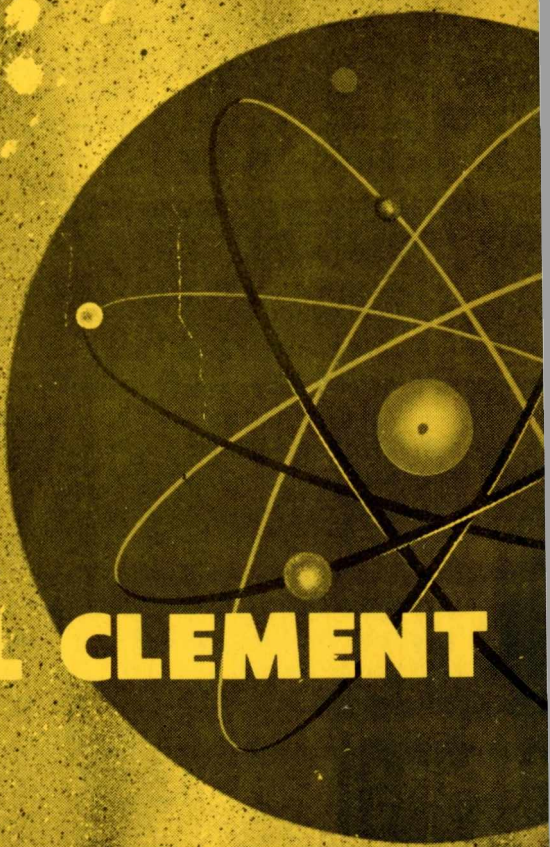
some notes on Xi Bootis



by HAL CLEMENT

Summary of the Xi Bootis System

as arranged for the talk "Interstellar Stage-Setting"
to be delivered before the
18th World Science Fiction Convention
Pittsburgh, Pennsylvania - September 2, 1960

by Hal Clement

I. ASTRONOMICAL FACTS

Xi Bootis appears as a star of slightly brighter than fifth magnitude, located nine degrees east of Arcturus. Its actual space location is closer to us than that of the latter star; the parallax has been measured a number of times and the results are not in complete accord (they seldom are), but the value adopted for this presentation corresponds to a distance of 22.2 light years. A ship bound for Arcturus would pass about three and a quarter light years from the Xi Bootis system when a little more than half way to its destination.

Unfortunately, the Arabs don't seem to have gotten around to naming this particular star. Henceforth in this discussion the primary will be called Smith and the secondary Jones.

As the foregoing sentence implies, the star is a binary. Smith is a G6 main sequence star not too much fainter than Sol --absolute mag 5.6 against Sol's 4.85. Because of the slightly different color, the bolometric mag--the one accounting for total energy, which is more useful here--is about 5.4, corresponding to an energy output 58% that of our own sun.

Jones is a K4 dwarf, fainter and redder than Smith; absolute bolometric mag about 7.3 or 10% Sol's radiant strength.

Considering Smith motionless for convenience, Jones' orbit around him gives a mean distance of just over three billion miles. The orbit is eccentric enough (0.51) to cause this distance to vary from 1.6 to 4.5 billion. At no time is either star close enough to the other to change the temperature of a planet in

the habitable zone as much as a degree. The period of the orbit is given as 152.8 years; I would tend to view the last two digits with suspicion.

For this discussion, the "habitability zone" is considered to extend from the distance where the star's radiant flux per unit area equals that of the sun at Venus' orbit to the distance where it equals that at Mars' orbit (mean distance, that is). For Smith, these distances are respectively fifty million and one hundred eight million miles; for Jones, twenty-one and forty-six million. The "earth equivalent" distances are seventy-one million miles for Smith and twenty-nine million for Jones.

II. ASTRONOMICAL FICTION

Circling Smith at a mean distance of 68,000,000 miles (circling is a poor word; the orbit is eccentric enough to make the distance vary from 60 to 76 million) is the planet Creek. Its orbit is inclined 22° to that of Jones (see Fig. 1, Fig. 2 and models). The period of this orbit is 313 earth days.

