LUNAR CYCLES -- 1999

John E. Sanders
Professor Emeritus of Geology
Barnard College
Columbia University
New York, NY 10027

Office address:
c/o Silverman, Harnes, Harnes, Prussin & Keller
International Plaza
750 Lexington Avenue, 14th Floor, New York, NY 10022

S7632077@aol.com; ofc: ginabyte@aol.com

INTRODUCTION

In addition to my long-standing interest in the relationship between variations in predicted astronomic tidal heights and the Moon's variables of changing distance from the Earth, changing phase, and changing declination, I have expanded my scope to check the lunar-solar hypothesis formulated in 1914 by the Swedish oceanographer, Dr. Otto Pettersson [1848-1941]. According to Pettersson, the varying configuration of the Earth-Moon orbit affects the Sun, notably in the changing patterns of the sunspot cycle. Pettersson postulated that a major Earth-Moon factor which affects the Sun is the orientation with respect to the Earth's apse of the lunar apse-node coincidences. (See Sanders, 1995, p. 320-326 for further details on Pettersson's ideas.)

I have used the astronomic almanacs to compile the geocentric longitudes of the lunar apse (indicated by perigee) and the lunar node (indicated by the ascending node) for 1900 thru 1999. The other cycles I examine here include the perigee-syzygy cycle and the phase-maximum-declination cycle. I define these and then move to the situation in 1999.

MECHANICS OF SOME LUNAR CYCLES

Lunar cycles are driven by the irregularities of the orbital configuration of the Earth-Moon pair in their counterclockwise motions (as seen from above) around their common center of mass, the **Earth-Moon barycenter** and by the counterclockwise motion of the Earth-Moon barycenter in its orbit around the Sun. The Moon's elliptical orbit lies in a plane that makes an angle of 5° 09' with the plane of the Earth's orbit (named the **plane of the ecliptic**). The line of intersection of these two planes is the **lunar node**, one end of which is known as the **ascending node** (where the Moon crosses the plane of the ecliptic from south to north) and the other, the **descending node** (where the Moon crosses the plane of the ecliptic from north to south). The long axis of the Moon's elliptical orbit is named the **lunar apse**. The ends of the apse are defined by the Earth-Moon separation distances: **perigee**, for the closest distance, at one end and **apogee**, for the greatest, at the other (Figure 1).

