Observation on effects of heating and copper diffusion in feldspar (An on-going research)

Kamolwan Thirangoon
GIA Laboratory, Bangkok

Heating and subsequent copper diffusion were conducted on light yellow feldspar. The study was performed to monitor chemical and physical changes that occurred. Thirty-nine samples were acquired from John Emmett of Crystal Chemistry, Brush Prairie, Washington, for this study. They are from four different sources; Plush, Oregon, USA (8 pieces), Ponderosa, Oregon, USA (9 pieces), Mongolia, China (7 pieces) and Mexico (15 pieces). These samples were also treated by John Emmett. Simple heat treatment with no additive was shown to cause some changes in chemical composition and inclusions. It also creates internal diffusion of the metallic copper that gives rise to schiller effect in Oregon material. (The detailed result of the changes occurred after heating can be found on gia website, http://www.gia.edu/research-resources/current-research/index.html and http://www.giathai.net/lab.php.) Copper diffusion gives rise to red coloration of the samples.

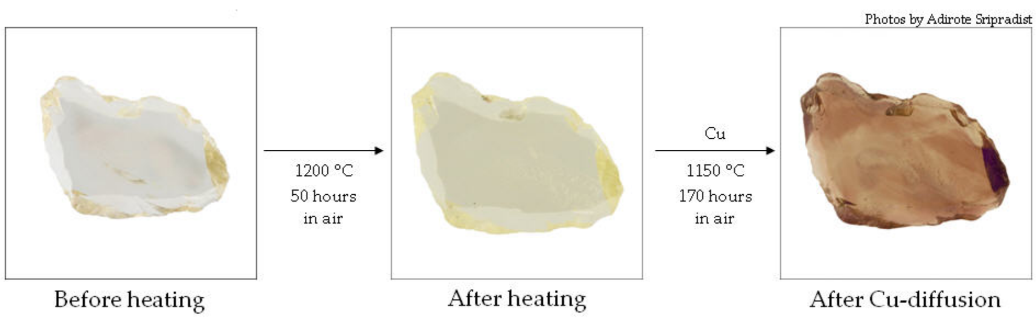

Figure 1. Sample 668715902 light yellow feldspar from Plush, Oregon, USA was subjected to heating and copper diffusion treatment causing the sample to turn into red color.

Simple heating did not improve appearance of near colorless to light yellow feldspar. The samples were heated at 1200°C for 50 hours in air (Figure 1). They showed less transparency and more yellow in color. The samples from Mongolia, China, Mexico and Plush, Oregon, USA showed drastic changes in the inclusions such as discoid fractures coming from strings of tiny crystals, discoid fractures from the metallic copper laths, deformed crystals with discoid fractures, disintegration on the surface of dark ovoid crystals. Copper was only detected in samples from Oregon but absent in samples from Mongolia and Mexico. One of the interesting observations was the internal diffusion of copper from copper platelets in material from Oregon after heating. Before heating, copper concentration was higher in the areas of the red schiller cloud and decreased in the areas away from the cloud (Figure 2). This changed after heating; the copper concentration is evenly distributed all over the sample meaning the copper content in the cloud area decreased and the areas away from the cloud showed an increase in copper. In addition, there was a loss in red coloration of the cloud (Figure 3). However, the average copper concentration of the samples before and after heating were similar, thus, simple heating without copper additive at 1200°C did not result in external copper diffusion. Spectroscopy was performed on the samples to compare the changes. The results showed that there was no detectable feature to distinguish the untreated from treated samples.

