Revisiting Low Band Propagation During a Full Moon
Carl Luetzelschwab K9LA   April 2019
This is an update to my column that appeared in the September 2012 issue of WorldRadio On-Line

The November 2001 issue of **CQ** included an interesting article titled "80 Meter DX – The Moon Effect". The opening paragraph stated that:

Many years ago I noticed a phenomenon on the 80 meter band when working DX. It seemed that one night each month the band would be incredibly good. From Arizona I would work 30 to 50 Europeans in one evening. A few days before and after that day would also be above average. As this time period passed, the following weeks would be back to the normal poor band conditions I had learned to expect.

Figures 1 and 2 in the article certainly suggested a correlation between a Full Moon and DX QSOs to Europe. I should mention that this is not the first observation of a possible correlation between the Moon and propagation. For example, the earliest observation I'm aware of was in the 1930s by Harlan Stetson (American astronomer and physicist). And more relevant to our Amateur Radio operations, Stew Perry W1BB, a 160-Meter pioneer, felt that 160-Meter propagation was influenced by the phase of the Moon.

So let's review several explanations for enhanced low band propagation during a Full Moon. Be advised that no definite conclusion will be forthcoming. In other words, we still don't know why the Moon (specifically, the Full Moon) would cause enhanced low band propagation – if it does at all.

Hypothesis 1 – Sunlight reflects off the Moon and causes more ionization

This is the hypothesis offered in the **CQ** article. We have to be very careful when we say 'sunlight'. Visible light has nothing to do with ionization [note 1], so all that Moonlight is irrelevant to our radio endeavors. What we really need to look at is how much radiation at ionizing wavelengths is reflected off the Moon.

Figure 1 is a plot of the Moon's albedo (reflectivity) at various wavelengths (from G. R. Gladstone, et al, *EUVE Photometric Observations of the Moon*, **Geophysical Research Letters**, Vol 21, No 6, pages 461-464, March 15, 1994). Also indicated on the plot are the wavelengths that ionize the F2 region, the E region and the D region, and the wavelengths of visible light [note 2].

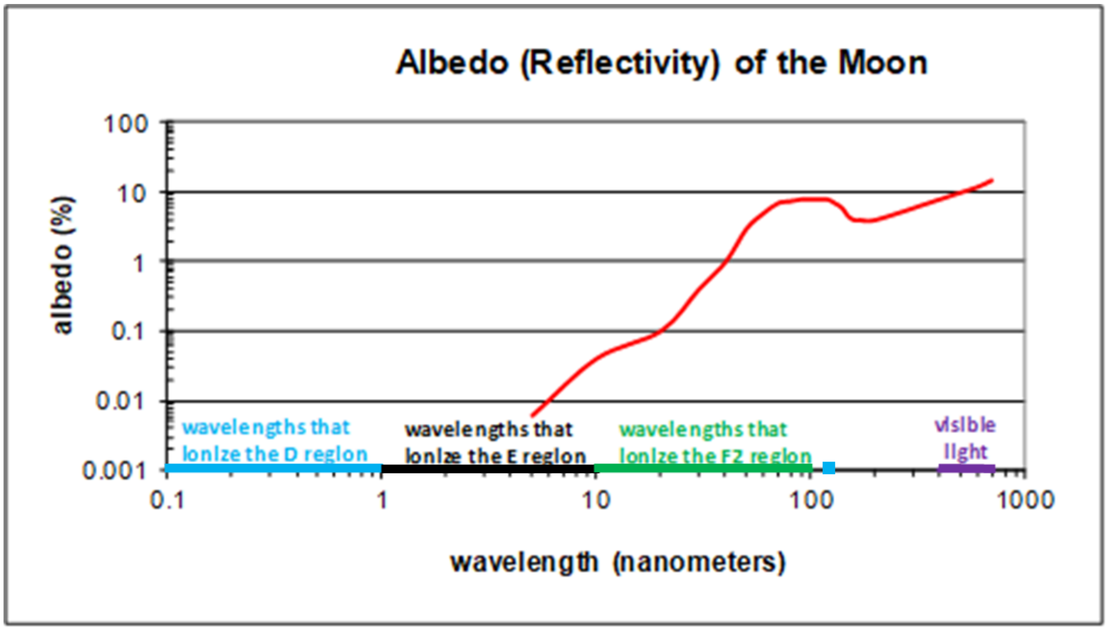

Figure 1 – The Moon's Albedo

The data says that reflected radiation at wavelengths that ionize the F2 region is but 0.06% to 8% of the incident radiation. We also know that approximately 60% of the F2 region is ionized by radiation from 26-34 nm – these wavelengths give an albedo of around 0.1%. This amount of reflected radiation is not enough to affect the nighttime F2 region ionization. We can confirm this by looking at nighttime ionosonde data. Figure 2 plots a month's worth of foF2 data (the ordinary wave F2 region critical frequency) from the Narrssassuaq (Greenland) ionosonde centered on the January 21, 2000 Full Moon date. The year 2000 is the year for which the **CQ** article presented data.

