ANDESINE & LABRADORITE

from Tibet, Inner Mongolia, Mexico & Oregon

a panel discussion

Moderator: Dana Schorr
Panelists: Richard Hughes, Ahmadjan Abduriyim, George Rossman & Adolf Peretti
with Shane McClure & John Emmett

Abstract

The mining of natural red and green andesine in Tibet and near-colorless andesine in Inner Mongolia has been a subject of controversy. Large quantities of diffusion-treated andesine from Inner Mongolia entered the world markets without proper disclosure starting about 2000; however the idea that there might also be a source of natural red andesine in Tibet has been met with extreme skepticism from some quarters. This has not only polarized the gemological community, but has also created a lack of confidence in natural Oregon sunstone.

This program will present the latest results from field visits to both Tibet and Inner Mongolia, along with advanced testing of stones from each of those deposits. Simple tests will be described to separate both Tibetan and Inner Mongolian andesines from Oregon sunstones. The purpose is to finally put to rest the controversy surrounding these stones.

Free samples will be handed out to all attendees.

Panelist Biographies

Dana Schorr (dana@schorrmarketing.com) is a Santa Barbara, CA-based gem dealer with over 32 years' experience in the gem and jewelry business. He sits on the board of Oregon's Desert Sun Mining & Gems, which operates the Ponderosa sunstone mine. Schorr has made several visits to that mine, as well as visiting Tibet's Zha Lin andesine deposit in 2011. He has also visited many other mining sites around the world.

Richard Hughes (rubydick@ruby-sapphire.com) is a gemologist with 33 years of experience in the field, much of it working with ruby and sapphire. Hughes has authored/co-authored several books and over a 100 articles on various aspects of gemology. He visited the Tibetan deposits in 2010 and 2011, as well as those of Inner Mongolia in 2011.

Dr. Ahmadjan Abduriyim (uqur@aa.cyberhome.ne.jp) received his PhD in mineralogy from Japan's Kyoto University. Dr. Abduriyim is a GIA consultant and was recently chief research scientist at the Gemmological Association of All Japan – Zenhokyo laboratory in Tokyo. He has made two field visits to the andesine deposits of both Tibet and Inner Mongolia and has done extensive laboratory research on stones from both localities.

Dr. George Rossman (grr@gps.caltech.edu) is Professor of Mineralogy at the Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, CA. He has authored or co-authored over two hundred papers on the science of gems and minerals and is considered one of the world's top authorities on the causes of color in crystals. Dr. Rossman has done extensive testing on andesines and labradorites from various world localities.

Dr. Adolf Peretti (adolf@peretti.ch) is the founder of GemResearch Swisslab. He received his PhD in petrology from the Institute of Mineralogy and Petrography at the Swiss Federal Institute of Technology (SFIT) in Zürich (Switzerland). His Contributions to Gemology is currently at Volume 10 and he has done extensive testing of feldspars from a variety of sources, including Tibet.

Shane McClure (smcclure@gia.edu) is Director of Identification Services at the GIA laboratory in Carlsbad, CA and has more than 33 years laboratory experience. He has authored or co-authored numerous papers on gemology and has done extensive testing of andesines and labradorites from all major localities, including Tibet and Inner Mongolia.

Dr. John Emmett (jlemmett@iinet.com) is one of the world's foremost authorities on the heat treatment, physics, chemistry and crystallography of corundum. He is a former associate director of Lawrence Livermore National Laboratory and a co-founder of Crystal Chemistry, which is involved with heat treatment of gemstones. Dr. Emmett has done extensive heating experiments involving diffusion of both copper and silver in feldspar.