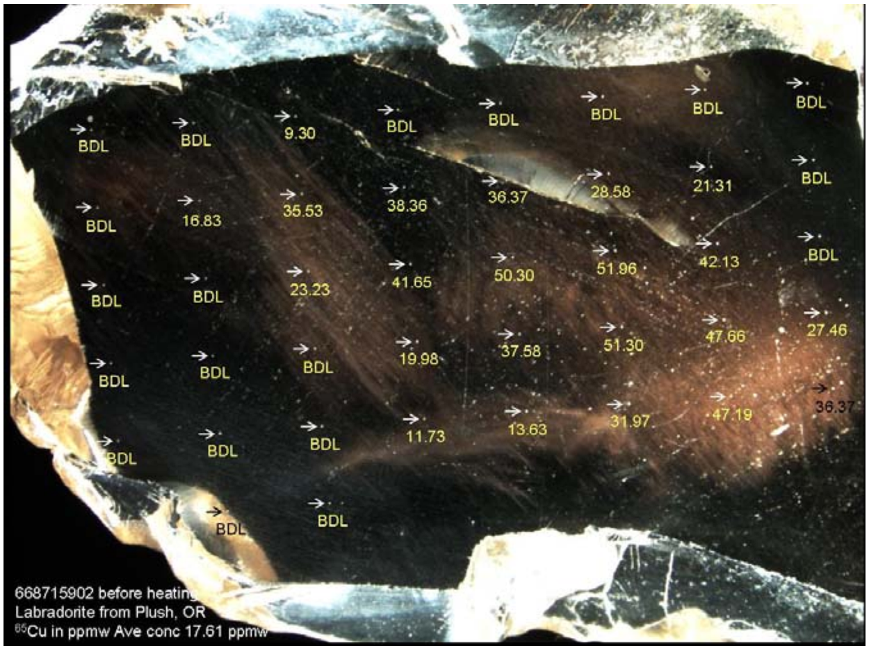

Figure 2. Sample 668715902 from Plush, Oregon, USA before heating. The sample exhibited red schiller cloud. Chemistry mapping using LA-ICP-MS revealed the presence of copper concentrated in the cloud area. Copper concentration decreased in the area away from the cloud.

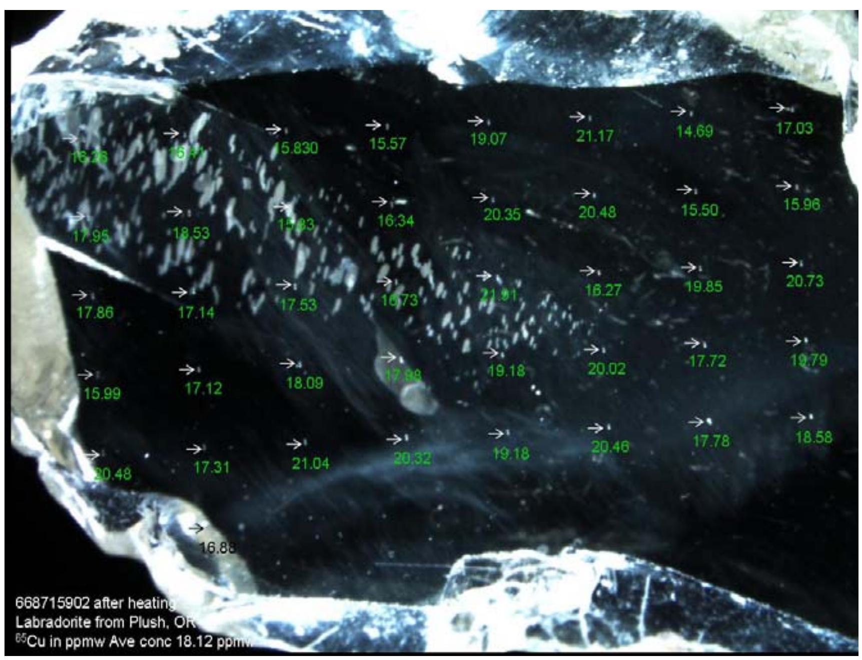

Figure 3. Sample 668715902 from Plush, Oregon, USA after heating. The sample showed discoid fractures of strings of tiny crystals, loss of red coloration of the red schiller cloud along with internal diffusion of copper from the cloud. Chemistry mapping showed copper content more evenly distributed as there was a decrease in copper concentration in the cloud area and the presence of copper in the area previously not detected.