Creek is a 61 Cygni C type object, 3,200 times the mass of the earth, 39,000 miles in diameter, surface gravity 132 times that of earth. Its escape velocity is 177 miles per second. The period of an artificial satellite in a circular orbit just outside the atmosphere--say, a mile up from the surface--would be a little over nine and a half minutes. The atmosphere is Jupiter type--mostly hydrogen, laced fairly heavily with helium, traces of light-element hydrides. Its rotation period is fourteen hours, with the axis of rotation less than two degrees from the perpendicular to its orbit.

Creek has three satellites:

Kusa, mean distance 163,000 miles, orbit nearly circular, period six hours thirty-three minutes, inclination to Creek's equator less than one degree. Rotation matches revolution. Diameter 6,100 miles, mass three eights that of earth, surface gravity 63% earth normal, escape velocity 6.3 miles per second.

Kawita, mean distance 293,000 miles, nearly circular orbit, period of fifteen hours forty-five minutes, less than one degree inclination to Creek's equator, rotation matches revolution. Diameter 8,750 miles, mass forty percent greater than the earth, surface gravity fourteen percent greater, escape velocity 7.8 miles per second.

Figure 1

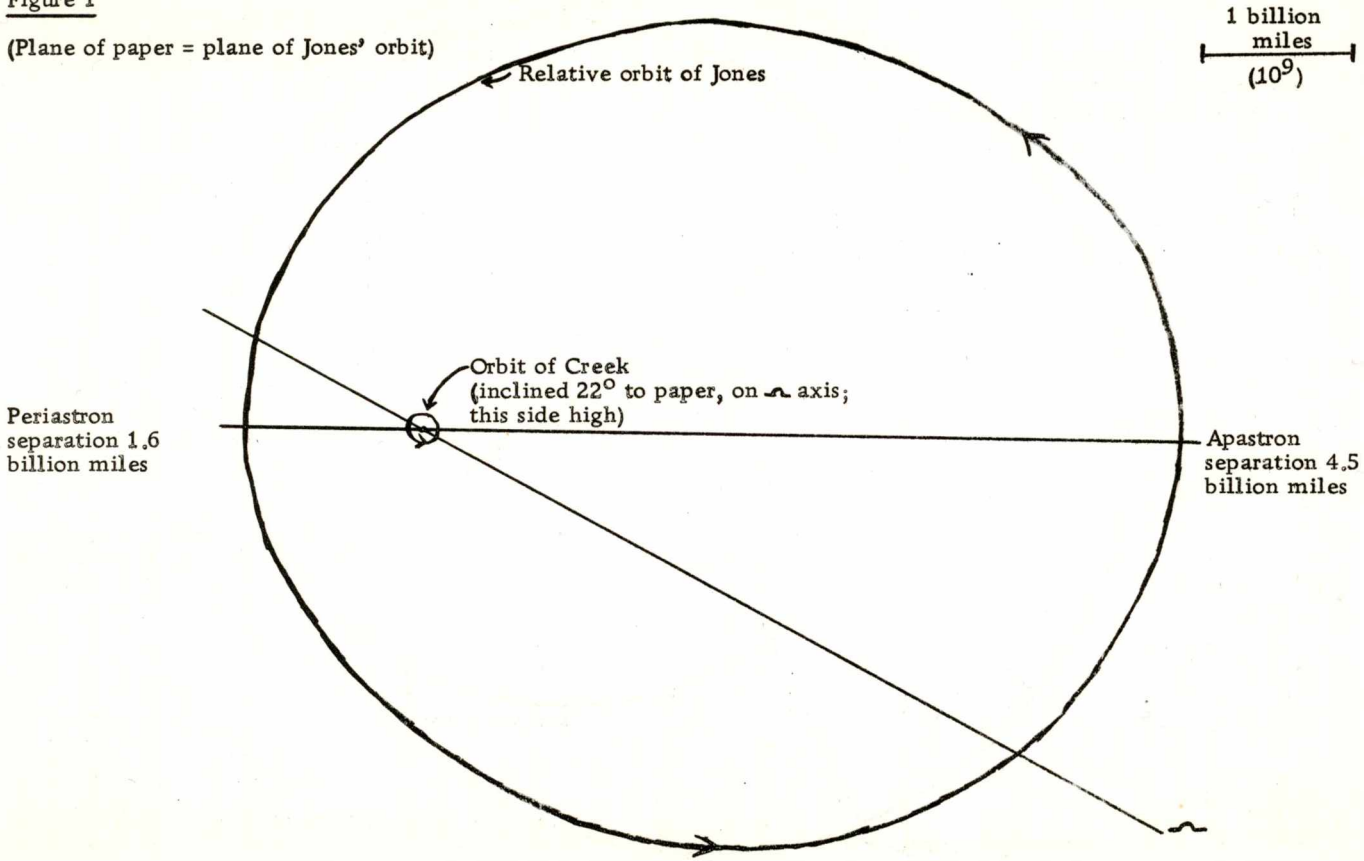

(Plane of paper = plane of Jones' orbit)
Relative orbit of Jones
1 billion miles
(10^9)
Orbit of Creek
(inclined 22° to paper, on ~ axis;
this side high)
Periastron separation 1.6 billion miles
Apastron separation 4.5 billion miles

Figure 2
(Plane of paper = plane of Creek's orbit)