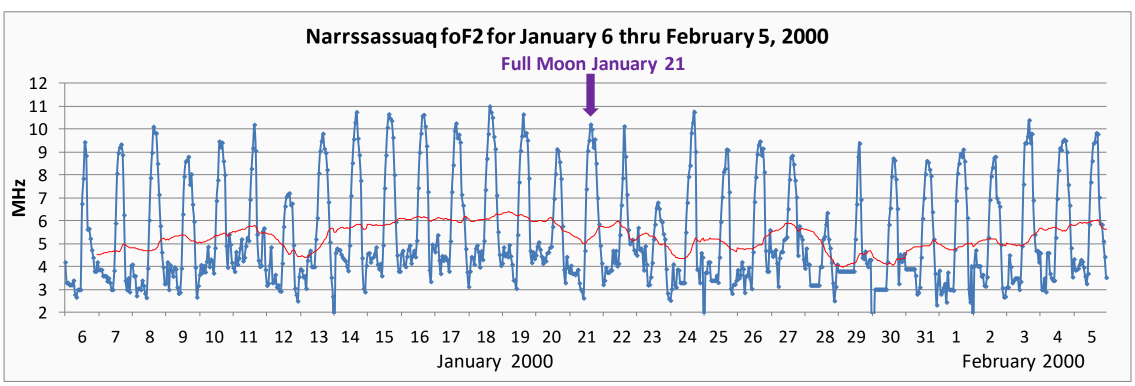

Figure 2 – Narrssassuaq Ionosonde Data for January 2000

This ionosonde is on the Arizona-to-Europe path. The red line is the 24-hour moving average. Although foF2 appears to be a bit higher for several days prior to the Full Moon, it's down a bit on the day of the Full Moon and on the day before and after. I think we are just seeing the day-to-day variation of the ionosphere. Additionally, I don't believe more ionization is what is needed for enhanced low band propagation [note 3].

Hypothesis 2 – Lunar tides

There indeed are lunar tides of gravitational origin (as there are solar tides of thermal origin). But the consensus of physicists is that the effect on the E region is extremely small – on the order of a couple kilometers variation in the height of the maximum E region electron density. And any 'major' change in the F2 region due to lunar tides would be expected to show up in ionosonde data – which it doesn't.

Hypothesis 3 – Geomagnetic field activity

With the solar rotation period being so close to the lunar orbital period, one has to wonder if the enhanced low band propagation is simply due to recurrent quiet geomagnetic field conditions. One way to assess this is to look at the planetary A index (Ap) for one year to see if quiet conditions fall around Full Moon dates. This data is presented in Figure 3 for the year 2000.

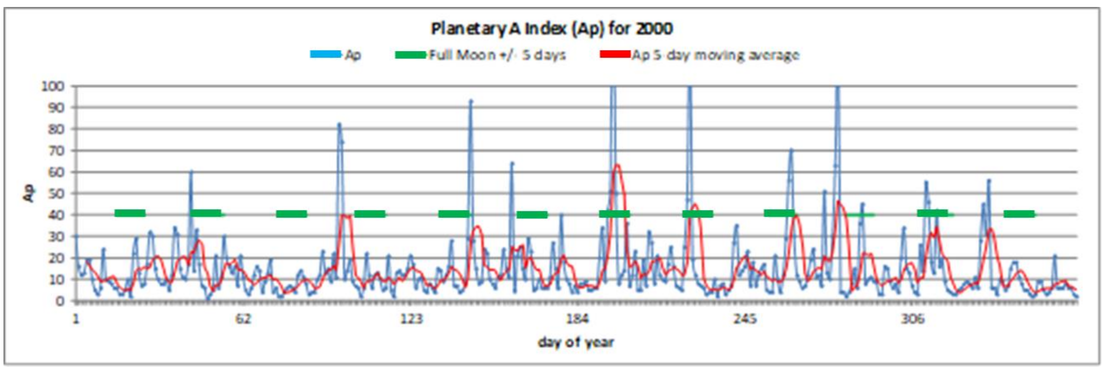

Figure 3 – Ap Index for January 2000

The first half of the year suggests that Full Moon periods were quiet in terms of geomagnetic field activity. But the last half of the year suggests the opposite – a couple Full Moon periods had relatively high geomagnetic field activity. For what it's worth, there is an interesting (but quite old) technical paper (H. L. Stolov, et al, *Variations of Geomagnetic Activity With Lunar Phase*, Goddard Institute for Space Studies, 1964) that concluded that there's a broad decrease (about 4%) in geomagnetic activity for seven days preceding a Full Moon.

This does bring up an interesting question – do <u>all</u> Full Moon periods result in enhanced low band propagation? I'll add a comment on this in the Summary section.

Hypothesis 4 – Signal Reflection off the Moon

Could the enhanced low band propagation not be of ionospheric origin? In other words, could the Full Moon be in the correct position for signals to reflect off the Moon? There would have to be a 'hole' in the ionosphere on each end – i.e., foF2 values less than about 3 MHz for 80m operation (to allow higher-angle electromagnetic radiation through). This is possible after perusing maps of foF2 along the Arizona-to-Europe path during the night.