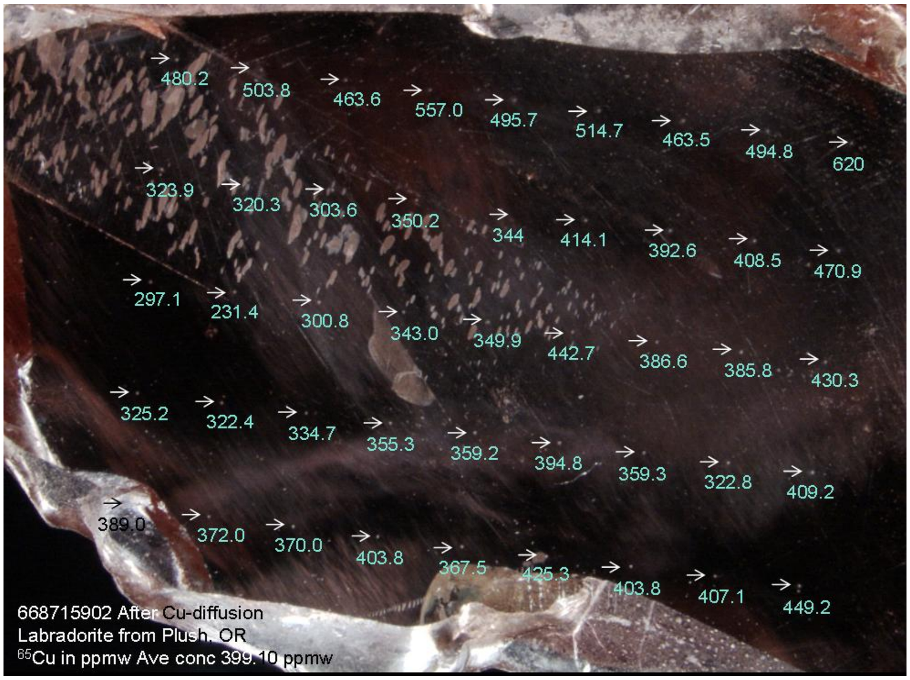

Figure 4. Sample 668715902 from Plush, Oregon, USA after copper diffusion. Sample did not exhibit much further change in its inclusions. Chemistry mapping demonstrated success copper diffusion from an external source. The sample turned into red color with much higher copper content that was evenly distributed throughout.

The heated samples were subjected to copper diffusion at 1150°C for 170 hours in air (Figure 1). This was done in a ZrO_2 powder containing 1% of -300 mesh copper powder. After the diffusion, all samples turned into red color along with an enormous increase in average Cu concentration (Figure 4). In most samples, the red coloration was caused by transparent red cloud. Color zoning is common. There are zones of intense red, light red, green to near colorless zone. The rim of the samples was usually colorless (Figure 5). Changes in inclusion suite were not much different compared to the scene before heating. Chemistry mapping showed that copper concentration is evenly distributed all over the sample even with different intensity of the red color.

