

The Potential for Silica-Related Health Effects

From the Proposed Liberty Quarry

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Executive Summary

Questions have been raised regarding the potential for silica-related health effects as a result of emissions from the proposed Liberty Quarry near the city of Temecula, California. Specifically, questions have been raised regarding the possible risk of silicosis, cancer, and asthma. A comprehensive scientific study and review was undertaken of data that modeled the likely ambient levels of crystalline silica resulting from the proposed quarry activities, actual measurements made near existing aggregate materials facilities in California, and the published scientific literature on the health effects of silica.

The environmental modeling data indicate that the proposed quarry will not be a substantial contributor to ambient levels of crystalline silica, and that ambient levels of crystalline silica will remain well below California's Reference Exposure Level (REL) of $3 \mu\text{g}/\text{m}^3$. Actual data from operating aggregate materials facilities indicate that the modeling data are reasonable and realistic. Further, based on data from active quarries, the proposed operations may have no measurable effect on ambient silica levels near the facility. This is due, in part, to the presence of existing background levels of silica from natural sources (the natural geology of the area coupled with high winds) and traffic.

Silicosis has historically been a problem in occupational settings with high, long-term exposures to crystalline silica without appropriate personal respiratory protection and/or dust suppression. The levels of ambient silica near the proposed facility will be orders of

magnitude lower than levels that have been shown to cause silicosis in occupational studies due to the nature of the operations and dust control measures at the facility.

Because the emissions from the facility will be low relative to ambient standards and occupational levels shown to result in silicosis, there will be no risk of silicosis among people living in the vicinity of the proposed quarry.

Studies of lung cancer in relation to silica exposures in occupational settings have been inconsistent (McDonald and Cherry, 1999). Importantly, studies that have looked at the change in risk of lung cancer in relation to change in exposure to crystalline silica have generally not found that risk of lung cancer increases as silica exposure increases (Soutar et al, 2000; Hessel et al, 2000). Even among those who believe that silica exposure may increase risk of cancer, it is generally accepted that exposures that do not pose a risk of silicosis do not pose a risk for cancer (American Thoracic Society, 1997). Emissions of crystalline silica from the facility will not have an effect on cancer risk for area residents.

Numerous studies (Irwig and Rocks, 1978; Wiles et al, 1982; American Thoracic Society, 1997) have looked at other lung problems in relation to silica exposure. There is no evidence that asthma is related to silica exposures.

There are no data to suggest that emissions of crystalline silica from the proposed Liberty Quarry will have an effect on the risk of silicosis, cancer, or asthma among those living near the proposed facility.

Preface

Dr. Patrick Hessel is an epidemiologist who has spent the past 25 years conducting and evaluating research into the health effects of silica. From 1982 to 1987, he conducted research on silicosis, lung cancer, and other respiratory health effects among hard rock miners in South Africa. He continued his research in the area of occupational lung disease from 1987 to 2002 as a professor at the University of Alberta in Edmonton, Canada. For the past five years he has consulted with a variety of groups and organizations in the area of occupational lung disease.

In preparing this report, a number of documents were reviewed. These include:

1. Pre-draft of an Air Quality Impact Analysis for the Proposed Liberty Quarry, Riverside County, California, by Kleinfelder, Inc.
2. Sampling and Analysis of Samples Collected in the Cities of Duarte and Azusa, by the South Coast Air Quality Management District
3. Crystalline and Amorphous Silica Concentrations in PM₄ Samples at Aggregate Handling Plants, by John Richards and Todd Brozell
4. PM₄ Crystalline Silica and PM₁₀ Particulate Matter Emission Factors for Aggregate Producing Sources. 2005 and 2006 Test Programs, Combined Report (Draft), by John Richards and Todd Brozell
5. A number of newspaper clippings related to the proposed quarry
6. The relevant scientific literature.

The following report is focused on the potential for silica-related health effects arising from the proposed quarry operations. Based on the concerns raised by members of the community (as reflected in the newspaper clippings) and the scientific literature, this includes silicosis, cancer, and asthma.