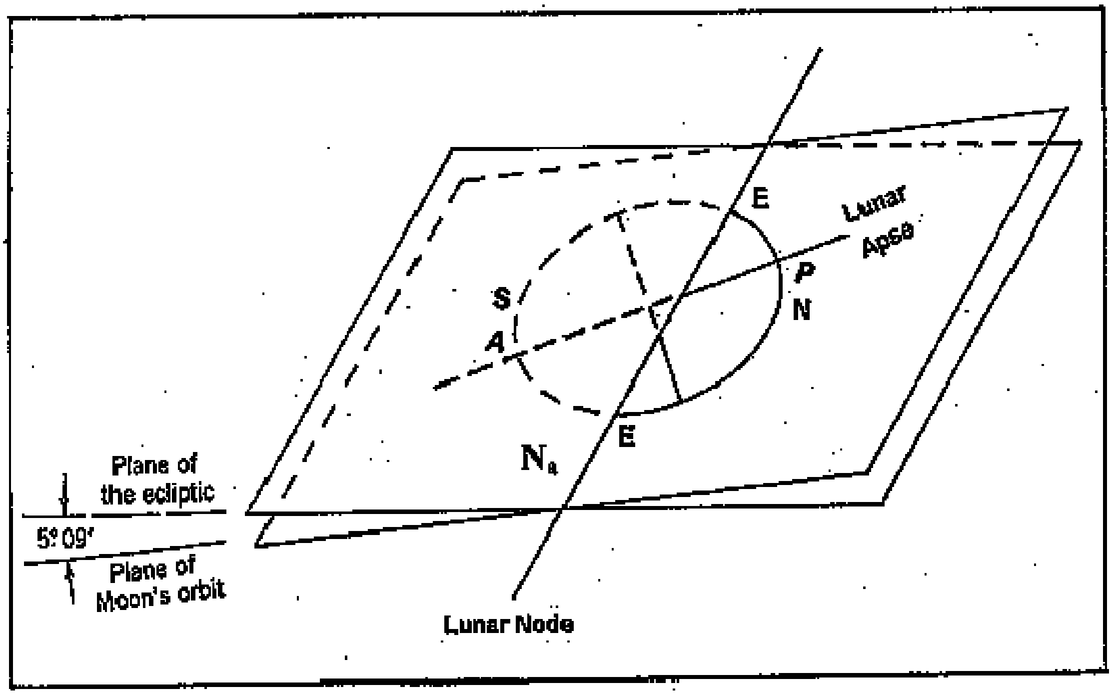

Figure 1. Schematic view of the Moon's elliptical orbital path (solid line where above Earth's orbital plane; dashed where below the Earth's orbital plane), the inclination of the plane of the Moon's orbit to the plane of the ecliptic (plane of Earth's orbit), and the line of intersection between these two planes). The letters are as follows [going counterclockwise from E (for Moon above the Earth's Equator) at the bottom]: N, far-north declination; P, perigee; E, Moon above the Earth's Equator; S, far-south declination; A, apogee; and Na, ascending node.

The lunar apse, rotating **clockwise** in the plane of the Moon's orbit, moves 360° in 8.849 yr (the **lunar-apse cycle**). By contrast, the **lunar node** (line of intersection of plane of Moon's orbit with plane of Earth's orbit) rotates **counterclockwise** in the plane of the Earth's orbit and moves 360° in 18.6 yr (the **lunar nodal cycle**). Approximately every 3 yr, the apse and the node coincide, and this coincidence defines the **apse-node cycle**, which Pettersson inferred affected the Sun's behavior.

During each orbit, the Moon passes through four phases: New Moon, First Quarter, Full Moon, and Last Quarter. During New Moon and Full Moon, the Sun, the Earth, and the Moon lie along a common line, thus defining a condition named **syzygy**. In the quarter phases, the line from the Earth to the Moon makes a right angle with a line from the Earth to the Sun.

The lunar apse moves systematically through the various lunar phases. Thus the perigee position coincides in turn with New Moon, with the First-Quarter Moon, with Full Moon, and with the Last-Quarter Moon and so on. The coincidences between the apse and the syzygy phases define the lunar **perigee-syzygy cycle**. One way to express the changing relationships during the perigee-syzygy cycle is to plot the speed of the Moon's orbital motion against time. Variation results from the changing Earth-Moon separation distance. When these two bodies are farther apart, their rate of orbiting around the Earth-Moon barycenter is slower than when they are closer together.

During each orbit, the Moon's declination also changes systematically, passing consecutively from a far-north position, to a position above the Earth's Equator, to a far-south position, to a position above the Earth's Equator, and back to a far-north position. (See Figure 1.) The Moon's changing declination affects the differences in heights between the morning and evening tides (known as **diurnal inequality**). The maximum differences coincide with maximum lunar declination. When the Moon is over the Earth's Equator, diurnal inequality disappears; that is the heights of the morning- and evening tides become the same. A fact that I find remarkable is that during the year, declination and phase repeat in systematic ways, forming a **phase-maximum-declination cycle**. During the equinox months of March and September, syzygy phases always coincide with minimum lunar declination (Moon over the Earth's Equator). By contrast, during the solstice months of June and December, syzygy phases coincide with maximum lunar declination (either N or S, always being the same during a given perigee-syzygy cycle). It takes ca. 8 yr for a given syzygy phase (Full Moon or New Moon) to change from one maximum-declination position (either N or S) in a solstice month to the opposite maximum-declination position.