A quick way to further assess this is to calculate the free space path loss for a path from the Earth to the Moon and back, assuming an electromagnetic wave at 3.8 MHz would be 100% reflected (which could be extremely optimistic). This works out to a -113 dBm signal at the receive end with one kilowatt at the transmit end and quarter-wave verticals over average ground (less than -6 dBi gain at elevation angles higher than 60 degrees), which would put it around S1 at best on an S-meter. This doesn't sound like 'enhanced propagation', so this cursory analysis says this is not a likely explanation.

Hypothesis 5 – The Full Moon is in the Earth's magnetosphere

An interesting (but perhaps not well known) fact is that the Moon during a Full Moon period is in the Earth's magnetosphere. This is the result of the Sun's solar wind on the Earth's magnetic field. Figure 4 (not to scale) shows the orientation of the Sun, the Earth, and the Moon (the big red dot) during a Full Moon period.

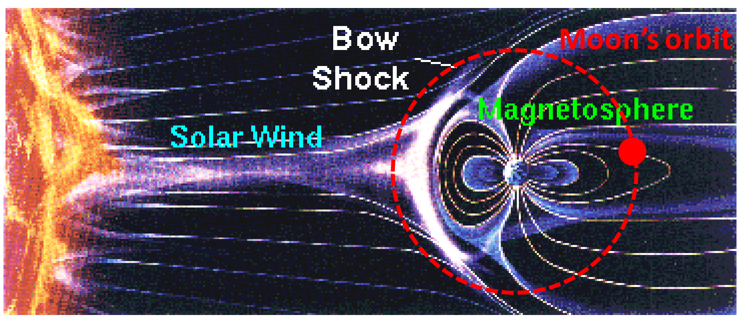

Figure 4 – The Moon, Sun, and Earth at Full Moon

Note that the Moon intercepts the Earth's magnetic field during the Full Moon period. The thought here is that the Moon may block those electrons that are bouncing between the Earth's hemispheres, which would be electrons on field lines arriving at the high latitudes. The resulting reduction in electrons would be beneficial to low band propagation due to less absorption.

This is a pretty radical hypothesis, and as expected there's not a lot on this topic in the technical literature. The only paper I found that was even remotely related to this scenario is one that discusses the impact on the nighttime ionosphere of electrons arriving from the sunlit ionosphere in the other hemisphere (A. F. Nagy, et al, *The effect of conjugate photoelectron impact ionization on the pre-dawn ionosphere*, **Journal of Atmospheric and Terrestrial Physics**, 1973, Vol 35, pages 2289-2291). This hypothesis requires more investigation – especially in the "is this even feasible?" category.

Hypothesis 6 – Mid latitude trough

The mid latitude trough is a depletion in F2 region ionization on the equator-ward edge of the nighttime auroral oval. Typically this trough is a detriment to low band propagation because of low maximum useable frequencies in the trough and skewing (off-great circle paths) from the walls of the trough. Could the Full Moon somehow negate the adverse effect of the trough? That's an interesting question that needs further investigation.

Hypothesis 7 – Planetary waves/gravity waves

These events in the lower atmosphere are capable of coupling up to the ionosphere. There is much research going on in this area. Could the Full Moon somehow result in a planetary or gravity wave that affects the ionosphere in a good way for 80m DXing?

Summary

In summary, three of the hypotheses (sunlight reflects off the Moon, lunar tides and signal reflection off the Moon) are not considered to be viable for reasons tied to ionospheric physics issues. The other four (geomagnetic field activity, the Full moon is in the Earth's magnetosphere, the mid latitude trough and planetary waves/gravity waves) need further investigation. And perhaps there are other ideas out there of which I am not aware. Regardless of the hypothesis, it should have a basis in ionospheric physics and it will likely be tied to an advantageous change in electron density.

Finally, in the discussion of hypothesis 3, I wondered if enhanced low band propagation occurred only during Full Moon periods. If it doesn't, then the Full Moon may have nothing to do with it. Or there may be more than one mechanism that provides enhanced low band propagation. And we have to watch out for the Full Moon becoming a self-fulfilling prophecy – if we only get on the low bands during a Full Moon expecting enhanced propagation, then we'd buy into the concept but we'd miss other possible nights with enhanced propagation. It seems to me the best way to sort this out would be to continuously monitor (and record) a low band beacon twenty four hours a day, seven days a week for a full year.

Notes:

1. Sunlight <u>may</u> have something to do with <u>detaching</u> electrons from negative ions right before sunrise since the electron affinity is low enough for visible light to do this. Once an electron is detached from a heavy neutral constituent, it can now contribute to the absorption process. But this is believed to be the opposite effect that would enhance low band propagation during a Full moon.

2. In addition to solar radiation at 0.1-1 nm ionizing the D region, Lyman-α radiation at 121.5 nm ionizes the D region. This long of a wavelength can ionize the D region (specifically NO – nitric oxide) as there is a window in the absorption cross-section of atmospheric O_2 (molecular oxygen) at 121.5 nm.

3. Usually the MUF (maximum useable frequency) is high enough on 160m and 80m to refract low elevation angle signals back to Earth. Thus <u>more</u> ionization is not needed.