.

Q Magnesium? Okay. Again, what we're talking about here is rock that is high sulfur and which has -- that is reactive and reactive quickly, aren't we?

A Quickly being within the lifetime of the mine, yes.

Q Yes. And with the life -- within the lifetime of storage in the TDRSA?

A Yes.

Q Okay. Good. I also want to talk to you about bullet number 4, which is on a little bit different subject but it has to do with leaching from the wall rocks of the mine. Okay? It says,

> "Incremental leaching from the wall rocks of the mine is expected, based on current test data, to be limited primarily because much of the intrusive rock

> has a substantial lag period before significant leaching occurs. The principal modeled constituent of concern would be nickel, which the initial calculations show could be present in these waters too at a part per million level."

What you're talking about here is that as a result of the mining activity most of the highly reactive ore is going to be removed. Isn't that what bullet 4 is saying; that the wall rock is not going to be as reactive as, say, the other rock that is mined?

A The wall rock will not be as reactive as the ore.

Q But it will be reactive and it would be more reactive as a result of blasting, wouldn't it?

A Than if it had not been blasted, yes.

Q Okay. By the way, in reaction to something you said this morning, there's no question in your mind that there will be ore remaining in the crown pillar; am I right?

A There will be sulfide mineralization in the crown pillar.

Q Well, but won't there also be ore in that crown pillar?

A It may be -- well, since the earlier plan had involved mining higher I assumed that there is ore grade material that is present in the crown pillar.

Q Okay. Essentially what I'm -- where I'm going here is that there's going to be material in that crown pillar that has the potential to generate acid and to leach metals?

A Only if -- if and only if it is exposed to oxygen.

Q Okay. Well, wouldn't you expect the crown pillar to be exposed to oxygen?

A No, I don't.

Q Why not?

A Because evidently there is going to continue to be water circulating downward recharging through the crown pillar, and if there's water moving down through the crown pillar, then the core space is filled with water. The amount of oxygen that can be carried in water is only ten parts per million, and in fact probably would be lower than that because some of the oxygen would be consumed along the route; therefore, there will be relatively little, near only no potential for oxidation of the sulfides in the portions of the crown pillar that remain at a high level of saturation.

Q So it would be your testimony that the crown pillar is going to remain wet; is going to be a wet crown pillar throughout?

A It can be wet without having a high flow of water moving through it. That's not the same thing. Wet has -- in the sense that I'm talking about is that the pore space has water in it, not only air. It has nothing to do with how much water is flowing through it.

Q Okay. Is it going to be -- is the crown pillar going to be wet sometimes and dry other times?

A I'd be surprised if that were the case, because it's sufficiently thick that I think variations in flow that are associated with seasonality at the surface would be damped out by the time one got far into the saturated zone of the total groundwater system.

Q So from your perspective we're going to have a wet crown pillar throughout; it's just going to be wet the whole time?

A There will be water in the pore space I would expect the whole time, except right at the roof of the mine.

Q Okay. From your perspective is there any impact on water quality from the crown pillar?

A If the crown pillar has background concentrations of water in it, then the background concentrations would need to be added to the values that I calculated.

Q Now, can we agree that there is going to be nitrates in the water that is generated from the mine as a result of blasting?

A It depends on what the blasting agents are that are used.

Q If the blasting agents contain nitrates there will be nitrates?

A The experience of the mining industry is that some level of nitrate would be present if ammonium nitrate is used as the explosive, but I don't know that ammonium nitrate is going to be the explosive.

Q Well, the testimony of the blasting expert who came in and testified was that they intend to use nitrates. You don't disagree with that I take it?

A I would have no basis for disagreeing with that. I'm telling you that I don't have personal knowledge of the blasting program.

Q Okay. The kinetic testing that you did; that's also known as humidity cell testing?

A You can call it humidity cells if you wish. It's not the traditional humidity cell that was first established by the EPA.

Q This is -- this kind of testing I take it is important; it's the kind of testing that is used in modeling for water quality? You used it?

A You use it to confirm the projections that are based on the static testing and also to produce effluent chemistries that can be used to evaluate future water chemistry.

Q Okay. Just a quick question about the kinetic testing of the areas where the ore will be, the massive sulfide unit and the semi-massive sulfide unit. It's my understanding that there's going to be something like 4.05 million tons of ore developed at this site. How many humidity tests did you do of the ore?

A We did three.

Q Okay. Doesn't the EPA recommend one test for every 10,000 to one million tons?

A That is their recommendation for the testing of waste.

Q Okay. Well, let me just -- we'll get to waste in a minute, but --

A No.