For further information, contact:
Email: rubydick@ruby-sapphire.com | dana@shorrmarketing.com
Web: www.ruby-sapphire.com/pdf/andesine-questions.pdf

Presentation Abstracts

Latest Field Visits to Tibet and Inner Mongolia by Richard Hughes

In August 2011, Richard Hughes visited the Tibetan andesine locality at Zha Lin for the second time. This was a surprise visit, with no advance warning given to anyone involved in the Tibetan andesine controversy. Hughes was accompanied by Dana Schorr. Through their Tibetan guide, villagers were interviewed. All said that the andesine occurred naturally in the area. Specimens were purchased in the village and samples were hand-collected on site. October 2011, Hughes visited the visited the Inner Mongolian andesine locality in Guyang County with Dr. Abduriyim. Again, villagers were interviewed and specimens were both hand collected and purchased. Both of these visits and the resulting testing of the specimens has verified that there is a natural red/green andesine deposit in Tibet and a natural pale yellow andesine deposit in Inner Mongolia.

Volcanic Glass Residues on Tibetan Andesine by Dr. Ahmadjan Abduriyim

One of the lingering questions regarding Tibetan andesine is the origin of glassy residues often found on the surfaces and surface-reaching crevices of the crystals. The surface glass residue has been confirmed as a silicate melt (glass). Its diverse chemical components suggest this silicate melt is not derived from a single melt source, but the mixture of several melt sources. This is an important clue, suggesting that the glassy residues on the surfaces and in veins of the andesine were not created by any known treatment, but formed in the earth's crust. Detailed analysis reveals this kind of silicate glass may contain 2–3% water (H_2O), which we believe was generated in the crust with pressure.

Separating Oregon and Mexican Labradorite from Chinese Andesine by Dr. George Rossman

Tibetan and Inner Mongolian andesines are so similar they require destructive advanced testing to be separated. Thankfully, both Oregon and Mexican labradorite can be easily separated from the Chinese stones by refractive index and by chemical composition in labs with the appropriate facilities. Also, the abundant copper schiller has only been seen in the Oregon stones. It has been postulated that labradorite from Mexico might be diffused with sodium (Na) to change it into andesine, and that this diffused Mexican andesine is actually the source of the red/green artificially diffused stones that have hit gem markets since 2000. Experiments have shown that, in order to diffuse Na in, one has to take calcium (Ca) out. Ca diffusion is much slower than Na diffusion and, importantly, if Na goes in, silicon (Si) has to come out and be replaced by aluminum (Al) for charge balance. Al diffuses much more slowly than Ca, and Si diffuses much more slowly than Al. The time scale of such diffusion processes is geologic time and thus is not possible.

Latest Lab Findings and a Geological Model for Tibetan Andesine by Dr. Adolf Peretti

Specimens of andesine collected and purchased in Tibet, along with additional specimens acquired from a major supplier have been subjected to a battery of tests. Fluid inclusions were analyzed by micro-Raman and found to contain the a tremendously wide range of daughter minerals, along with pure CO_2 bubbles. None of the fluid inclusions showed heat damage and so are strong evidence for a natural, untreated origin.

In addition, black volcanic rock was found coating one Inner Mongolian and several Tibetan specimens and this was carefully analyzed. In the case of Tibetan samples, the rock corresponded to rhyodacite or rhyolites of vitroclastic (glassy) lava, slightly increased in alkalies, low in magnesium (Mg) and depleted in HREE (Heavy Rare Earth Elements). The rock on the Inner Mongolian sample showed important differences from that of Tibet. Since the minerals in the volcanic rock matrix would likely be damaged or altered by artificial copper diffusion treatment, it also provides strong evidence of natural, untreated origin.

Literature searches have revealed much regarding the region in Tibet where the andesine is found. Geologic reports suggest the rock types in the region are compatible not just with the formation of andesine, but also contain copper and silver. Both of these elements have been found in Tibetan andesine.

Questions & Answers on Andesine & Labradorite

Buying andesine and labradorite

Is it safe to buy and sell andesine and Sunstone?