Silica

Silica is a mineral that makes up 12 percent of the earth's crust. The chemical formula is SiO_2 , that is, the mineral contains two oxygen atoms for each silicon atom. Silica can be either crystalline or amorphous. In crystalline silica, the silicon and oxygen atoms are aligned in organized arrangements called tetrahedra. In amorphous silica, the atoms are not neatly arranged. Most of the silica in the earth's crust is in the crystalline form. Most granitic rock such as found in Southern California contains crystalline silica.

Silica-Related Health Effects

Previous studies of workers exposed to amorphous silica have not found health problems. Studies of workers exposed to crystalline silica have shown that people occupationally exposed to high levels of silica over an extended period of time without proper protective equipment and/or dust suppression methods can develop silicosis. Silicosis has been recognized as an occupational disease for centuries. More recently, scientists have questioned whether people exposed to silica on the job are at increased risk of developing lung cancer. A couple of the clippings from newspapers near the proposed quarry site raised concerns that people with asthma may be at risk of problems as a result of silica in the air. These issues will be reviewed briefly below.

Silicosis

Silicosis refers to the formation of small, typically round nodules in the lungs of people exposed to crystalline silica dust. There are three kinds of silicosis that are recognized. Acute silicosis can develop after two to five years of frequent exposure to extremely high levels of silica dust. Cases of acute silicosis have been documented among underground miners working in uncontrolled conditions with no respiratory protection, in tunneling workers, and in sandblasters. Acute silicosis is extremely rare.

Accelerated silicosis can occur in workers after 10 or more years of exposure to very high levels of silica dust. These sorts of levels are seldom seen anymore due to dust control measures in industrial settings. In the past, workers with accelerated silicosis have been found among miners, tunneling workers, and sandblasters. Cases of acute and accelerated silicosis essentially do not occur outside occupational settings and are not relevant to the discussion of the proposed quarry.

Chronic silicosis can occur in workers exposed to fairly high levels of silica dust for extended periods of time. Even among workers with heavy exposures (in mines, tunnels, and foundries, and in sandblasting operations), silicosis seldom occurs before 20 years of consistent, high occupational exposure.

The risk of silicosis increases with the total amount of exposure to silica dust. Studies have shown that, except for advanced levels of silicosis, silicosis does not have an effect

on lung function or on people's ability to exercise (Gamble et al, 2004; Wiles et al, 1992). These levels of chronic silicosis are not found outside the occupational setting.

It has been shown that, among people with the same amount of total exposure, those who get their exposures over a shorter time (and therefore, at higher exposure concentrations) have a greater chance of developing silicosis. In other words, as the exposure concentration decreases, the risk of silicosis goes down even if the duration of exposure is higher. This has important implications for the proposed quarry because the allowable concentrations for ambient air (not occupational exposures) have been set by extrapolating the results of occupational studies without considering the accelerated "fall-off" in risk of silicosis as the concentration of silica decreases. It should also be noted that the allowable concentration of silica in ambient air for California has been set using a significant margin of safety to prevent silicosis. The existing standard, therefore, has two very important built-in safety factors:

- Allowable concentrations of crystalline silica were set by extrapolating from heavy occupational exposures, without considering the reduction in risk of silicosis per unit of exposure with decreasing exposure levels, and
- After applying elevated risk estimates, a significant safety factor was added.

Based on the draft *Air Quality Impact Analysis*, prepared by Kleinfelder, Inc.(2007), the amount of silica dust that will be produced by the quarry will result in levels of silica in the ambient air about one one-hundredth of the Reference Exposure Level (REL) of 3 $\mu\text{g}/\text{m}^3$. These projected levels are consistent with monitoring data obtained in the

vicinity of working quarries in California. The South Coast Air Quality Management District sampled silica levels in the communities of Duarte and Azusa. There are two quarries operating in the vicinity. It was not possible to identify the sources of the crystalline silica that was found in the ambient air in these two communities; however, all of the measured levels were well below the REL – even the highest measured level. Sampling for crystalline silica was also conducted upwind and downwind of aggregate materials facilities near Tracy and Bradshaw (Sacramento), California in 2004. Only one downwind sample showed a level of crystalline silica above the level of detection, and this was far below the REL. One upwind sample also had a measurement above the level of detection, but it was still well below the REL. Sampling for crystalline silica was also done in 2005 upwind and downwind from plants in Tracy and San Diego. Again, all measured levels were below the REL and most of the downwind samples were **lower** than the upwind samples.