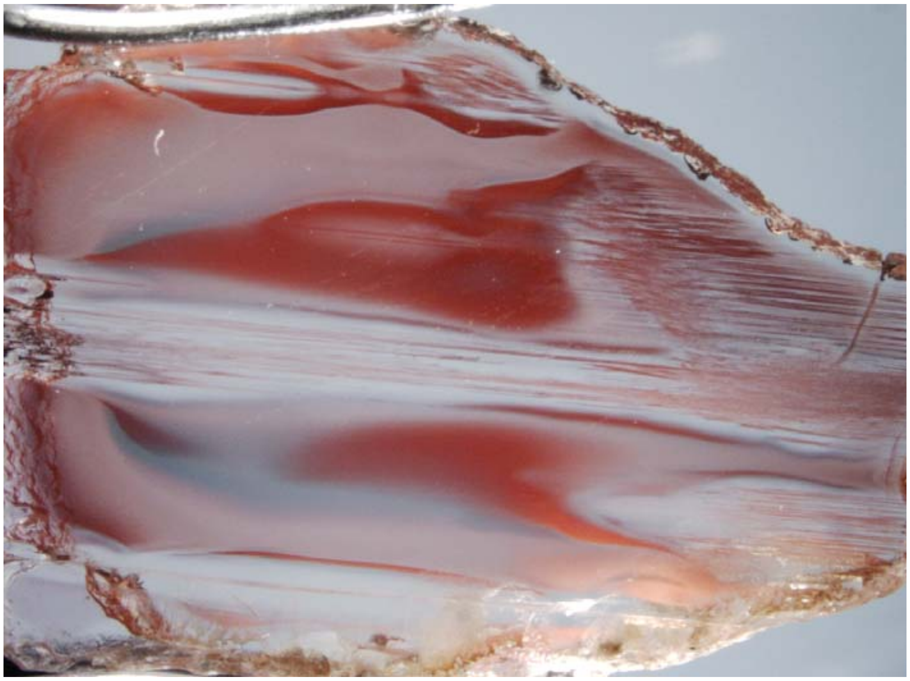

Figure 5. Sample 668715002 copper diffused feldspar from Mexico under diffused light. Note the colorless rim around the edge of the sample. There are intense red and green zones. Some of the cloud turned red after the diffusion. There are colorless areas surrounded planar cloud areas.

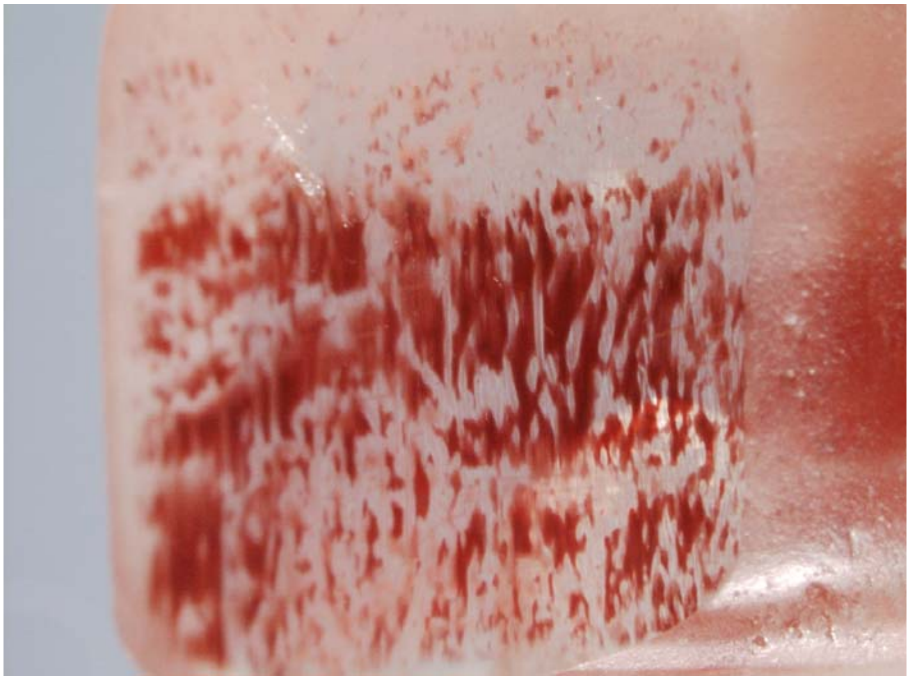

Figure 6. Sample 17402161 red feldspar from Tibet under diffused light.

Figure 7. Sample 17401911 red feldspar from Tibet under diffused light.