Q -- if we're dealing with ore, are you suggesting that there should be fewer tests then with ore than with waste?

A Yes, because the ore is not going to remain on site over long time frames that the kinetic testing is used to project the behavior. The long-term behavior that has potential to affect water quality is going to be associated with the rocks that remain at the site, not at the rocks that are moved from the site.

Q So if the EPA suggests that you have one test for every million tons and you did three, at least according to the EPA you would not have done enough testing?

A If those were waste, according to their criteria it would have been a small number.

Q Well, then let's talk about the development rock. How many tons of peridotite are at this site?

A Well, there's 669,000 tons of total rock and it's about 50 percent intrusive, then it's half of that number. So 300- -- 600- -- 350,000 tons.

Q 360,000 tons?

A Something like that. Approximately half of the total development rock.

Q How many long-term kinetic tests were done on the peridotite?

A I'd have to count them up. Five or six.

Q About six? Bear with me. I'm just getting information here. There's no tricks.

A I understand.

Q Okay. Focusing on that ore that you talked about. What is your understanding of what's going to happen to the ore once it is taken out of the ground?

A My understanding when we were designing the work and the basis on which all of this discussion is predicated is that the rock would be -- the ore would be moved to a crushing facility probably located underground and reduced in size to be suitable for direct shipment away from the site rapidly, probably --

Q Do you know; by rail? By truck? By car?

A I don't know. The early discussions were rail because I remember hearing people talk about railroad lines, but there also were discussions of roads. So I don't know. It would be moved rapidly away from the site by direct shipment.

Q Okay. And in your experience is there leakage from railcars; is there leakage from trucks?

A I've not studied that, but I'm sure there is.

MR. EGGAN: Okay. I don't think I have any other questions. Mr. Haynes, I'll pass to you.

MR. HAYNES: Thank you. Mr. Logsdon, my name is Jeff Haynes; I represent the National Wildlife Federation and the Yellow Dog Watershed Preserve.

CROSS-EXAMINATION

BY MR. HAYNES:

Q In your preliminary testimony you talked about projects that were like the proposed Eagle Mine in which there have been predictive -- predictions of acid mine drainage that have turned out to be essentially accurate in terms of the effects of acid mine drainage, and I -- my notes say that you talked about 13 of those projects. Do you recall that testimony?

A Yes, but I think your characterization of it is not quite what I said. What I said was that there are 13 projects that I counted up when looking at my CV that are in the category of exploration and feasibility studies on which I have done the type of water quality calculations that I did for Eagle. I did not compare them to the Eagle project.

Q Oh, I see. And so those are situations where you have performed the calculations like you did for the Eagle project?

A I've done the test work and then done the same kinds of calculations.

Q Right. And for those projects you haven't done any long-term studies, have you, on the actual effects of those mines?

A I have one where we just completed the effects ten years after the predictions.

Q Which mine?

A It's the Diavik Diamond Mine in the Northwest Territory.

Q Have you published any literature on that?

A No. We published the results of our characterization studies, but not the comparison of the recent results.

Q You also testified that in your view the ability of more recent mines to handle acid mine drainage has improved over older mines. Is that a fair characterization of your testimony?

A Yes, both the ability and the capacity.

Q Okay. And do you have any long-term studies that you can quote for that statement?

A No, I don't. That's just experience.

Q Do you know which mines we're talking about?

A New mines?

Q Yes. Which ones; can you name them?

A Yeah, Diavik was -- is one. The programs that have been put in place at Kennecott Utah Copper in the last number of years are very much better and the performance data shows that than the earlier programs were. There are mines other places in the world that have come on line in the last number of years that are -- have large environmental staffs and careful engineering work that's going on and are performing very much better than older mines in the same areas.

Q And how many of those are underground mines?

A Oh, goodness. I haven't counted them up. So I would say underground mining is less common than open pit mining in the last number of decades because of cost issues.

Q Can you name me one underground mine in which you consider that the ability of the operator to control acid mine drainage to be better than the older mines? Name one.

A Yeah, Greens Creek Mine operates very much better than almost any old underground mine that I could come up with.

Q You testified about the Kuipers Maest comparisons report, which has been identified and admitted here as Petitioner's Exhibit 65. That's not the one that you -- that's not the report that you peer reviewed, but that's the subsequent report -- or the companion report; correct?

A It is the companion report.

Q Yes. And you said that -- you testified that in that report the authors reviewed mines that have been permitted under NEPA. Am I characterizing your testimony correctly?

A That is probably what I said; what I probably ought to have said is that they were characterized under NEPA and evaluated with EIS's or EA's subsequent to the requirement of NEPA, not that there is necessarily a NEPA permit.