MOON'S ORBITAL CONFIGURATION IN 1999

In the following paragraphs, I present data about the configuration of the Moon's orbit in 1999 as this affects predicted tidal heights at Willetts Point, NY; about the relationships between maximum lunar declination during the solstice months (June and December) and the changing motion of the Moon at perigee-syzygy coincidences; and about the apse-node cycle.

Predicted Astronomic Tidal Heights for 1999 at Willetts Point, NY

A convenient way to express graphically many of the attributes of the Moon's orbit is to make what I have termed **Pettersson diagrams**. I have given this name after seeing similar graphs of tide-producing forces that Otto Pettersson first published in 1912 (Pettersson 1912; 1914a; 1930). (See also Pettersson 1914b, 1915, 1923.) Pettersson's objective was to show lunar control, especially by the perigee-syzygy maxima, on the heights of internal tides (his "Moon waves") in the Gullmarfjord on the W coast of Sweden. Figure 2 shows a Pettersson diagram for each month of 1999 displaying the predicted levels of high water and low water at Willets Point, NY (taken from the 1999 NOAA tide-prediction tables for the east coast of North America). I entered the numbers into a spreadsheet that Peter Buttner helped me to devise using Quattro Pro spreadsheet programs. (I have used, and still prefer, the mid-1980's, pre-Windows version of Quattro Pro for this purpose.)