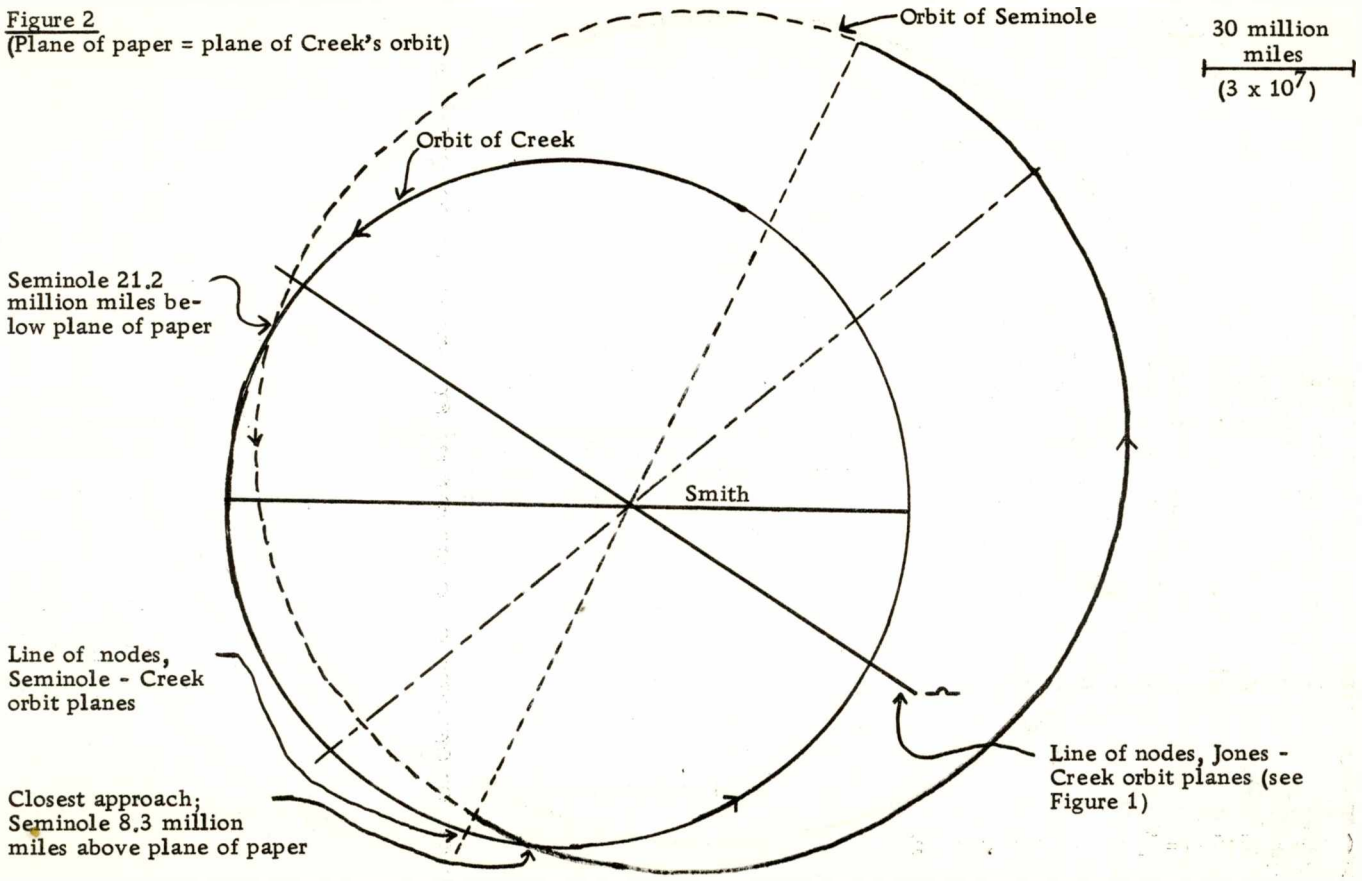
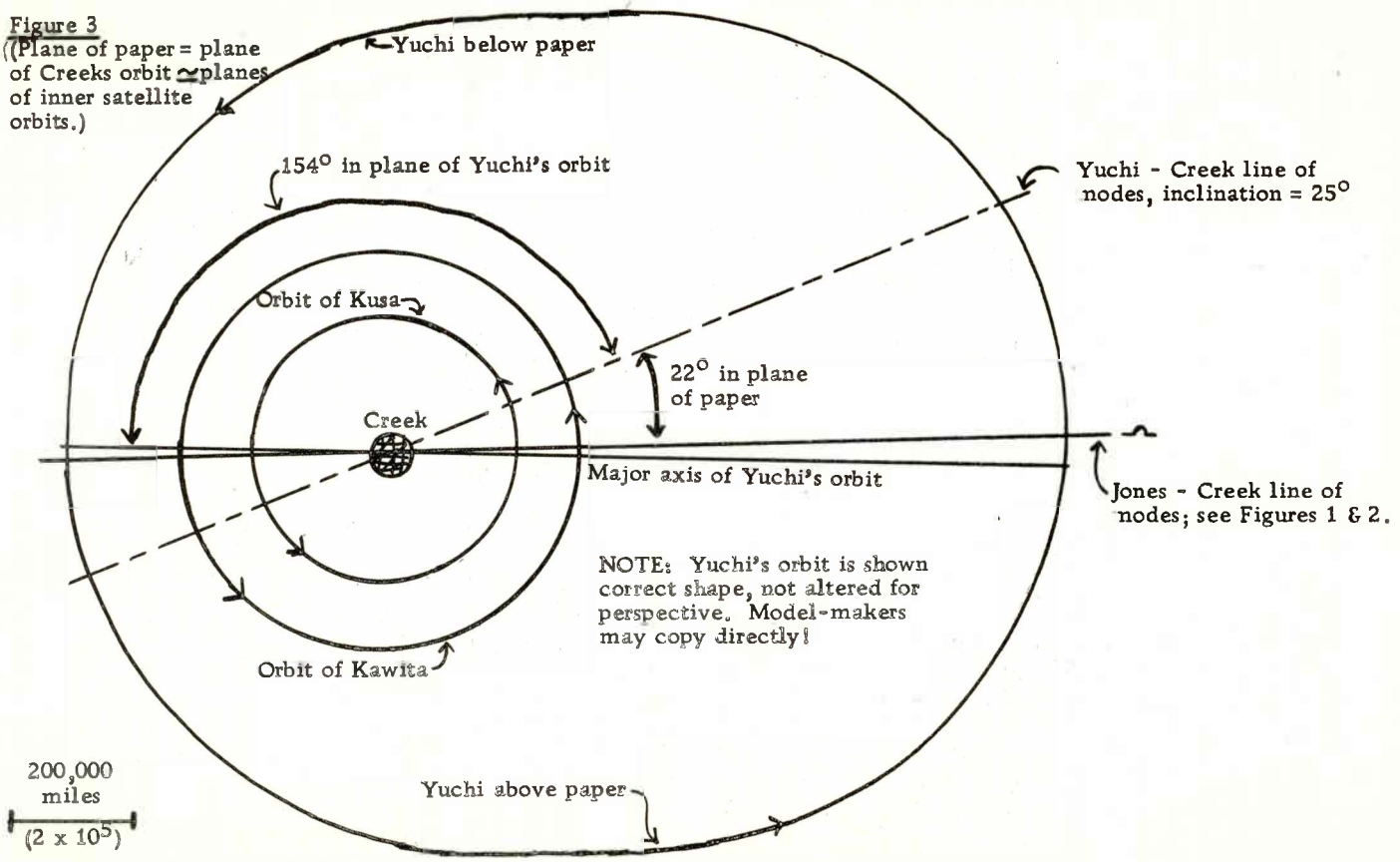


Figure 3
(Plane of paper = plane of Creeks orbit ≃ planes of inner satellite orbits.)