Q I see. And you're aware that the mines that were studied by Dr. Maest and Dr. Kuipers were all hard rock mines; correct?

A Yes.

Q And they were hard rock mines mostly on federal lands but some on state lands; correct?

A That's my general recollection of the report.

Q Okay. And that in essence they are similar to the proposed Eagle Mine in that they are hard rock mines that have the potential for acid mine drainage; correct?

A They are hard rock mines with sulfide ores, yes.

Q So in fact there's no functional difference between that kind of a mine, those mines studied by Maest and Kuipers and the proposed Eagle Mine for purposes of predicting or comparing acid mine drainage from those mines so that the fact that there's a NEPA study involved is really irrelevant to the conclusions, isn't it?

A I'm not sure that's the case, because the questions that are being asked under NEPA -- I'm not a specialist in NEPA, but the questions that are being asked under NEPA are not necessarily the same questions that are being asked in the state of Michigan. So I think one -- that the essential issue is that one must evaluate the environmental performance of the mine in its own right. It either has characterized the material and has developed engineering plans that are adequate to treat the circumstances of that mine, both its own geology and its own environmental setting, and it either meets the requirements that are set out by the appropriate authority or it does not. So if we have performance that's required, then it's this performance that is significant, not performance elsewhere.

Q Right. And the study that would be required under NEPA for an environmental impact statement would involve environmental impacts, consideration of alternatives, consideration of cumulative impacts. You understand that, don't you?

A Yes.

Q And you understand that those three in part are also required by Part 632 under the Michigan statutes: environmental impacts, addressing alternatives, and addressing cumulative impacts; right?

A I haven't studies your state regulations, but I'm pleased to accept your characterization.

Q All right. You testified on direct examination and also in answer to Mr. Eggan's questions concerning the probability -- or the possibility of acid formation in the crown pillar. Do you recall that testimony generally?

A Yes.

Q And you said that there has to be dissolved oxygen in order for the acid to form; correct?

A Yes.

Q On your PowerPoint presentation, which is Kennecott Exhibit 630, the third slide has the generalized chemical formula; correct? I'm looking at the third page entitled, "Eagle Project Background"?

A Yes, the FES-2 plus --

Q All right. And you highlighted and you read the oxygen component of that equation; correct?

A I did.

Q That's the dissolved oxygen component; correct?

A It can be atmospheric oxygen, and in fact in most cases it would be atmospheric oxygen.

Q But it can be dissolved oxygen; correct?

A It could be dissolved oxygen.

Q In water?

A Yes.

Q And in the crown pillar -- by the way, when you performed your calculations in Appendices D-1 and D-2 -- that is, the Phase I and the Phase II studies -- you were basing those studies on a thickness of the crown pillar that was 30 meters thick; correct?

A Yes.

Q Not the 87 and a half meters thick that we now know will exist; correct?

A That's correct.

Q So your calculations do not take into account -- have not modeled any effect of the -- of thickening the crown pillar; correct?

A I have not.

Q That would be important, wouldn't it, to properly characterize the site?

A Only if you thought that there was an incremental impact from oxidation occurring in the crown pillar.

Q And your testimony today is that there is no incremental impact?

A No, that's not what I testified to.

Q All right. So if there were an incremental impact and you believed that there would be, then you would want to model the effect of the thickening of the crown pillar, wouldn't you?

A The reports on the inflow to the underground workings, the D-3 and D-4 reports, lay out the that I did not include mass moved into the mine in groundwater in the calculations. It was set up to be incremental calculations of the impact associated only with rockiness that I was using to which one would have to add additional mass.

Q Right. And additional mass would be not only -- well, one portion of the additional mass would be the crown pillar, the thicker crown pillar; correct?

A It would be any mass that is moving in the aqueous phase through the crown pillar.

Q So my -- the answer to my question is "yes," you would have to take account of the thicker crown pillar; correct?

A If you were trying to evaluate the specific water chemistry that would exist in the underground workings at a particular point in time.

Q Okay. And it's important, isn't it, to determine the capacity and the ability of the treatment plant to treat that water to understand what the chemistry of the water is that's going to be treated; isn't that true?

A The general way that this works is the water treatment engineers accept advice from a geochemist, such as myself or Dr. Maest, and evaluate what the methodologies are that are available for the treatment of that water.

Q So they have to know what the geochemistry of the water will be in order to treat it; correct?

A Not in specific detail. They need to know the type of water chemistry that they're going to have. Will it be acidic? Will it have sulfate? Will it have nickel?

