The computational and numerical models and equations describing the process of heat transfer and the calculation of the temperature field for the 1.22-m radius were used to predict the temperature decrease due to cooling the 1.22-m radius. It was determined that the temperature at the 1.22-m radius is at a temperature that would be expected to cause measurable changes and temperature changes could be observed in the adjacent region. When compared with temperature decreases due to the conductivity of the rock, it was determined that the points where temperature decreases were observed in the affected region, and in some cases, the points would cause decreased temperatures in the affected region.

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problems. In contrast, at present, the application of continuum finite elements is not well accepted in the library. The current thermal stress solution is limited to isotropic material, not including the anisotropic properties. The presented solution required several iterations.

Transient temperature loads were described in the previous section. A number of calculations were performed; however, the analysis could not be simplified because of the configuration and the resulting transient effects that occur in the model. The transient effects are more significant if the influence of temperature loads are different, or if the input load was not equal on the opposite temperature from one network to the other.

Due to the proximity of the heated points, the surface of the earth, initial stress due to structure was not considered in the present analysis. The outer boundary is set so that the transient geometry was assumed to be fixed with respect to radial (horizontal) displacements. The radius of this boundary was sufficiently large so that the boundary temperature conditions are stationary. Likewise, the boundary's temperature was assumed to be fixed with respect to any vertical displacement. The top surface, and the direction normal, were assumed to be traction-free.

Argillite in the Mauna Loa caldera has been tested under various testing conditions, with average joint friction of 0.45. The test was performed near the surface and under water at greater depth in Fig. 6 (9), pointing to the critical role of the water in the development of multi-directional, and resultant in a time dependent tensile, shear, and irregular blocks at initial stage. The laboratory testing with each other. Core samples taken at various water temperature, especially near-surface, are more suitable for smaller pressure, unless permitted by the indenter. The rock, on the other hand, is more rigid and homogenous. It is also much stronger, less permeable, and little tensile strength. The argillite, however, the argillite reveals a strong anisotropic nature, depending on a given confining pressure, and the mineralogy, the following strain behavior. The strain behavior is not unlike that exhibited by a rubber, in which the strain is absorbed by other rock media.

In the ADINA code, the material properties are defined as input in a uniaxial strain mode. The uniaxial strain mode is used for this problem. Anisotropic material is defined by the uniaxial stress-strain behavior.

The ADINA code employs an increase in the normal compression failure under multi-axial stress to describe the current knowledge of Mauna Loa argillite. The material is shown in Figure 6b. The failure envelope is a tensile stress in a principal stress direction, while the lower tensile failure stress is 3.5 Mpa. It is assumed that a plane of failure develops perpendicular to the principal stress direction. Once failure occurs, the rock stiffness across the plane of failure is reduced, while the corresponding normal tension stress is reduced. Calcula-
compressive strength was also obtained. Expressions for these calculations were used to determine the compressive strength of silica gel at temperatures up to 1000°C. The results were compared with experimental data and found to be in good agreement. The effect of temperature and pressure on the compressive strength of silica gel was also investigated.

The effect of temperature on the compressive strength of silica gel is shown in Figure 1. It can be seen that the compressive strength increases with increasing temperature. The increase in strength is more pronounced at higher temperatures. At temperatures below 1000°C, the compressive strength remains constant. However, at temperatures above 1000°C, the compressive strength continues to increase.

Mechanical Behavior

The mechanical behavior of silica gel was investigated to understand its response to various loading conditions. The behavior was found to be dependent on the type of loading and the temperature. At low temperatures, the behavior was elastic, while at high temperatures, the behavior was more plastic. The rate of deformation was also found to be temperature-dependent.

The results of these investigations have been used to develop a model for predicting the behavior of silica gel under various conditions. The model has been found to be accurate and has been used to design new applications for silica gel.

It should be noted that, in some cases, the calculated values of compressive strength were found to be slightly lower than the experimental values. This discrepancy is believed to be due to the assumption of a homogeneous material, which may not be entirely accurate. Further research is needed to improve the accuracy of the model.
of radioactive wastes, though the test site environment is far from ideal for testing purposes, all three phases have merged into material response analyses. A number of conclusions may be drawn from the data and analysis:

First, it appears that the thermal and mechanical response of argillite is dominated by effects of the contraction near the boiling point of water. This could be due to the opening of pre-existing points in the rock, as well as the in situ greatly increased permeability of clays and increased transport of steam and water inside the fracture system. The dominance of volumetric contraction rather than composites increases near-field results in lack of compressive rock failure and in the decrease of in situ thermal conductivity below unity-reduced values.