Absolutely. Andesine and labradorite are no different than any other gemstone on the market today. Almost all gemstones are treated in some manner and/or synthetics exist that can be "salted" into parcels of natural stones. You buy and sell these gemstones regularly including ruby, sapphire, emerald and diamond – there is no need to treat andesine and Sunstone differently. The following rules will protect you in buying and selling any gemstone:

1. Know your vendor.
2. Have your vendor provide full disclosure in writing.
3. Fully disclose any known or suspected treatments to your customer in writing. It is OK to sell treated gemstones as long as you disclose.
4. If you are a regular or large-volume buyer (of any gemstone), send randomly chosen stones to a lab you respect for testing, including destructive testing if necessary. Get your supplier to agree to:
   - ❏ Pay for all costs if a gemstone he/she states is natural turns out to be treated.
   - ❏ Agree to take back and provide a full refund for any material that proves to not be as they guarantee.

Figure 1. Map of China showing the location of the andesine mines in Tibet and Inner Mongolia, along with the locations of the major treatment centers. Map: R.W. Hughes

Figure 2. Map of Tibet showing the location of the Nai Sa-Bainang/Zha Lin/Yu Lin Gu andesine mines southeast of Shigatse, along with the Gyaca locality visited by Adolf Peretti in 2009. Map: R.W. Hughes; inset map after Abduriyim et al., 2011

Tibetan andesine (Nai Sa-Bainang, Zha Lin, Yu Lin Gu)

Do you really believe Tibet produced all the andesines that flooded the market since 2000?

No and none of us has ever said that. We believe the vast majority of Chinese red and green andesines traded since 2000 have originated from an artificial copper diffusion of andesine from Inner Mongolia. The production from Tibet probably represents less than 1% of the stones traded since 2005.

If the Tibet deposit produces so little, why all the bother?

Because gemologists should make correct identifications. If the deposit is real, the Tibetan miners deserve to be able to sell their production just like miners in Oregon or anywhere else in the world. The controversy was created when some questioned the appearance of the Tibetan stone so soon after the diffused gems from Inner Mongolia hit the market. This, coupled with the difficulty of separation, created the belief that there was yet another fraud being perpetrated on consumers. Further field trips and testing have confirmed the fact that red/green andesine occurs naturally in Tibet and pale yellow andesine occurs naturally in Inner Mongolia.

Regarding colors of the Tibetan stones, where are the greens? Where are the bright reds?

The 2011 Hughes et al. article has a photo of two pieces obtained at the deposit that have green areas. The article clearly stated in one photo caption that: "Stones ranged in size from less than 0.25 cts to over 10 cts each. They also showed variation in transparency (from transparent to near opaque) and the colors ranged from pale orange to a rich, intense red. A small number of stones had green areas." Dealers who have handled the Tibetan stone estimate that less than 3% cuts to an overall green color.

Speaking of colors, how can stones naturally diffused with copper all be exactly the same color?

They're not. One photo from the 2011 Hughes et al. article shows a transparent gem-quality red stone right in the front. There are stones that are quite pale and others quite dark. When one piles up a bunch of any gem, stones tend to look similar. In the gem trade it's known as "drawing color." This is why savvy dealers spread a parcel out before passing judgment.

Is any of the Tibetan material of gem quality?

Yes, but like most gem mines, the majority of stones recovered are not facetable. From the Nai Sa-Bainang deposit in Tibet, a variety of grades occur, ranging from uncuttable, through bead, carving and cab material, to facet quality. According to sources that have handled quantities of the rough, less than 5% of the production from Nai Sa-Bainang is of facet quality. Similarly, at Oregon's Ponderosa mine, only 4% of the production finishes to clean faceted stones with a red, pink or light pink color. Clean colorless to light yellow can be up to 26% of production.

The 2011 Hughes et al. article shows a bright red gem-quality stone in one photo. It was purposely put in the front of the picture so people could see that some of the Tibetan material is of gem quality and of a red color. Adolf Peretti has now issued reports on faceted stones from the deposit and showed all the attendees of the September 2011 GILC meeting in Hong Kong the stones he had certified and explained how the separation was made. Abduriyim's reports have shown faceted and cabochon red stones.