Q Okay. And your predictions are not specific as to -- don't have specific numbers attached to them; correct?

A They have specific numbers that are attached to them, but those don't represent models of water chemistry that is expected to exist in a specific future.

Q It would be important, would it not, to have a range of those chemistries of the water?

A The water treatment engineers are very familiar with the uncertainty that is associated with geochemical characterizations and they take those uncertainties into account as they design their systems.

Q All right. I want to go back to your phrase -- use of the phrase "incremental." The incremental predictions that you're making have to be -- that is, of the additional acid formation as a result of the mine workings have to be added to the background that's going to -- the background concentrations that will flow into the mine; correct?

A Yes.

Q Both from the sides and from the newly increased -- the newly thicker crown pillar; correct?

A If one were trying to imagine what the specific concentrations were.

Q And that's not what you were trying to do is imagine those specific concentrations?

A No, I was not.

Q Okay. Buy that would be important, wouldn't it?

A I don't know. It might be for some purposes; it was not for mine.

Q Do you know the -- do you have an understanding of the term "vadose zone"?

A Yes.

Q What is your understanding of the term "vadose zone"?

A A vadose zone is a portion of the groundwater in which not all of the pore space is completely filled by water.

Q All right. And is it your testimony today that the crown pillar, the newly thickened crown pillar is not in any portion of the vadose zone?

A That's not what I said.

Q Okay. So a portion of the crown pillar in fact is in the vadose zone at this site?

A I haven't studied that in detail, but I would expect that at least a portion of the crown pillar that is within a meter or two of the roof of the mine is not fully saturated because there's air available to the fractures.

Q And so for that area that is not fully saturated that would provide an area where either dissolved oxygen or atmospheric oxygen could generate acid mine drainage; correct?

A And that's exactly the reason that I did the calculation on the expanded surface area in the underground workings; that's what that's intended to address.

Q In your PowerPoint on page -- on the sixth page -- these are unnumbered but I'm looking at the sixth page which has the sample distributions in space, the large purple figures. That figure I think you testified is also Figure 2-2 in Appendix D-2.

A It was Figure 2-2 in the report that I submitted to Kennecott, so I -- probably.

Q Right. I don't want to -- this is not a memory test.

A Yes.

Q But just for the record, it's Figure 2-2 on page 58 -- the 58th page of Appendix D-2. And you testified on direct examination that -- and maybe I should clear this up, because I may not have caught all of the designations of the various colors of these squares. Tell us again what the green squares represent in this figure.

A Those are the country rock.

Q All right. And what do the blue squares represent?

A Intrusive.

Q And are there any other colored squares here?

A I think it's hard to see in this, but the samples in red and orange would represent -- red would be the massive sulfide and the orange would be the semi-massive sulfide.

Q I will agree with you it's hard to see, because the red figure here appears to be the massive sulfide and the orange figure appears to be semi-massive, so that -- it's tough to see.

A Yes.

Q Okay. If we were to try to find the location in space -- in three-dimensional space where these samples were taken, apart from this figure where would we find that in the appendices in the report you prepared?

A It wouldn't be in a report that I prepared, but it is almost surely in the database that was entered into evidence through Mr. Ware last week. All of these have specific sample numbers and those sample numbers are related to XY Zed locations in space. So it would be possible to determine that but I don't have that.

Q And as I recall from the chart that Mr. Eggan put up that showed the number of samples taken in the massive sulfide there was one sample; is that right?

A It was one sample for kinetic testing.

Q For kinetic testing. All right. And that one sample was taken in the massive sulfide but not in the crown pillar; correct?

A That's correct.

Q All right. And there were three samples in the semi-massive sulfide; is that correct?

A Two semi-massive sulfide.

Q Oh, two.

A For kinetic testing.

Q For kinetic testing. All right. Oh, I see. The sample distributions from the figure -- Figure 2-2 are not only the kinetic testing but all the other tests as well?

A Yeah, that's the total set of samples.

Q I understand. And if we were to look for the locations of the kinetic testing we would have to look at Mr. Ware's database?

A I believe that's the case. That's where I would go to find it.

Q Okay. And is there a particular -- I don't have that exhibit in front of me. Where in his databases would you look for the samples for kinetic testing? Is there a specific label that you would look for?

A No, you'd have to identify which sample is -- it was by what Kennecott calls their "VR number" which uniquely identifies each sample that's been tested and you would then go to the database and find the locations of those.

Q Okay. The two samples that were taken for kinetic testing in the semi-massive sulfide were not taken in the crown pillar area; correct?

A No.

