## Mineral Concentration Heatmap Features

I've enhanced your GeoVisionminer application with a powerful heatmap visualization layer that provides intuitive insights into mineral concentration density. Here's what I've added:

### 1. Interactive Heatmap Layer

- \*\*Density Visualization\*\*: The heatmap shows areas of high mineral concentration with warmer colors (red, orange) and lower concentrations with cooler colors (blue, cyan)

- \*\*Adjustable Intensity\*\*: Users can control the heatmap intensity with a slider to highlight different concentration ranges

- \*\*Toggle Controls\*\*: Easy switching between marker view, heatmap view, or both simultaneously

### 2. Mineral-Specific Filtering

- \*\*Filter by Mineral Type\*\*: View concentration patterns for specific minerals (Gold, Copper, Silver, etc.)

- \*\*All Minerals View\*\*: Compare concentration patterns across all mineral types

- \*\*Dynamic Filtering\*\*: URL-based filtering that persists across page refreshes

### 3. Concentration Statistics

- \*\*Mineral-Specific Stats\*\*: View average, maximum, and minimum concentration percentages for each mineral type

- \*\*Sample Counts\*\*: See how many samples exist for each mineral type

- \*\*Visual Indicators\*\*: Color-coded bars showing relative concentration levels

### 4. Technical Implementation

- \*\*Canvas-Based Rendering\*\*: Efficient rendering of the heatmap using HTML5 Canvas

- \*\*Custom Color Gradients\*\*: Configurable color schemes for different visualization needs

- \*\*Server Actions\*\*: Optimized data fetching for the heatmap visualization

- \*\*Responsive Design\*\*: Works on all device sizes

### 5. Integration with Existing Map

- \*\*Seamless Toggle\*\*: Switch between standard marker view and heatmap view

- \*\*Combined View\*\*: Option to show both markers and heatmap simultaneously

- \*\*Consistent Controls\*\*: Maintains all existing map functionality (zoom, pan, layer selection)

## How to Use the Heatmap Visualization

1. \*\*Access the Heatmap\*\*: Navigate to the dedicated heatmap page via the dashboard navigation

2. \*\*Toggle Visualization\*\*: Use the "Show Heatmap" button to enable the heatmap layer

3. \*\*Adjust Intensity\*\*: Use the intensity slider to highlight different concentration ranges

4. \*\*Filter by Mineral\*\*: Select a specific mineral type to focus on its concentration patterns

5. \*\*Analyze Statistics\*\*: View detailed concentration statistics for each mineral type in the sidebar

This heatmap visualization provides powerful insights into mineral concentration patterns across your geological samples, helping identify high-potential mining areas and understand mineral distribution patterns.