Colored Stone magazine's Jordan Clary spent two weeks in Lhasa, Tibet looking for the Tibet andesine deposit and couldn't find a trace of it (Clary & Clary, 2008). Why not, if it really exists?

The fact that someone cannot find something does not mean it does not exist. The Chivor emerald mine was found and then "lost" for over 200 years.

Tibet is a huge, poorly developed region with low population density. This is compounded by ultra-strict security. Imagine someone who speaks only Chinese going to a craft market in Washington, DC. Through their translator (who has no knowledge of gems and minerals), they ask if anyone knows where to find fire agate. What would probably happen?

Why is there a lack of scientific evidence on the Tibetan deposits?

This is not true – there is now a significant quantity of scientific evidence. Samples have been collected on site and the most advanced testing methods (including argon dating, copper isotope and inclusion analysis) have found them to be natural. The geology of the area has been studied and a likely geological model has been created. The result of LA-ICP-MS and X-ray diffraction analysis may allow separation between natural Tibetan stones and copper diffused Inner Mongolian stones in some cases.

Why haven't qualified geologists visited the Tibetan sites?

Not true – several have. Ahmadjan Abduriyim has PhDs in earth sciences. Thanong Leelawatanasuk and Brendan Laurs have MS degrees in geology. Flavie Isatelle has an engineering degree in geology and mining exploitation. Those involved with the lab testing included several PhD's and gemologists with decades of experience.

Could someone have planted stones beneath the bushes excavated at Zha Lin[1] in 2010 in Tibet?

Everything and anything is possible, but one must consider probabilities. We did our best under the circumstances to rule out the possibility of the mine being salted. Thus we did not simply dig holes where locals told us to dig, but deliberately chose undisturbed locations at random, away from places we were directed to by Li Tong[2] and the people around him. No one knew in advance that we would attempt to dig beneath bushes. To salt this deposit, one would have had to literally plant stones under a thousand or more bushes at a time when they had no idea we would even be digging under bushes. The probability of this is slim.

Does the existence of quantities of a gemstone on the surface indicate that a deposit has been salted?

Not at all. Gems are often found on the surface in alluvial deposits. Indeed, these are found so often the term "floaters" was coined to describe them.

If the stones found beneath the bushes in 2010 proved the validity of the deposit, why did you return again in 2011?

In order to properly characterize a deposit, multiple visits are often needed. This certainly proved true with this deposit, as one of the andesines obtained on the 2011 trip turned out to have large areas of volcanic rock matrix on its surface, proving its natural origin.

Why is the discovery of volcanic rock matrix on specimens from Tibet so important?

It helps prove natural origin because minerals in the matrix would likely be significantly altered by artificial diffusion treatment. The intact fluid inclusions found in other specimens would also not have survived such a treatment. Taken together with the argon release and copper isotopes data, this makes the evidence for a natural red and green andesine deposit in Tibet extremely strong.

What about the glassy residues found on the surfaces of many specimens. How can these be natural?

Natural glass is common in nature. Peeling back the volcanic rock matrix on specimens has revealed the same glassy residues beneath that matrix. These are very likely a reaction of andesine with the host rock.

Did monks really prevent gemologists from visiting the Nai Sa-Bainang locality in 2010?

Yes. They also prevented a group of Chinese researchers from China's NGTC from visiting the site (Wang et al., 2010). There is a common belief by Tibetans that digging in the ground causes bad weather and earthquakes. This is clearly documented in Hughes et al. (2011).

Why didn't Li Tong go with Hughes & Schorr in 2011?

Our visit would not have been unannounced if he were invited or even told. The 2011 visit was conducted with no advance warning whatsoever to anyone. Even the guide and driver did not know of the stop at the andesine village until just minutes before they arrived.