The copper diffused samples were compared with the red feldspar samples from Tibet that were received from Ahmadjan Abduriyim of GAAJ-ZENHOKYO Lab. From UV-visible-NIR spectroscopy, copper diffused and red feldspar from Tibet exhibit similar absorption spectra. The color zoning of the red feldspar from Tibet is peculiar and different from the diffused samples (Figure 5, 6 and 7). Trace element chemistry allowed separation of feldspar from Mexico, Plush, Oregon, Ponderosa, Oregon and China (Mongolia and Tibet together). Elements giving good separations are K, Mg, Ca and Ba. However, the method could not separate feldspar from Mongolia and Tibet implies their very similar chemistry (Figure 8). Interestingly, Copper was absent in yellowish material from Mongolia but present in the range of 390 to 450 ppmw in the yellow area of one of the sample from Tibet. Comparison of the copper concentration in diffused samples and the material from Tibet showed that the concentrations overlap. Copper diffusion introduced up to 700 ppmw of copper while the Tibet material contains 350 to 600 ppmw. Thus, copper concentration cannot be the criteria to separate naturally red and copper diffused red feldspar based on the observation so far.

Inclusion comparison between natural light yellow feldspar (received from Ahmadjan Abduriyim) and copper diffused red material (received from Wang Ming of KING STAR) from Mongolia revealed different inclusion scene as shown in Figure 9 and 10. The solid reflective laths broke up as a result of diffusion treatment.

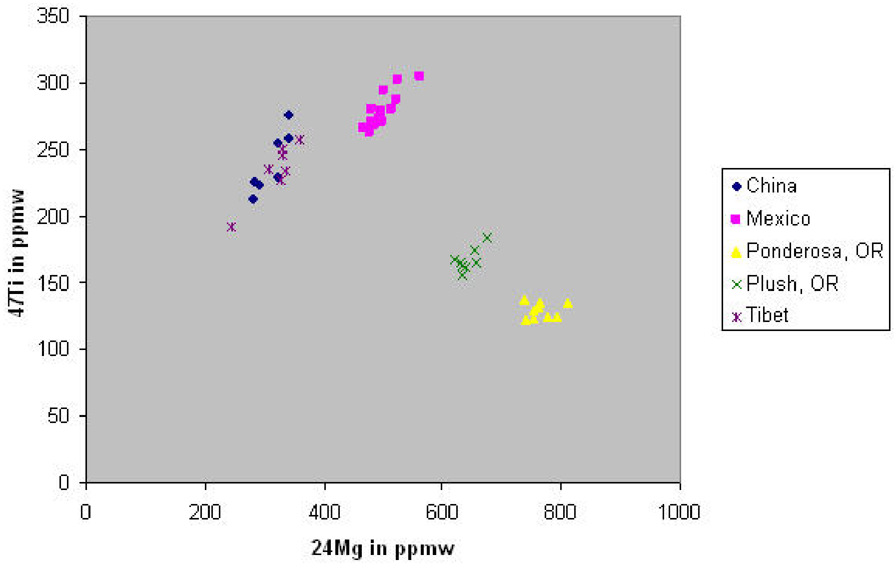

Figure 8. Population field of trace element chemistry. This is an example plot between Titanium (Ti) and Magnesum (Mg) showing separation of feldspar from Mexico, the two sources in Oregon, USA. The material from Mongolia(marked as China in the diagram) and Tibet could not be separated as their chemistry is very similar.