Q You testified on direct examination -- and I think this is in relation to slide -- the twelfth page of your slides, which is the mass balance calculation of the geochemical controls. Do you have that in front of you?

A I do.

Q You testified that you obtained the particle size distribution from the folks at Kennecott; correct? That is, you took -- you got their estimate of the size of the rock that was going to be put in the development rock storage area; correct?

A I discussed with them how I would go about estimating the particle size for the rock in the TDRSA.

Q Who?

A I don't know whether it would have been someone in Foth and VanDyke or whether it was Andrew Ware or all of the above. I believe I probably went to them and said, "Does ten centimeters seem like a reasonable average value for the diameter?"

Q And they said "yes"?

A Yes.

Q And you didn't consult any published literature to determine some other value that could have been used?

A No, I didn't.

Q You just took their word for it?

A Well, their word plus my experience with the size of rock that one sees in underground mines; it seemed like this size sample was a pretty good estimate for the average rock size that one would see.

Q Not a best estimate, but just a pretty good estimate?

A It's an estimate that was adequate to the purposes to which it was put.

Q You talked on direct examination about solubility controls. Do you recall that?

A Yes.

Q And it's true, isn't it, that there is no solubility control for dissolved nickel?

A No, that's not true.

Q Mr. Logsdon, you'll have to bear with us. The technology here is mind numbing.

A Not a problem.

Q Mr. Logsdon, I've had put on the screen -- this is DEQ Exhibit 29. This is Appendix D-5, the "Post Reflooded Mine Water Chemistry." It's been admitted into evidence. In the first paragraph of this page starting in the section called "discussion," the third sentence reads -- no, fourth sentence reads: "Unlike some other transition metals (e.g. iron) there is no geochemically credible solubility control for nickel once it has been released, so its elevated concentration during operational conditions is expected." Do you see that?

A I do.

Q Didn't you just say that there's no solubility control for nickel?

A You're mixing up a bit of the chemistry. The question you asked me, which I tried to respond directly, is, "Is there a solubility control for nickel or is there not a solubility control for nickel?" As a general matter of chemistry there is solubility control for nickel. In the pH range of the waters that we are talking about it would not be effective. That's not the same thing.

Q I see. So for this mine for the pH that you expect there's no solubility control for nickel?

A Under the underground water conditions or the TDRSA, not in the water treatment plant.

Q That's fine. I understand. You testified that the amount of the development that will be backfilled, you used in your models 327,000 tons and the total is actually closer to 670,000 tons?

A And I used 379,000 and the total is 669,000.

Q Okay. And you said that was a result of a miscommunication between you and Kennecott?

A Yes.

Q The figures -- the actual figure's contained in the mine permit application, isn't it?

A Yes, but I produced my calculations before the mining permit was organized.

Q So maybe they were mis-communicating with you, then, not the other way around?

A Well, a mis-communication I take to be a matter of at least two parties.

Q Okay. And you say that that would increase the concentrations in the backfill by 50 percent?

A The concentrations in the underground by about 50 percent.

Q Okay. That's a significant amount, isn't it, 50 percent?

A It's a discernable amount, yes.

Q It's not trivial?

A It depends on what basis one is making the judgment. It is a larger number. It may or may not be significant with respect to a particular purpose.

Q In your calculations for the acid-generating potential of this mine, did you take into account the tunnel workings as well as just the mine itself?

A Oh, yes.

Q It's true, isn't it, that leaching of metals can occur even with a neutral pH without an acid-based water?

A In the infinitesimal sense that some water -- that something is leachable in any water, yeah. Part of the plastic is leaching into the water that's in here (indicating). So, yeah, some leaching can occur even under neutral conditions.

Q Mr. Logsdon, you understand that the ore that is mined at the site would be either trucked or sent by rail offsite; correct?

A That is my understanding.

Q And do you know how long the ore is going to be stored at whatever site it's going to be at before it gets milled?

A I have no idea.

Q Okay. You didn't take that into account in your calculations, did you?

A It does effect the site.

Q My question was, you didn't take that into account in your calculations?

A No, I did not.

Q Now, you testified at the end of your direct examination that the geochemical program is designed to minimize the impact on the environment and be protective of the environment; do you recall that testimony?

A I believe the question that Mr. Lewis asked me was whether the mine plans and engineering designs of the Eagle operation are intended to minimize the impact.

Q And your expertise is in geochemistry, isn't it?

A Yes.

Q It's not in mine design, is it?

A No, sir.

Q It's not in design of the wastewater treatment plant, is it?

A No.

Q It's not in predicting the effects on the environment outside the mine area, is it?

A No.

Q You don't claim any particular expertise in environmental impacts to flora and fauna, do you?

