THE MYTH OF BONE : SPECTRAL SOUND ANALYSIS REVEALS TRUE TONAL PROPERTIES

What are the magical properties that make a quality acoustic guitar sound so spine-tinglingly good? When you strip away the tradition, romance and folklore, the answer is firmly grounded in science.

Acoustic guitars are fundamentally designed to convert the mechanical energy of string vibration into pressure waves that are transmitted to the ear through the air.

Very little of the sound heard from a guitar comes directly from the vibrating strings. Rather, the strings transmit the energy to the guitar top via the saddle. The saddle acts as a selective filter, allowing some frequencies of the vibrating string to transfer to the soundboard while others remain in the string.

The guitar string actually vibrates in a complex manner. For example, while oscillating at 440 hertz, the string is also vibrating in halves, near 880 hertz. Simultaneously, the string vibrates in thirds, near 1320 hertz; in fourths, near 1760 hertz; and so on. These various modes of vibrations are known as partials, overtones or harmonics.

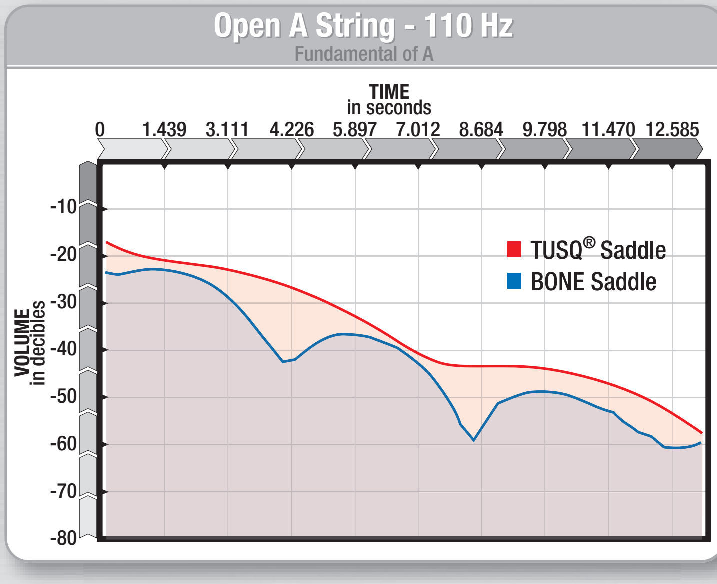
Here's where the saddle enters the picture: The saddle tends to be discriminating. It governs the strength of the excitations produced by some harmonics and may deny others any access to the guitar top. It also meters the rate at which energy is transferred from the string to the guitar top.

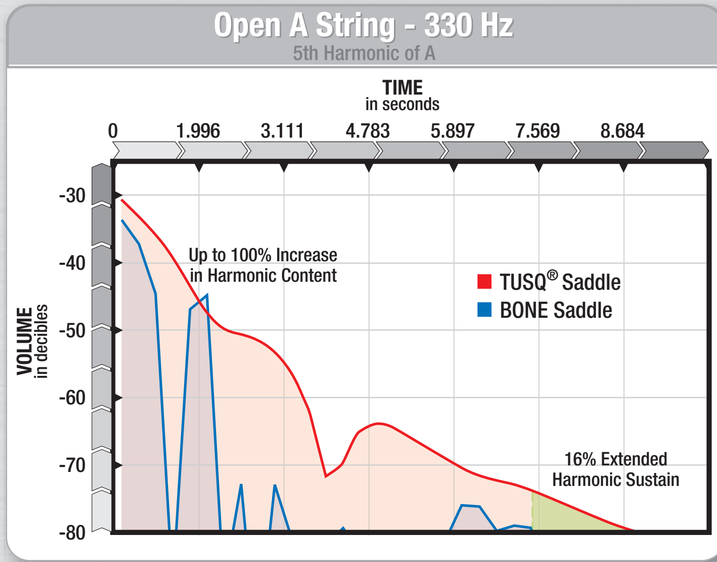
The efficiency with which the saddle performs these chores depends on what is called the "impedance match" between the string and the guitar top. A perfect impedance match, with no obstruction from the saddle, would allow all the energy of the vibrating string to be transferred to the guitar top at once. The result would be a loud and not too musical "bang", with no sustain. A poor impedance match would have just the opposite effect. It would take a long time for the energy or the vibration string to dissipate (sustain), but little sound would be heard.

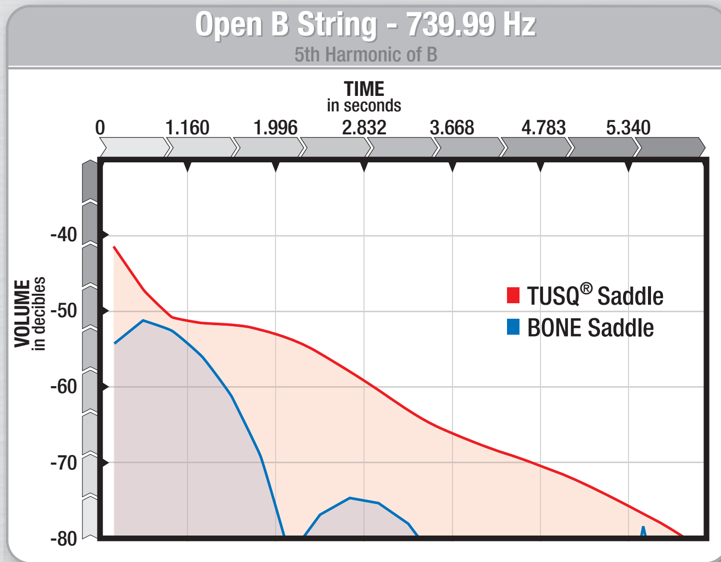
The challenge is to balance the impedance of the strings with the guitar top, combined with the right frequency filtering, provided by the saddle, to allow the appropriate frequencies to excite the guitar top (tone) while denying access to other frequencies and keeping them in the string (sustain). This is essentially a trade off: an increase in sustain must, according to the laws of physics, come at the expense of volume, and vice versa. Treat any claims of "increased volume and sustain" with healthy skepticism!

This where the nature of the saddle material comes in to play. For acoustic guitars, the saddle is an integral part of the tone of the guitar, as it determines what frequencies and harmonics transfer into the guitar top, what frequencies and harmonics remain in the strings, how loud the note is and how long it lasts. Because Graph Tech can measure different materials and formulations, we can design performance characteristics into TUSQ that was not achievable to the guitar industry before. With computer analysis, deficiencies of natural materials like bone becomes apparent. Due to the inherent "grain" in bone, (hard spots and soft spots), balancing energy transfer, impedance matching, and harmonic content is hit or miss at best, and definitely not "tweakable" in material design. Again, because of the grain, each string may vary in harmonic content and sustain, which becomes even more evident with an under the saddle pickup.

The results, apparent in the sound charts at right, demonstrate the tonal advantage of TUSQ over bone, and challenge cherished beliefs regarding the superiority of bone as a saddle material.







All tests performed using a Larrivee acoustic guitar equipped with GHS Acoustic Phosphor Bronze strings.
Sampling Rate: 44,100 Hz. • Decimation Ratio: 1 • F.F.T. Size: 4096 pts. • Smoothing Window Hanning. • 16-bit Sampling Format.