1 A.K.A. Dhongtso 5

2 The Chinese miner who had been working the Nai Sa-Bainang deposit and who organized the various trips to the Tibetan localities

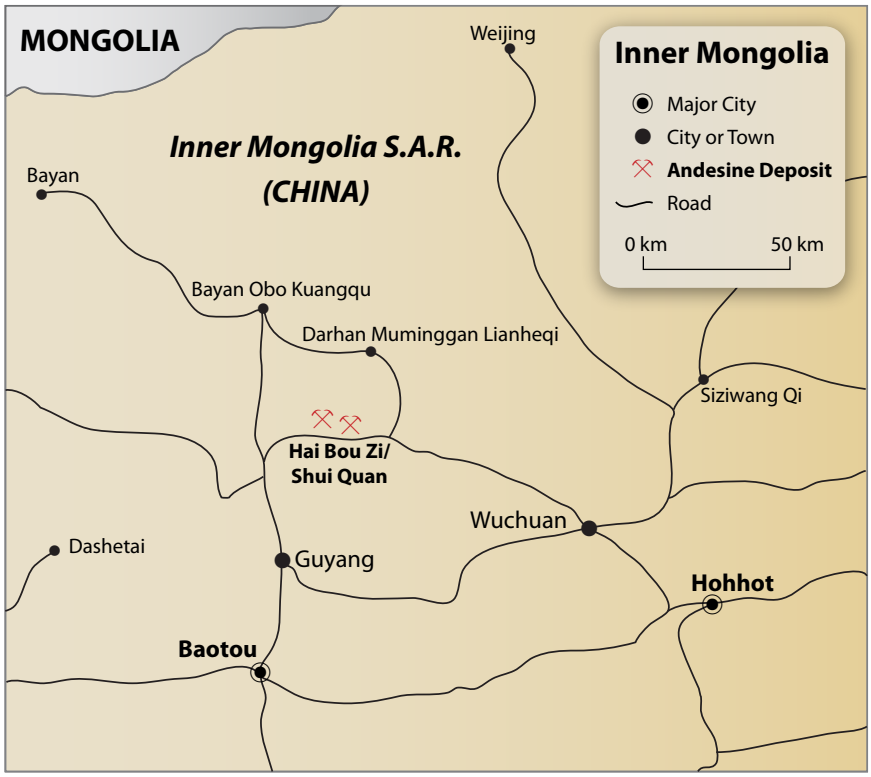

Figure 3. Map of Inner Mongolia showing the location of the Hai Bou Zi/Shui Quan andesine mines. Map: R.W. Hughes, after Abduriyim, 2009b)

In 2009, Dr. Adolf Peretti was taken by Li Tong to Gyaca, an alleged andesine locality some 400 km from Nai Sa-Bainang/Zha Lin/Yu Lin Gu. Peretti found the locality to be salted. If the Nai Sa-Bainang locality was real, why didn't Li Tong simply take him to Nai Sa-Bainang?

Peretti was told by Li Tong that there were other localities in Tibet (other than Nai Sa-Bainang) with andesine. He thus requested to go to a locality that had not yet been visited by outside gemologists. By 2009, the lamas at the Nai Sa-Bainang locality were unhappy with the mining; they claimed it had disturbed the spirits, causing bad weather, and thus stopped it. We don't know what went on in the mind of Li Tong, but there are many reasons dealers may misrepresent a site. However, just because one site is salted does not mean that all sites are salted.

What about the large "white matrix" specimens from Tibet that were tested? Are these natural or fake?

We believe they are fake (McClure et al., 2011); they were probably assembled after gemologists started demanding matrix specimens (in order to confirm the validity of the deposit).

Drs. George Rossman (2009) and Adolf Peretti (Fontaine et al., 2010) were previously on record as believing the Tibetan deposit was salted. Now they have changed their opinions. Who got to them?