A No, I do not.

Q So when you testified that in your belief the mine design is going to be protective of the environment, that's just a guess on your part, isn't it?

A It's a judgment by a professional in the field based on 30 years experience with such undertakings.

Q And without expertise in those areas; correct?

A In those specific areas.

MR. HAYNES: Okay. Thank you, Mr. Logsdon. I have nothing further at this time.

THE WITNESS: Thank you, sir.

REDIRECT EXAMINATION

BY MR. LEWIS:

Q Mr. Logsdon, at one point Mr. Eggan was asking you a question as to this so-called armoring effect. And you indicated, I believe, that it is something that can occur, but he did not let you complete the answer to his question. And I think if you had been permitted to do so, what would you have added to that answer, Mr. Logsdon?

A When Kennecott asked me to do a calculation of the amount of limestone that they should consider adding to the development rock, I did the calculation initially as if the limestone were pure calcium carbonate. I then took account of my experience with limestones to recognize that limestones are not 100 percent calcium carbonate. So I included a factor of about 2 percent on the assumption that they were buying high calcium limestone, as I'd been told that they would do. And I then accounted for another 30 percent unavailability of the limestone due to whatever reasons the limestone might not be available that would include incrustations and anything that could occur. And that 70 percent number is a number that is very widely used in both mining calculations and, to my knowledge, in soil science when one needs to add an alkaline amendment to soil, one discounts the availability of the calcium carbone by about 30 percent. And, therefore, you need to increase the total amount of limestone that would be added in order to get back to the target neutralization potential that you're working for. So I provided those estimates of availability to Kennecott so that they could consider the possibility that not all of the limestone would actually be effective.

Q And has that input been adopted by Kennecott in the limestone amendment program?

A My understanding is that they have in fact adopted the assumption that not all of the limestone would be available and, therefore, there needed to be more volume added.

Q Now, you were also asked about I think it was a table in a report. I don't recall which. But the point of the questioning seemed to be that some metals may not -- that the release of some metals in the materials may not be slowed or effected by the addition of limestone. Do you recall that question matter?

A I do.

Q And in reference to our earlier discussion about lag time, would limestone be expected to increase the lag time for the metals that Mr. Eggan asked you about on the table for which it was not indicated there would be a decrease in their release rates?

A Yeah. The addition of limestone would be intended primarily to increase the lag time before the onset of acidification. And that would have the effect of reducing the amount of metals that are present in solution. So the question of how much further they would be reduced by the limestone that's present as a solubility control is secondary. The principle purpose is to prevent the release of the metals. They are to decrease the release of the metals in the first instance. It's not simply a question of solubility control after one has done a mass balance calculation.

Q As to the Maest-Kuipers comparison paper, Mr. Logsdon, to your recollection, was there any information in that paper about the various mines as to the specific permitting standards that applied to those mines?

A I don't recall that being covered.

Q Was there any information in that paper as to the mines that were discussed there as to whether in fact there had been any violation of any permitting standards that applied to those mines, if such permitting standards applied?

A I don't have a recollection of that either.

Q But was it reported in that paper for these mines that were reviewed what the background water quality information was before the investigation done by Kuipers and Maest?

A Most of those mines would not have had that information.

Q And just to be clear also, I believe it was Mr. Eggan asked you some questions about your reporting as to the -- when the time for reactions to begin might be expected to occur. And I believe the TDRSA based on the column leach test results and you had indicated that it may be some number of years, as I recall. But I wanted to ask you again for purposes of clarification as to those questions. Your reporting and the conclusions stated therein, did they include accounting for the limestone amendment?

A No, they did not.

Q And I think Counsel also asked you questions more -- a question about your specific -- some specific experience with mines where you had been involved with the water quality predictions and whether you had been able to observe over some period of time whether the initial predictions of how they compared with the mine water quality later on. I believe you mentioned the Diavik diamond mine specifically.

A Yes, I did.

Q And based on what you said earlier in response to that question, how did the pre-mining predictions compare to the results later?

A We made predictions in 1997 and 1998 for years three and ten of the operating open pit mine that they call A-154. And those are part of the water licensing record of the mine.

In 2008 the February data, which were the last data that we took a look at, and we looked at the time series for the entire six years to date of the operation of the A-154 mine, so we're between the year three and the year ten predictions. We are within a factor of two of all of the values. And for almost all of those values we're on the low side by up to a factor of two; that is, we were conservative in our estimates. And within the type of estimation that one does in mining geochemistry to be within a factor of two to a factor of five for the largest differences in the material is considered a very fine match indeed. And there are no water quality violations associated with any of the parameters that we model in that operation.