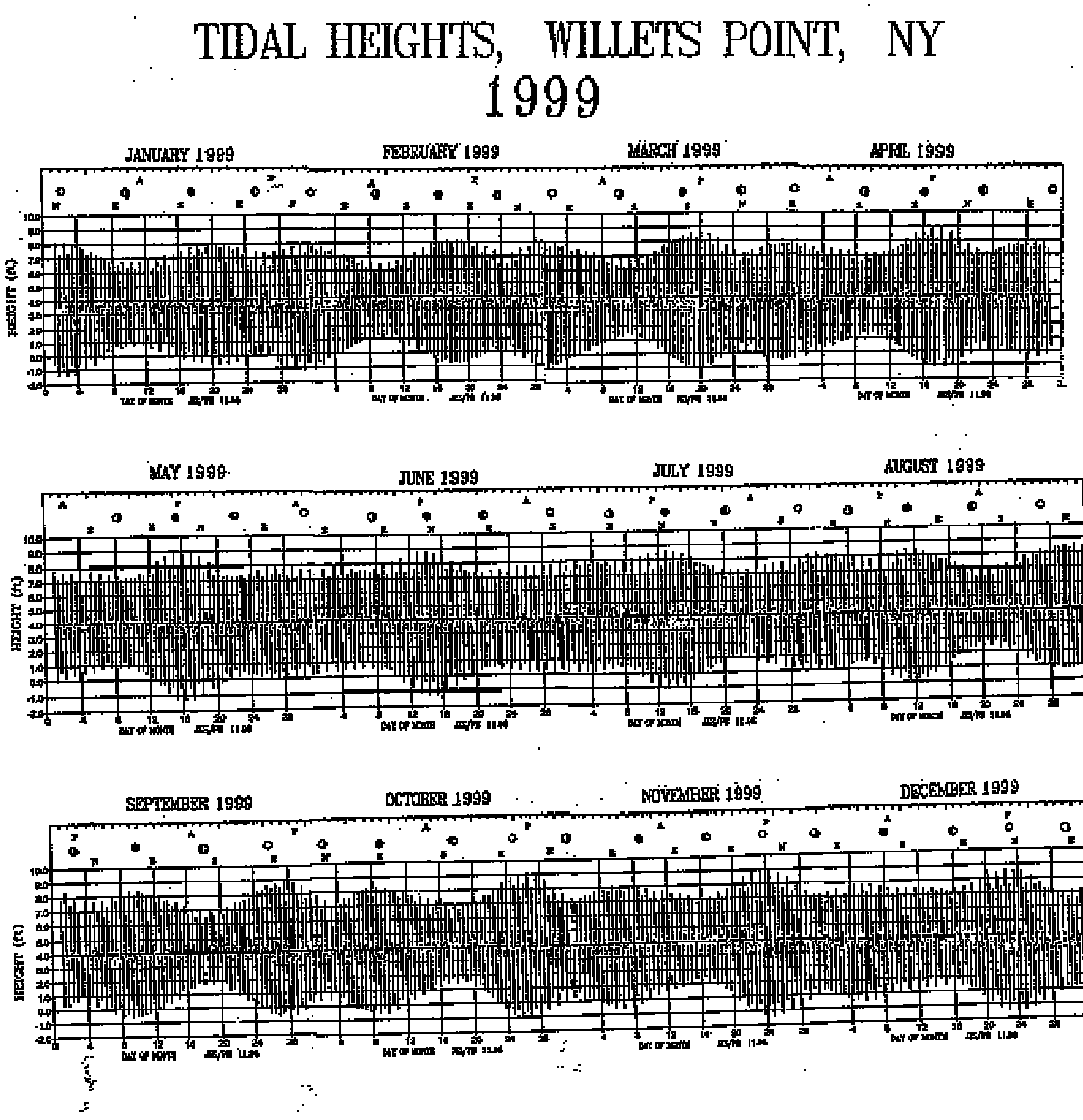

Figure 2. Pettersson diagrams showing predicted heights of high water and low water at Willetts Point, NY for 1999, and aspects of the Moon's configuration. Text explains three rows of letters/symbols at the top. The datum is mean low low water (MLLW).

The three rows at the top, above the zig-zag lines connecting the points of predicted high water and predicted low water, represent important attributes of the Moon's orbit: (1) distance (upper row), (2) phase (middle row), and (3) declination (bottom row). In the top row, the letter A stands for Apogee (Moon at maximum distance from the Earth) and P, for Perigee (Moon at minimum distance from the

Earth). In the middle row, lunar phases are open circles for Full Moon, filled circles for New Moon, and partially filled circles for the Quarter phases. The bottom row shows lunar declination by the letters N (for maximum North), S (for maximum South) and E (for Moon over the Earth's Equator). These letters and symbols are aligned using the days/times based on Greenwich (UK) mean time (GMT).

The shifting of the A's and P's with respect to the lunar phases creates a cycle of higher-than-normal (*i.e.*, "Spring") tides. The maximum astronomic tidal ranges take place when P (perigee) coincides with Full Moon or with New Moon (the syzygy phases). The shifting from a Full-Moon-perigee-syzygy alignment to a New-Moon-perigee-syzygy alignment and back again to a Full-Moon-perigee-syzygy alignment (or vice versa) defines the **lunar perigee-syzygy cycle** whose duration is about 14 months. The maximum amplitudes of the astronomic tides are always associated with the syzygy phase that coincides with perigee. Notice that in the equinox months, when syzygy phases and minimum lunar declination coincide, the amplitudes of the predicted astronomic tides are not only greater than usual, but coincide with minimum (or zero) diurnal inequality. I think this regular coincidence could amount to a regular pressure "signal" capable of being sensed by some marine organisms whose spawning cycles coincide with the "spring" tides of March. If so, then to these organisms, the "Ides of March" may translate into the "tides of March."

The last Full-Moon perigee-syzygy coincidence was in early November 1998. Two New Moon/perigee coincidences will take place in mid-April and mid-May, 1999. A corresponding set of Full-Moon-perigee-syzygy coincidences is scheduled for late November and late December, 1999. Early in 2000, perigee will again coincide with New Moon. This year's highest predicted astronomic tide, 9.1 ft at Willets Point, is scheduled for 1238 (DST) on 26 October.

Maximum Lunar Declination and Lunar Motion at Perigee-Syzygy Coincidences

Figure 3 is a plot of the rate of lunar motion at perigee-syzygy coincidences and declination. My only previous attention to lunar declination has been in preparation of the Pettersson diagrams, in which the declination affects the diurnal inequality (maximum at the maximum north or south positions, and as mentioned, zero where the Moon is over the Earth's Equator).