The evidence got to them (Abduriyim et al. 2011; Peretti & Bieri et al., 2011; Peretti & Villa et al., 2011). Further testing of specimens has shown that they are both genuine and provably different from the labradorites from both Oregon and Mexico.

Could traders take natural stones from Tibet and treat them and mix them into parcels of untreated Tibetan andesines?

Of course. This is not only possible with Tibetan andesine, but with Oregon sunstone and every other gem on the planet. Has this been done? It's hard to say, as the separation between the natural Tibetan and the diffusion-treated stones is so difficult.

What about the team of gemologists from the National Gemstone Testing Center in China who visited the Zha Lin deposit in 2010? They suggested that it was likely salted (Wang et al., 2010).

That summary was based on circumstantial evidence, rather than hard testing data. Even their conclusion held out the possibility of a natural origin: "…limited access to the investigated area means that the field investigation performed by our whole team lasted only one day. The second opportunity for fieldwork by just part of the team lasted two days. Since the local geology could in theory allow for the presence of feldspar, we suggest that the relevant Government Department undertakes a more detailed investigation as soon as possible."

Inner Mongolian andesine (Guyang County)

Beyond the reports from Abduriyim (2009a–b) based on his 2008 visit, what evidence is there for the existence of a gem-quality feldspar mine in Inner Mongolia?

A lot. JTV's "Jewel Hunter Jack" visited the deposit and video clips of that visit can be found on the Internet. Ahmadjan Abduriyim and Wong Ming (a Hong Kong-based dealer) visited the Inner Mongolian deposit in 2008. Wong Ming had been there several

times before. In October of 2011, Abduriyim again visited the deposit, this time accompanied by Richard Hughes and his daughter, Billie. One of the specimens purchased during this visit had attached volcanic rock.

Then there are the papers published in the Chinese scientific literature on the deposit since 1991 (Li, 1991, 1992; Cao, 2006). The date of publication of many of these papers was long before there was any mention of treated andesine. Indeed it was a full decade before the first "Congo" andesines appeared in the market. But most importantly, the stones speak for themselves. They are provably different from feldspars from Mexico. Those who argue against the reality of this deposit must explain away a huge body of evidence to the contrary.

Why do the Inner Mongolian mine photographs from 2008 and 2011 contradict one another?

They do not. In the Hughes et al. 2011 article, Billie Hughes is pictured at an abandoned jig near Hai Bou Zi village. There is another larger mine at Shui Quan village. Photos from Abduriyim's 2008 visit showed jigs from both mines. Obviously, a single mine often has more than one jig.

Could the starting material for the diffused andesines in the market have come from Mexico?

The andesines of Inner Mongolia show significant chemical differences compared with the labradorite feldspars from Casas Grandes (Mexico) and Oregon. If someone wants to copper-diffuse feldspar, they need a natural starting material of low cost. The available evidence from a number of different sources shows that the starting material for copper-diffused andesines is material from Guyang, Inner Mongolia (China). Guyang material is easily and quickly separated by refractive index. The material from Guyang is andesine (more Na) and the material from Mexico is labradorite (more Ca), with a significant degree of separation between the two.

Can Mexican labradorite be treated to change it into andesine, as suggested by Arem (2011)?

No. Sodium (Na) would have to be diffused into the labradorite. If one puts Na in, one has to take calcium (Ca) out. Ca diffuses much slower than Na and, importantly, if Na goes in, silicon (Si) has to come out and be replaced by aluminum (Al) for charge balance. Al diffuses much more slowly than Ca, and Si diffuses much more slowly than Al – therefore it is not possible (Grove et al., 1984).

Even if this were possible, why would a dealer take the risk of loss/damage (as well as the added expense) to change labradorite to andesine, when there is little or no price difference between the two?

What about India? Could the starting material have come from India?

No. Indian sunstone falls into the oligoclase range of the plagioclase series. None of the treated andesines in the market have tested out as oligoclase. Furthermore, the Indian sunstones contain hematite plates, rather than copper.