MR. LEWIS: Thank you.

MR. REICHEL: I have no questions, sir. Thank you.

MR. EGGAN: Nothing further.

MR. HAYNES: Your Honor, I have one series of questions that I overlooked on my cross-examination with Mr. Lewis' permission if I could inquire of the witness.

RECROSS-EXAMINATION

BY MR. HAYNES:

Q Mr. Logsdon, when you talked about the water chemistry for the mine during the operation, there's one thing that wasn't clear. And that is, what's your understanding of how the water will be handled when it comes into the mine? Let me be more specific with my question. You understand that the mining plan involves developing mining out of stopes one level of stope at a time; correct?

A I do.

Q And there will be water coming into the mine during the mining operation; correct?

A Yes.

Q It has to be pumped out and then treated; correct?

A That's the plan.

Q And is it your understanding that the water -- as the mining goes up from stope to stope, that the water will continue to be treated as the mining continues and that the mine will not be re-flooded stope by stope; is that correct?

A I don't -- I have no detailed understanding of that part of the mine plan.

Q Okay. But your understanding is that the inflows will be treated during the mining and then at the end of the mining period the entire mine will be re-flooded; correct?

A That's my general understanding.

MR. HAYNES: All right. Thank you. Nothing further.

MR. LEWIS: Nothing further.

MR. REICHEL: Nothing.

JUDGE PATTERSON: Thank you, sir.

THE WITNESS: Thank you, sir.

JUDGE PATTERSON: A few minutes before the next witness?

MR. LEWIS: Yes, Your Honor. Thank you.

(Off the record)

JUDGE PATTERSON: Everybody ready?

MR. LEWIS: Yes, Your Honor. Intervenor Kennecott Eagle Minerals Company calls Dr. Stuart Miller.

REPORTER: Do you solemnly swear or affirm that the testimony you’re about to give will be the whole truth?

DR. MILLER: I do.

STUART D. MILLER, PH.D.

having been called by the Intervenor and sworn:

DIRECT EXAMINATION

BY MR. LEWIS:

Q Would you state your full name and spell it for the record, please?

MR. EGGAN: Your Honor, with respect to this witness, we would -- at least I would interpose an objection to this testimony. This witness is Dr. -- excuse me -- is Stuart Donald Miller. From what I understand, and it's very difficult to understand exactly what this witness has done in this case, but he did not have any participation in the application process. He didn't offer comments, he didn't submit a report, he didn't do any of that. Nor has he prepared a report for our review and giving us an opportunity to understand what he is to testify about. His expected testimony as identified in the so-called recitation offered by the -- offered by the Intervenors is,

> "Review and analysis of geochemistry work and reports submitted with the mine permit application by Geochemica and MFG, DEQ's consultant and rebuttal of geochemical opinions and calculations of Petitioner's geochemical expert witnesses as appropriate."

Essentially, this recitation tells us nothing about what he's going to testify about. We have as of about ten minutes ago been given Intervenor's Exhibit 631, which is a slide presentation of some 50 slides of what this person is going to testify about. This is something -- and I think Mr. Haynes would amplify on this, but this was just given to us a few minutes ago and we're expected to somehow digest this and understand it and offer some form of effective cross-examination. Again, I object. From my perspective, this is another example of an effort to really come in here and spring someone on us we really have no effective ability to conduct any sort of effective examination of this witness.

MR. HAYNES: Your Honor, I join in the objection for a number of reasons, including those forced by Mr. Eggan, but also because to the extent that this witness will simply comment on what Mr. Logsdon has already testified to, it's cumulative and it's duplicative and, therefore, ought to be barred. Secondly, to the extent that this witness is going to as disclosed to us in this very brief recitation of his testimony, is going to rebut the geochemical opinions and calculations of Petitioner's geochemical expert witnesses as appropriate, those calculations have been in the record in the comments submitted by Petitioners in October of 2007. The witness list was sent out -- the witness lists were distributed and served on March 7. So this witness presumably had about six months to prepare some sort of a report for us to look at and has apparently prepared none, because there's none listed in the -- in Kennecott's witness disclosure.