Yuchi, mean distance 765,000 miles but varies from 450,000 to 1,080,000 miles, period sixty-six hours forty-eight minutes. Inclined 25° to plane of Creek's equator. Rotation matches revolution, averaged over period. The only satellite which sometimes escapes eclipse in Creek's shadow. Diameter 9,550 miles, mass 2.05 times earth, surface gravity 36% higher than earth's, escape velocity 9.1 miles per second (Fig. 3).

Smith's remaining planet is Seminole, travelling in an eccentric orbit between 66,000,000 and 122,000,000 miles from the star (e = 0.298). Its year is 456 earth days. Inclined nineteen degrees to Creek's orbit about Smith. Its diameter is 5,770 miles, mass about 31% that of earth, surface gravity 58% earth's, and escape velocity is 4.5 miles per second. Its rotation period is sixty-eight hours and five minutes, the axis inclined about twenty degrees to the perpendicular of its orbit plane (Fig. 2).

The foregoing facts are consistent with the idea that Seminole is a former satellite of Creek, which escaped through dynamic interaction with Yuchi--the latter's orbital peculiarities lend further support to the notion.

III. GEOLOGICAL FICTION

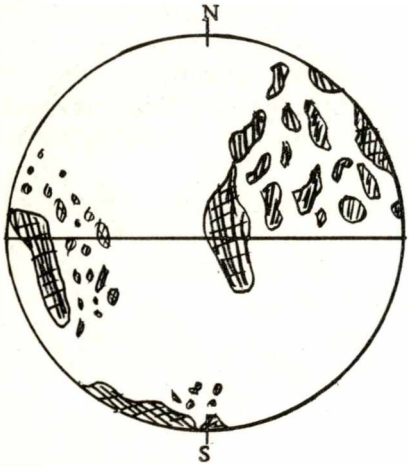
A. Kusa. Like the other satellites, its chemical composition is close to that of earth--the crust is primarily of silicate minerals. It has less water per square mile than the earth, as far as actual tonnage goes; but its smaller gravitational potential has resulted in less diastrophism. Hence, the continents are not as high as those of earth, the ocean basins are not as deep, and a larger fraction of its surface (over 80%) is covered by shallow seas. Erosion is extensive along the shores of these, especially in the equatorial regions; for though the tide raised by Creek has no effect, those of Kawita and to a lesser extent Yuchi are strong and complex. It has been a long time since its last geological revolution, and there are no mountains higher than about eight thousand feet on the planet.

Most of the land is concentrated in four large archipelagoes which are geologically nearly submerged continents. Planetary air circulation is almost unimpeded by mountains, though the ocean currents are less uniform; climate is roughly Bermudian on all land masses. Total air pressure is twelve pounds; the critical factors of the atmosphere composition are sixteen percent oxygen and almost one percent carbon dioxide.

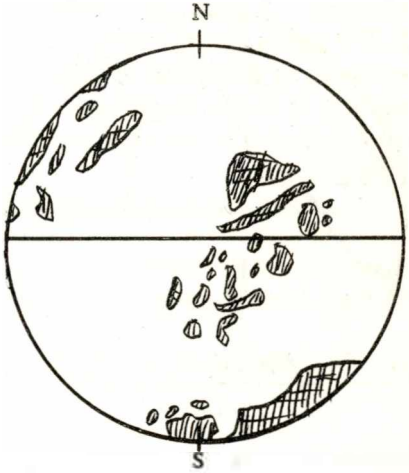
Figure 4

KUSA

Shaded areas represent land.