Laboratory & identification issues

Who was the first to publicly unmask the treatment of andesine?

From what we've been able to determine, it was Jewelry Television (JTV) in late 2007/early 2008. Simultaneously, the Japan German Gemmological Laboratory (JGGL) was developing evidence of diffusion treatment, something they had been working on with the Gemmological Association of All Japan (GAAJ)'s Ahmadjan Abduriyim since 2006.

Why didn't labs such as the AGTA GTC and the GIA catch this treatment earlier?

For a variety of reasons. First, even today no gemologist in the world could catch this treatment, using standard gemological testing methods because, after cutting, diffusion-treated andesines show no features that allow separation from the natural Tibetan stone. The only current separations we have involve expensive and destructive tests.

Labs cannot afford to use extraordinary and expensive testing methods on every gemstone submitted unless there is reason to suspect that it is necessary. It was not until 2008, after JTV announced the stone was treated and the JGGL evidence was released, that gemologists began serious work on making a separation. This is not unlike the appearance of AIDS. For many years the disease went undetected; still more time passed before the first tests were developed to detect HIV, and many more years passed until useful therapies were developed.

At major gem labs, the majority of stones submitted are diamond, ruby, sapphire and emerald. Only a small number of andesines were ever submitted to labs for testing. Subsequent testing has shown that, if the submitted stones originated from Tibet, they would probably have been natural and untreated.

Why weren't gemologists more suspicious when cut stones of this new gem appeared, but there was no rough?

The first suspicions were raised about this material in early 2005 after large amounts of clean red andesine appeared on the market, with no known source to support this availability. Later that year, Jackie Li appeared with a quantity of rough from Tibet. Thus the suggestion that "there was no rough" is simply untrue. It is also not unusual for gem dealers who have discovered a new deposit to keep the find secret. This allows them to maintain profitable exclusivity, and avoids government interference and conflicts with claim jumpers.

Is it possible to separate natural Tibetan andesine from diffusion-treated stones from Inner Mongolia based on simple gemological tests such as refractive index, pleochroism or color zoning?

No. Separation of treated from natural is possible but the testing is expensive and destructive. This is viable only for sampling batches to verify parcels.

Can immersion-based microscopy separate the natural Oregon stones from those that have been artificially copper diffused?

No. While the Chinese andesines (both treated and natural from Tibet) sometimes have green cores and Oregon stones have red

cores, exceptions do exist. The various zoning patterns found in verified natural plagioclase sunstones from Oregon are replicated by both the treated stones (Rossman, 2009; McClure, 2009) and natural Tibetan stones. This is thought to be because the natural stone also had copper introduced into it by natural diffusion processes in the ground.

Other questions

Is Dana Schorr really on the Board of Desert Sun Mining & Gems?

Yes, he has been a board member since 2008. A simple phone call to the company can verify this.

Don't those who have suggested that the Tibetan and Inner Mongolian deposits are genuine have a vested interest in that outcome?

No. None of the scientists and gemologists who have contributed to this panel and paper has a financial interest in either andesine or labradorite. They are among the most respected of all the gemologists in the field and their professional records and accomplishments speak for themselves. More than a thousand work hours and over $100,000 dollars has been spent both by them personally and by the organizations they work for just to get to the bottom of this.

Who was responsible for the massive fraud surrounding the artificial diffusion treatment of andesine?

The treaters and dealers who had knowledge of the treatment and knowingly sold the stones without informing their customers of that treatment.