As Mr. Eggan said, ten or 15 minutes ago we were handed 50 slides at the -- when Mr. Logsdon stepped down from the witness stand, we were handed 50 slides by Mr. Lewis. These slides -- and I've had that time to look at this. These slides contain graphs that were apparently prepared for this testimony today. They contain analyses of both Mr. Logsdon's work and of Ann Maest's work and John Coleman -- Dr. John Coleman's work. This is the kind of thing that in the normal course of events that provided for timely I would have spent at least a day looking over this trying to figure out what it meant, what it said and talking to my experts about it. I got 15 minutes and no chance to talk to my experts about what these conclusions are that the witness apparently has had six, eight -- about eight months to work on. And we're handed it 15 minutes before he's supposed to start testifying. It is completely prejudicial, completely against this tribunal's order that witnesses be required to -- that the counsel be required to produce some recitation of what the witness is going to testify to, not summaries of the subject matter, but actual testimony -- recitation and a summary of what testimony, not the subject matter of the testimony. So I object.

JUDGE PATTERSON: Mr. Lewis?

MR. LEWIS: Yes. Your Honor, most for this we've been through before. There's been the same objection and rulings as to the degree of disclosure or the amount of disclosure or the witness list. Just to bring the Court back to some of that, the amount of disclosure is appropriate. It's within the realm of what's required by this tribunal both in its scheduling order and otherwise. And we -- the Petitioners ought not throw too many stones as, again, as I pointed out before, neither party was under an obligation to prepare new reports for this proceeding. And in fact, for a number of Petitioner's witnesses there were no reports prepared. As I recall, one example of that would be Mr. Prucha who testified earlier for the

Petitioners. As to the duplicative claim, that the testimony may be duplicative, I would also remind the Court that, once again, stones perhaps should not be thrown as we did go through a fairly length direct exam in this case of Petitioner's witnesses Maest and Coleman, both of which talked about and criticized the geochemistry calculations done by Mr. Logsdon, much of which was duplicative. It took a long time. But I think the duplicative complaint also has little merit here.

As to the 50 slides, they were handed out as a courtesy. Petitioner's counsel had done likewise with me on prior occasions with some of the witnesses. I did not get those slides at any time until the witness was prepared to testify. In some cases, new slides, new information, summary conclusions and so forth. And in fact, I'm not obligated to provide slides here. I can put Mr. Miller up there and we can go through his testimony. It's simply a courtesy to the Court and to the other counsel to give them, because this is simply an outline format for Dr. Stuart to go through his testimony. I would also note that we did submit in our exhibit list as Exhibit Number 210 a number of the graphical summaries that in fact are in the slides that I handed to Counsel earlier. Those were made available on the date by which we were to share exhibits. So we did provide some additional information and so forth in that way as to Dr. Miller's expected testimony today.

JUDGE PATTERSON: Anything further?

MR. EGGAN: Nothing, except to say, Your Honor., that your order, your pre-hearing order, required the parties to submit a recitation. Now, we submitted a full-fledged recitation of what Dr. Prucha was going to testify about. And everybody in the courtroom knew what Prucha was here to testify about. That is not the case with this gentleman. We don't know what he's going to testify about. And this so-called recitation expected testimony offers -- sheds no light on that issue. So again, the case law would suggest that the Court really ought to do everything it can to avoid trial by ambush, trial by surprise. And that's what we're asking the Court to do is just impose a reasonable restriction and not allow a witness to testify who simply has not abided by the rules.

JUDGE PATTERSON: Mr. Haynes, do you have anything to add?

MR. HAYNES: Yes. As to Mr. Lewis has in the past brought up the example of Dr. Prucha's testimony, and I will again reiterate for the record that our summary, our recitation of Dr. Prucha's testimony was a full page single-spaced recitation. It had his conclusions, it had the basis for his conclusions. So the idea of using Dr. Prucha as an example of a small or modest recitation compared to the four lines that we have for Dr. Miller is just -- it's out of bounds. And I join Mr. Eggan. The recitation here gives us no idea what this witness will testify about except the general subject matter. And it's not -- it does not comply with this tribunal's order to require recitation of testimony. So we are once again at a disadvantage and highly prejudiced.

JUDGE PATTERSON: Mr. Reichel, do you have anything to add?

MR. REICHEL: I would note that my understanding of a principle subject of this witness' testimony or anticipated testimony is by way of rebuttal the testimony offered by Drs. Maest and Coleman. And I think that that is certainly a legitimate subject for the Intervenor to offer evidence.

JUDGE PATTERSON: What I'm going to do is I'm going to adjourn the hearing now for today to allow you to digest these slides, which I assume will be illuminating as to what the substance of Dr. Miller's testimony is going to be. And Mr. Lewis can start with his direct examination in the morning. And hopefully that will give you enough time to at least get an idea of what he's going to testify to. Okay?

MR. EGGAN: Thank you, Your Honor.

JUDGE PATTERSON: You're welcome.

MR. HAYNES: Thank you.

(Proceedings adjourned at 3:29 p.m.)

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