Hemisphere toward Creek



Hemisphere away from Creek

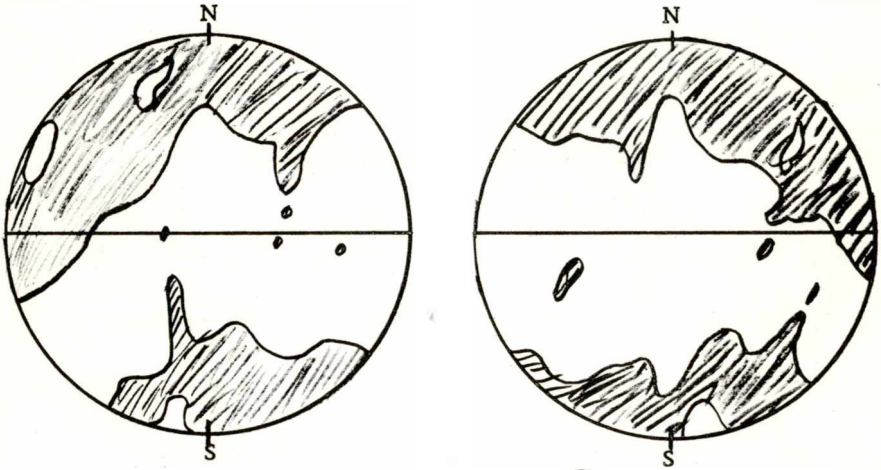
The rest is nitrogen and inert gases in about earthly proportions. Water vapor is of course variable. Seas about 1% dissolved salts--roughly a third of earthly oceans.

B. Kawita. Extremely earthlike, though less water area. Very rugged; apparently in the middle of a geological revolution. Mountains up to thirty thousand feet or more; pronounced earthquake and volcanic belts comparable to those of the earth. Climate far more extreme than Kusa, ranging from ice-capped poles to tropical. Surface air pressure eighteen pounds, twelve

Figure 5

KAWITA

Shaded areas represent land.



Hemisphere toward Creek

Hemisphere away from Creek

per cent oxygen, trace of CO_2--rather more than earth, but much less than one per cent.

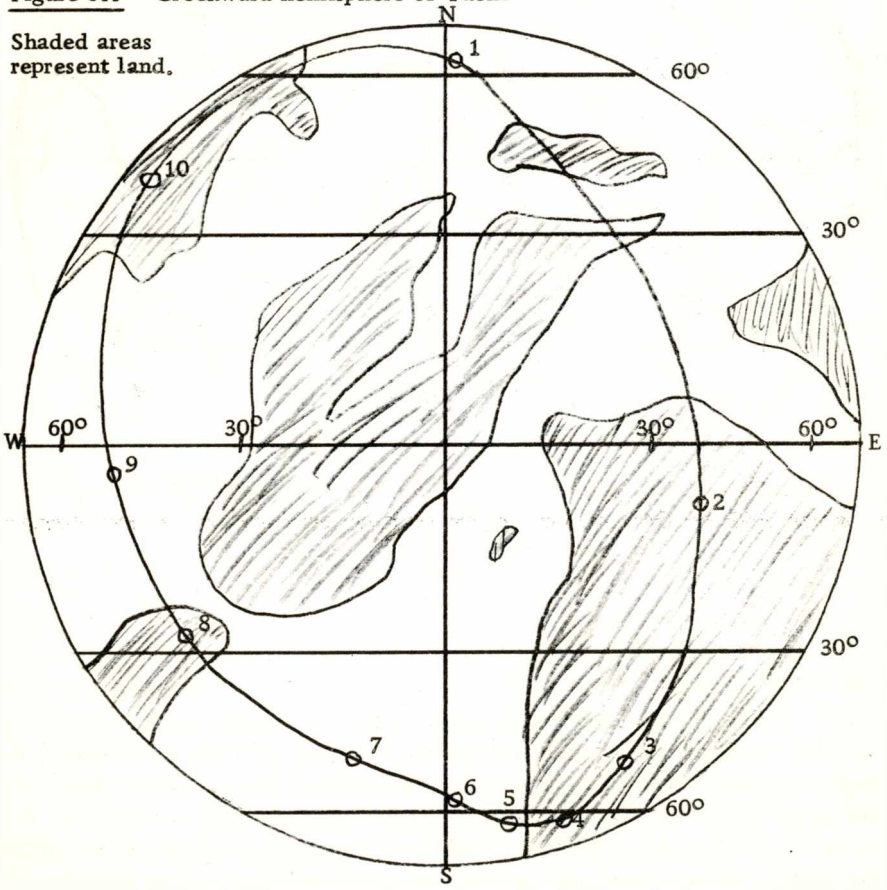
Water area covers only about 55% of Kawita's surface, but the seas average much deeper than earth's. Seas about as salty as earth's.