Figure 3 shows that most of the times of maximum ranges in rates of lunar-orbital motion coincide with times of maximum north or south declination during the solstice months of June and and December. One point that I think is worth pursuing is to find out whether atmospheric-tidal effects, specifically the extent of the seasonal migration away from the Equator of the Intertropical Convergence Zone (ITCZ), coincide with these declination maxima.

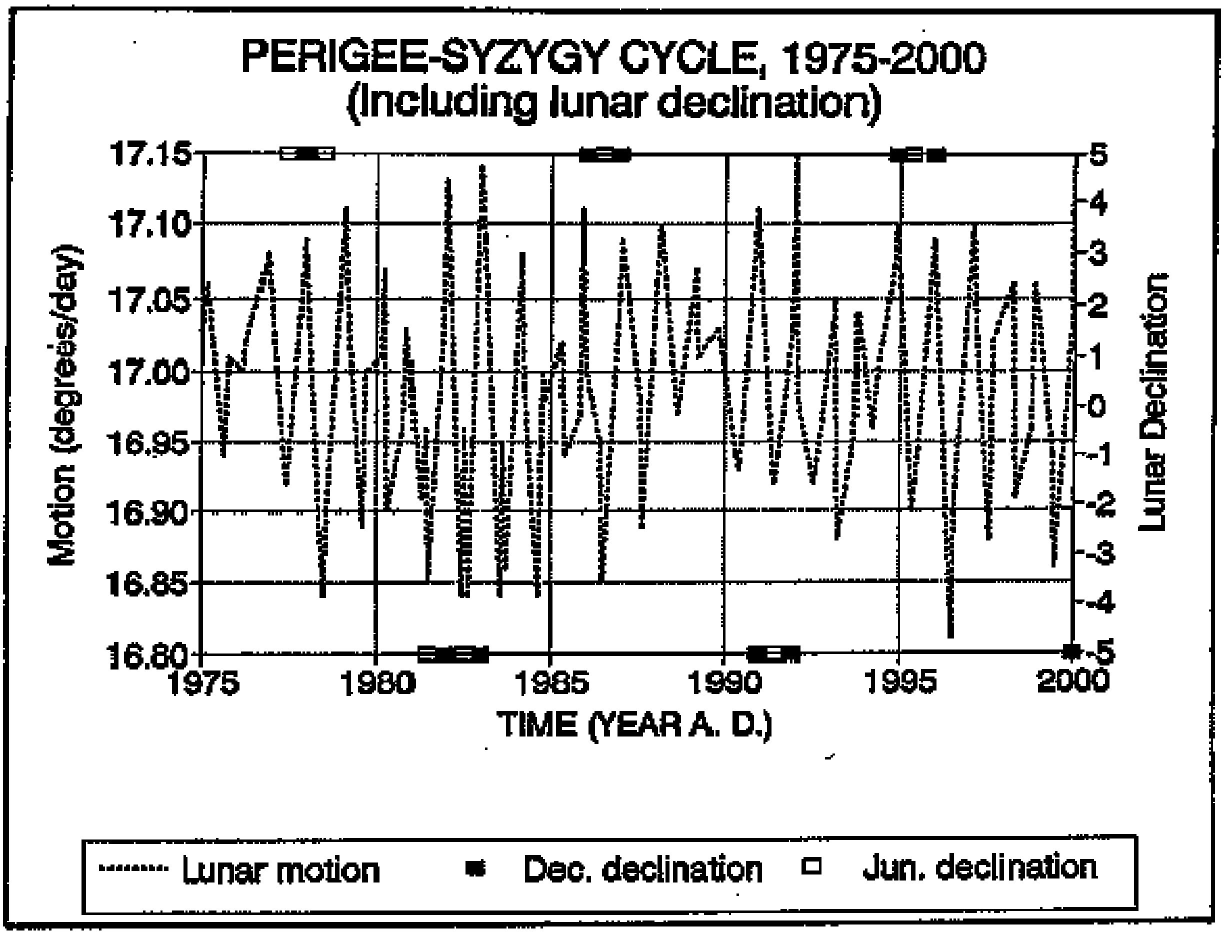

Figure 3. Rate of lunar motion at perigee-syzygy coincidences and maximum declination in solstice months of June and December. Scale of lunar declination is arbitrary; maximum N declination is assigned +5 and maximum S declination, -5. Data on rate of lunar motion from Fergus Wood (1978, table 16). See also Wood (1985). Declination from astronomical almanacs.