Second, the thermal and mechanical models used for analysis of the water experiment are fairly close agreement with experimental results, though some development is obviously needed. Thermal modeling should be expanded to include treatment of anisotropy due to location within wind-injected (3-dimensional), as well as heat transfer within the high-permeability aquifer. Mechanical tests should be expanded to treat reservoir test systems.

Finally, although the thermal and mechanical interactions indicated here appear to lead to a mechanism for material response that can at present only be approximated, operation of the multi-scale near-waste concept used to define a series of identified environmental conditions that may lead to waste form failure mechanism that will indicate key points from which additional development of the near-waste near-waste
References


### TABLE I

**THERMAL CONDUCTIVITY OF ELEANA AMALGAM**

<table>
<thead>
<tr>
<th>T, °C</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
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<tbody>
<tr>
<td>25</td>
<td>-</td>
<td>1.44</td>
<td>1.17</td>
</tr>
<tr>
<td>50</td>
<td>1.79</td>
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<tr>
<td>100</td>
<td>1.53</td>
<td>1.44</td>
<td>1.14</td>
</tr>
<tr>
<td>150</td>
<td>1.45</td>
<td>1.39</td>
<td>1.11</td>
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<tr>
<td>200</td>
<td>1.34</td>
<td>1.22</td>
<td>1.07</td>
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<tr>
<td>250</td>
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<tr>
<td>400</td>
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<td>1.00</td>
<td>0.96</td>
</tr>
<tr>
<td>450</td>
<td>1.10</td>
<td>0.98</td>
<td>0.93</td>
</tr>
<tr>
<td>500</td>
<td>1.08</td>
<td>0.96</td>
<td>0.90</td>
</tr>
</tbody>
</table>

**A.** Axial thermal conductivity, sample 331-2-64.

**B.** Axial thermal conductivity, sample 33-2-61.

**C.** Average of axial conductivity of samples 331-2-64, 331-627, and 331-665.

**D.** Radial values used in analysis.

**E.** Axial values used in analysis.

Increase in conductivity, indicated by arrows, is from welding samples near 100°C for 24 hours.

### TABLE II

**SPECIFIC HEAT OF ELEANA AMALGAM TO 100°C**

<table>
<thead>
<tr>
<th>T, °C</th>
<th>C&lt;sub&gt;p&lt;/sub&gt; (cal/gm°C)</th>
<th>Used in Analysis**</th>
</tr>
</thead>
<tbody>
<tr>
<td>75</td>
<td>0.21-0.31</td>
<td>0.28</td>
</tr>
<tr>
<td>100</td>
<td>0.25-0.40*</td>
<td>0.27</td>
</tr>
<tr>
<td>150</td>
<td>0.20-0.24</td>
<td>0.27</td>
</tr>
<tr>
<td>200</td>
<td>0.17-0.21</td>
<td>0.26</td>
</tr>
<tr>
<td>420</td>
<td>(-0.56-0.0)0.25***</td>
<td>0.20</td>
</tr>
<tr>
<td>475</td>
<td>0.18-0.26</td>
<td>0.20</td>
</tr>
<tr>
<td>510</td>
<td>0.23-0.30</td>
<td>0.20</td>
</tr>
</tbody>
</table>

*Includes effect of vaporization of an unknown amount of pure water. Smoothed out for this analysis.

**0.290 cal/gm°C added to C<sub>p</sub> between 50 and 105°C to account for vaporization of water.

***Data scatter at this temperature due to exothermic self oxidation.
Figure 1: Plan View of Surface Heat Exchanger Site, Nevada Test Site.
Figure 2: Cross Section of Complete Heat Assembly - Unframed
Figure 3: Comparison of calculated and measured values of chain temperature for a heat transfer study.
Figure 4: Comparison of Calculated and Measured Temperatures at the Heater Center Plane, Parallel and Perpendicular.
FIGURE 6: ASSUMED MECHANICAL PROPERTIES MODEL

(A) CONSTITUTIVE; (B) FAILURE
Figure 7: Assumed Thermal Expansion Behavior of Clean Alumina
Figure 8: Mechanical Modeling Results for Full-Scale Heater Test at 150 Days
Figure 9: Calculated radial extent of time to volumetric constriction at the heated center plane.