C. Yuchi. Near the end of the active part of a diastrophic cycle; numerous young mountain ranges, one continent in particular very active volcanically and seismically. Water over 65% of surface; one major continent (as with the earth)

one medium sized one and numerous very large islands--New Guinea type. Climate through the full earth range, complicated by axial tilt--unlike the other two, Yuchi's axis is highly inclined not only to its own orbit perpendicular but also to that of Creek; seventy and fifty degrees respectively. Air pressure twenty pounds, twelve per cent oxygen, the rest approximately earthlike. Seas almost six per cent dissolved salts, nearly twice as salty as the earth's.

D. Seminole. No permanent bodies of water, no high mountains, surface air pressure two pounds, one per cent oxygen, ditto carbon dioxide. Generally Mars-like.

Figure 6A Creekward hemisphere of Yuchi

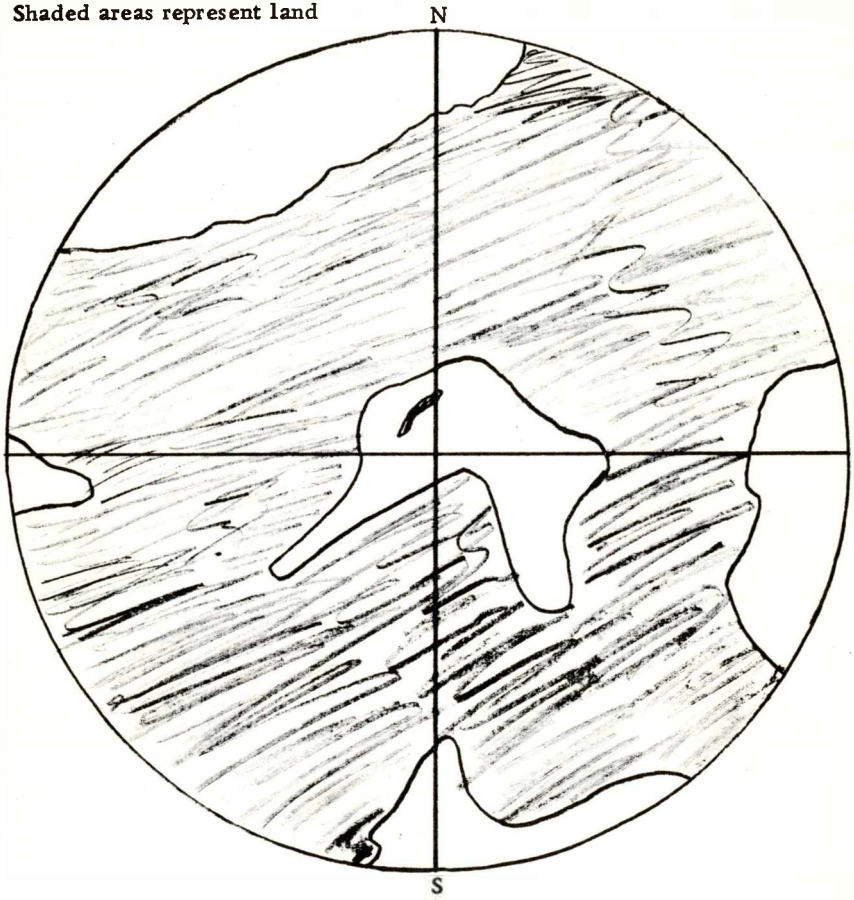


Numbered points - Creek directly overhead at equal intervals during day. #1 at closest; intervals about 400 minutes.

Figure 6B

Yuchi - hemisphere away from Creek

Shaded areas represent land



IV. BIOLOGICAL FICTION

All three satellites have carbon based life generally similar to that of earth. All three classes of life are based on right-handed amino acids like Terrestrial forms, but land life in each case has blood ion content comparable to that of the oceans of its own satellite. Phyla comparable to most of those on earth have evolved on all three satellites. Leave species details to authors; any reasonable ecological slot is likely to have been filled. The system is probably older than that of Sol.

NOTES

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