References

- Abduriyim, A. (2009a) A Mine Trip to Tibet and Inner Mongolia: Gemological Study of Andesine Feldspar. *GIA, News from Research*. Sept. 10, 27 pp.
- Abduriyim, A. (2009b) The characteristics of red andesine from the Himalaya Highland, Tibet. *Journal of Gemmology*, Vol. 31, No. 5–8, pp. 283–298.
- Abduriyim, A., McClure, S.F., Rossman, G.R., Leelawatanasuk, T., Hughes, R.W., Laurs, B.M., Lu, R., Isatelle, F., Scarratt, K., Dubinsky, E.V., Douthit, T.R. and Emmett, J.L. (2011) Research on gem feldspar from the Shigatse region of Tibet. *Gems & Gemology,* Vol. 47, No. 2, pp. 167–180.
- Arem, J.E. (2011) Observations on the occurrence of plagioclase feldspars. *InColor*, No. 18, Winter, pp. 46–53.
- Cao, Yue (2006) *Study on the feldspar from Guyang County, Inner Mongolia and their color enhancement.* Master's thesis, Geological University of China, Beijing, 66 pp. [in Chinese with English abstract].
- Dong, X.Z., Qi, L.J. & Zhong, Z.Q. (2009) Preliminary study on gemological characteristics and genesis of andesine from Guyang, Inner Mongolia. *Journal of Gems and Gemmology*, Vol. 11, No 1, pp. 20–24 [in Chinese with English abstract].
- Fontaine, G.H., Hametner, K. & Peretti, A. (2010) Authenticity and provenance studies of copper-bearing andesines using Cu isotope ratios and element analysis by fs-LA-MC-ICPMS and ns-LA-ICPMS. *Analytical and Bioanalytical Chemistry*, Vol. 398, No. 7–8, December, pp. 2915–2928.
- Grove, T.L., Baker, M.B. et al. (1984) Coupled CaAl-NaSi diffusion in plagioclase feldspar: Experiments and applications to cooling rate speedometry. *Geochimica et Cosmochimica Acta*, Vol. 48, No. 10, pp. 2113–2121.
- Hughes, R.W. (2010) Hunting Barack Osama in Tibet: In search of the lost andesine mines. Ruby-Sapphire.com.
- Hughes, R.W. (2011) Andesine: Timeline of a controversy. *Ruby-Sapphire.com*, 9 pp.
- Hughes, R.W., Hughes, B., Manorotkul, W. & Schorr, D. (2011) Faith: In search of the lost andesine mines, Part Two. *Ruby-sapphire.com*.
- Li, Haifu (1991) Discovery of feldspar type moonstone gem in Inner Mongolia. *Bulletin of Geological Science and Technology*, Vol. 11, pp. 136–137 [in Chinese].
- Li, Haifu (1992) First study of gem-quality Inner Mongolian labradorite moonstone. *Jewellery*, Vol. 1, No. 6, pp. 45–47 [in Chinese].
- McClure, S.F. (2009) Observations on Identification of Treated Feldspar. *GIA, News from Research,* Sept. 10.
- McClure, S.F., Rossman, G.R. and Scarratt, K. (2011) A study of andesine matrix specimens purported to be from Tibet. *GIA: News from Research*, 6 pp.
- Peretti, A., Bieri, W., Hametner, K., Günther, D., Hughes, R.W. and Abduriyim, A. (2011) Fluid inclusions confirm authenticity of Tibetan andesine. *InColor*, No. 17, Summer, pp. 50–55.
- Peretti A., Villa I., Bieri W., Hametner K., Dorta L., Fontaine G.H., Meier M. and Günther D. (2011) Distinguishing natural Tibetan copper-bearing andesine from its diffusion-treated counterparts using advanced analytical methods. *Contributions to Gemology*, No. 10, 105 pp.
- Rossman, G. (2009) The Red Feldspar Project. California Institute of Technology, 8 pp.
- Rossman, G.R. (2011) The Chinese red feldspar controversy: Chronology of research through July 2009. *Gems & Gemology*, Vol. 47, No. 1, Spring, pp. 16–30.
- Wang, W., Lan, Y., et al. (2010) Geological field investigation on the reported occurrence of 'red feldspar' in Tibet. *Gems & Jewellery*, Vol. 19, No. 4, Winter, pp. 44–45.