Lunar Apse-Node Cycle

During the third week in March 1999, the lunar apse (perigee end) attained a geocentric longitude of ca. 51° and the lunar node (ascending node end), that of ca. 141° (Figure 4). This right-angle

arrangement marks a kind of mid-point position in the apse-node cycle. The last apse-node coincidence took place during the third week in September 1997, when the geocentric longitude of lunar perigee (the apse) was 350° and that of the ascending node, ca. 170° The previous 90° configuration was attained during the third week of March

1996, and the previous apse-node coincidence (geocentric longitude of both ca. 228°), in the third week of September 1994.

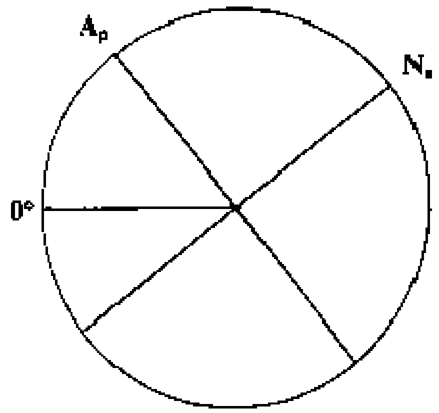

Figure 4. Moon-lines diagram (viewed from above) on 23 March 1999, when the lunar apse and lunar node attained right-angle positions. Geocentric-longitude angles increase clockwise from zero on the -X axis. Ap = perigee end of lunar apse; Na = Moon's ascending node. (Data from astronomic almanac.)

CONCLUSIONS

The subject of lunar cycles, long relegated by many scientists to a less-than-respectable status verging on "astrology," is gaining in stature as a result of the application of spectral analyses (Keeling and Whorf, 1997) and of various signal-processing techniques (Currie, 1981; 1982; 1984a, b, c; 1987, 1992, 1994, 1995; Currie, Wyatt, and O'Brien, 1993). This change of attitude is becoming so prominent that one should not be astonished to find numerical treatment of lunar cycles creeping into computer models that attempt to simulate the Earth's climate.

I am not far enough along with the relevant parts of this investigation to be able to carry out one of my original goals of evaluating Otto Pettersson's hypothesis that the configuration of the Moon's orbit, particularly the changes that accompany the apse-node cycle, can affect the Sun's behavior. The early returns on the interaction between maximum lunar declination in June and December and the changing lunar orbital motion suggest that no serious study of lunar cycles should ignore declination.

ACKNOWLEDGEMENTS

Professor Emeritus Rhodes W. Fairbridge (RWF), Columbia University, has always advocated the view that various astronomic cycles serve as extra-terrestrial forcing functions for the Earth's atmosphere and hydrosphere. RWF gave me copies of Otto Pettersson's long-lost papers, reprints of many of which Otto Pettersson's grandson, who had found a stock of them among his grandfather's papers, gave to RWF some years ago. In 1998, RWF emphasized to me the possible importance of lunar-solar cycles in determining the timing of El Niño's in the eastern Pacific Ocean (Fairbridge, 1990). We are currently engaged in a joint research project on that subject. Peter J. R. Buttner, Altamont, NY (formerly of the NYS Department of Parks, Recreations, and Historic Preservation) helped refine the spreadsheet programs in Quattro Pro that I have used to display the predicted tidal heights in the Pettersson diagrams and has assisted me in many ways as I have struggled with various computer-graphics problems. Charles Merguerian, of Hofstra University, assisted with the printing and assembly of the camera-ready copy.

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