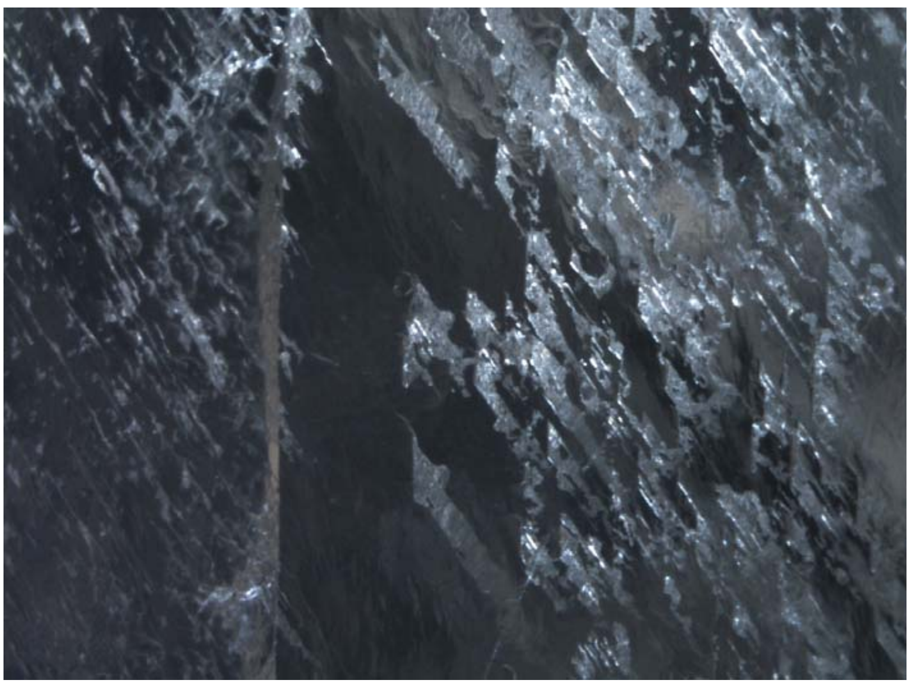

Figure 9. Solid reflective laths in sample 17402157 light yellow feldspar from Mongolia.

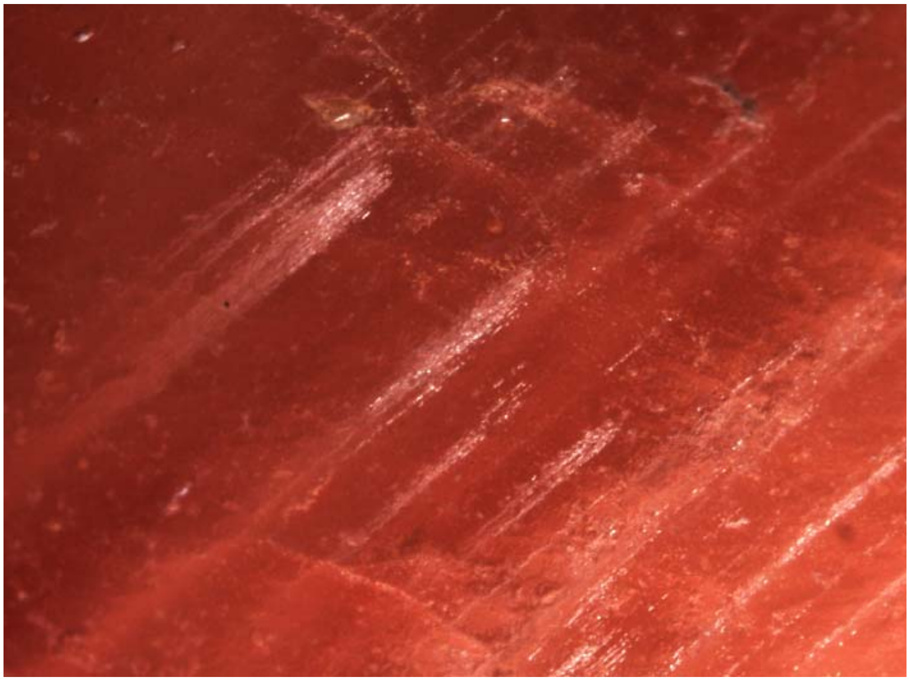

Figure 10. Broken up stripes in sample 17402187 red feldspar from Mongolia. The sample was reported to be subjected to copper diffusion treatment.

This study demonstrates that spectroscopy does not provide evidence for treatment identification and that we will have to rely on inclusion observation and chemistry information to separate treated and untreated material. This, however, is an on going study. The next step is characterization of the criteria to distinguish naturally red from copper diffused red feldspar. Also, criteria for separation of feldspar from Mongolia and Tibet must be established. The more detailed report of this study is updated on gia website, www.gia.edu and www.giathai.net.