As noted above, the levels of crystalline silica projected for the proposed quarry are low – well below the REL. The data obtained from six active quarries operating in California indicate that the levels projected for the Liberty Quarry are likely to be reasonable estimates. Bearing in mind the previously mentioned safety factors built into the REL by the State of California and the fact that silica exposures from the quarry will be one hundred times lower than the REL, there will be no risk of silicosis for people living in the area of the proposed quarry.

Additional evidence for the lack of risk of silicosis comes from an informative study of workers in granite quarries in Vermont. The workers were in the industry for an average of 18 years (many for more than 40 years) at levels of silica exposure that averaged $60 \mu\text{g}/\text{m}^3$, or 20 times higher than the REL of $3\mu\text{g}/\text{m}^3$. Twelve percent of the silica measurements were higher than $100 \mu\text{g}/\text{m}^3$, over 30 times higher than the REL. Only seven of the 972 chest x-rays of the workers (less than one percent) showed changes consistent with silicosis. Even in studies of people not exposed to silica at all, the percent with x-ray changes consistent with silicosis is usually higher than this (things other than silica, such as infectious diseases and other dusts can cause small, rounded opacities on the chest x-ray). Thus, even among workers exposed to levels of silica dust 1,000 times higher than the levels projected for the quarry, silicosis is virtually unknown.

Cancer

A number of studies have been done over the past 20 to 30 years to try to determine whether silica can cause cancer. The main focus has been on lung cancer. The studies have been inconsistent (McDonald and Cherry, 1999). Some have found that workers exposed to silica are at increased risk of developing lung cancer and other studies have found no increased risk of lung cancer among workers exposed to silica. In general, those studies that have shown increased risk of lung cancer did not account for the effects of smoking.

Some of the studies have tried to find out if, among the workers exposed to silica, people who had higher exposure were more likely to develop lung cancer than the people with

lower exposures. In general, these types of studies (exposure-response studies) are helpful in determining whether an increase in cancer in a group of workers is actually related to the substance being studied, instead of, for example, differences in smoking habits. The exposure-response studies of workers exposed to silica have also been inconsistent (Soutar et al, 2000; Hessel et al, 2000). In fact, in some studies, the workers with the lowest exposures to silica were found to be at the highest risk of lung cancer and those with the highest exposures to silica were found to be at the lowest risk.

The inconsistent results of these studies have made it difficult for various governmental agencies to determine whether they should consider silica to be a carcinogen, and scientists are not in agreement on whether silica causes cancer. Some agencies have decided to label silica as a possible carcinogen – this includes the State of California. However, even among those who believe that silica causes cancer (and this author is not among those who believe that silica causes cancer), there is general agreement that there is no increased risk of cancer when silica levels are kept low enough that there is not a risk of silicosis (American Thoracic Society, 1997).

Clearly, there should be no concern about silica-related risk of cancer to nearby residents from the proposed quarry. The dust levels are far below levels linked to silicosis and they are far below allowable levels in occupational settings and the ambient environment. These levels of silica exposure are not related to risk of silicosis or cancer.

Asthma

Asthma is not a recognized health effect related to silica exposure. Numerous studies have been conducted to evaluate lung conditions and lung symptoms in workers exposed to silica. Asthma has not been suggested as a problem. In fact, there was a controlled study (Wiles et al, 1982) in which workers were exposed to silica in an exposure chamber and their lung function was measured before and after exposure to look for an asthma-like reaction. None was found.

Conclusions

There has been much research and regulatory activity in the area of silica health effects over the last couple of decades. In some jurisdictions, allowable levels of silica exposure in occupational settings have been reduced and the use of protective equipment has been required in situations where exposures cannot be reduced by technological means. The State of California has introduced a REL for ambient exposure to silica that incorporates significant safety margins for known and suspected health effects. The levels of silica dust projected to arise from the proposed quarry are orders of magnitude below this very low reference level.

Based on the anticipated levels of crystalline silica generated from the proposed quarry, the dust mitigation measures proposed for the Liberty Quarry, and the existing research on the health effects of exposure to crystalline silica, it is my opinion that there will be no risk of health effects from crystalline silica (silicosis, cancer, or asthma) on residents that might live near the quarry.

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