WATER-VAPOR ON MARS.*

REPLY TO CAMPBELL'S CRITICISM.

BY F. W. VERY.

IN Lick Observatory Bulletin, No. 169, Prof. Campbell, in the course of comments on Dr. Slipher's and my results which show the presence of water vapor on Mars, says: "Very's results make the 'intensification' of a in the Martian spectrum more than twice as great at one time as at another. His greatest intensification is with spectrogram No. 3,062, for which Slipher says the a band is 'strong in both' Mars and moon; whereas only average intensification was obtained from spectrogram No. 3,050, on which 'the a band is all but invisible in both lunar images, but conspicuous in Mars'; a result apparently difficult to explain" (p. 161). The apparent discrepancy is not at all difficult to explain. It arises from the mode of reduction. By referring to Lowell Observatory Bulletin, No. 36, it will be seen that the apparent intensities of the telluric, or of the combined telluric and Martian, bands on each plate and in each spectrum have been reduced to the standard of their respective $H\alpha$ lines, on the supposition that the latter are solar and therefore constitute one fundamental comparison object which is not subject to change through the variations of our shifting atmosphere, and which also enables us to eliminate any error depending on variation in the appearance of the spectral lines, due to changes of focus in the spectrograph, which are liable to occur in these long exposures owing to changes of temperature.

The method does not eradicate all possible variations capable of affecting the result, for there remain certain exposure and development factors on which Prof. Campbell frequently comments in describing his own plates, and to which I have alluded in describing the Lowell Observatory plates in Lowell Observatory Bulletin, No. 41, p. 223. Lowell Observatory Plate Rm. 3,062 is a little over-developed. The intensification of the a band would be normal without any reduction to C standard. In this case the reduction to C does not improve the result, but gives a ratio which is larger than the other ratios, and with a residual nearly twice as great as any of the others. Nevertheless, since the reduction to C appears to be justified, and, indeed, demanded by the necessities of the case, I cannot throw out a single aberrant measure for no better reason than that it is aberrant.

Prof. Campbell goes on to say: "It would seem either that Very's methods lead to erroneous quantitative conclusions, or that the quantity of water vapor over the whole equatorial region of Mars varied several fold between the dates of observation. Is the latter condition probable?" To this question the obvious reply is that a world-wide variation of aqueous vapor in the course of a few days is next to impossible; but no such interpretation of my measurement is necessary, since the discrepancies are no greater than those attributable to photographic factors. Must I then accept the other horn of the dilemma which Mr. Campbell presents, namely, that "Very's methods lead to erroneous quantitative conclusions?" It seems to me that such a characterization of my work is unjust and unjustified. The measured intensification of little a in Mars, given in my paper in conventional units from the mean readings for the five plates, was nine times as great as the probable error of the mean. No greater accuracy has been claimed for the result than that which is given by the probable error, and I have only used two significant figures in stating the final value.

Although the photometric measurements are difficult, the photometric methods are sufficiently trustworthy for the present purpose, and the final limit of accuracy resides in the uncertainties of the photographic process. The only way in which we can get rid of errors due to the circumstances of exposure or of development is by confining the investigation to those spectrograms which are not seriously affected by photographic disturbance; and here, by Campbell's own confession, the Lowell Observatory spectrograms must be given preëminence. He says (p. 162, *loc. cit.*): "In this connection, inasmuch as Very's measures refer to $H\alpha$ (in the region of maximum sensitiveness on my spectrograms) and to a (in the region of very little sensitiveness), I note with unusual interest Mr. Slipher's success in giving the a region good density without over-exposing $H\alpha$ and B . He makes no mention of having used an occulting screen, absorbent screen, or other reducer for the region to the violet of a , and one must conclude that he depended upon his chemical formulæ to achieve this result. The Mount Whitney spectrograms have intensity curves such that when a is fully exposed, $H\alpha$ is essentially lost in over-

exposure." In other words, it appears that Dr. Slipher has succeeded where Campbell has failed. It will be understood that I have not seen the Lick spectrograms.

In a letter to me, dated January 22nd, 1909, Mr. Slipher says: "The Mars and moon spectrograms were made for the lower end of the spectra, and no regard was given to having the actinic part, but, on the other hand, no screen was used to reduce the action of that part." This disposes of the doubt implied in the last quotation from the Lick Bulletin.

The last criticism which Prof. Campbell makes upon the method of measurement which I have employed is contained in the following paragraph: "Again, and of special interest in connection with Very's measures, it has long been known that the color curves of Mars and the moon are different; the spectrum of the planet is relatively rich in red. When the lunar and Martian spectrograms are equally dense at $H\alpha$, their D regions are unequally dense, with the lunar one plainly the stronger. With the a regions equalized in density, the $H\alpha$ region is for the same reason a little stronger in the moon than in Mars. Are the ratios of the apparent intensities of $H\alpha$ and a in the two spectra not affected by these conditions?" (P. 162.) On this point I answer that the variation in question does make a difference in the result, but only a very slight difference, and one which is negligible where the variation is no greater than in the present case. I have satisfied myself as to this by making measures under conditions far more unfavorable than those in the poorest of the present plates.*

Passing to the criticism made upon the interpretation of these measures, Prof. Campbell asks: "What assurance have we that the air columns through which Mr. Slipher observed Mars immediately after dark and the moon from two to eight hours later were carrying equal quantities of aqueous vapor? He appears to have taken no psychrometer observations at the observatory, but to have depended upon those made at the Weather Bureau Station, a kilometer distant and 105 meters lower, at 5:33 P. M." My answer to this is that measures of atmospheric transmission, made at a time when there were no marked storm movements at the given place, are but little affected by such slight changes as those indicated by the variation of the psychrometer reading at the earth's surface. It is the distribution of moistures through the entire air column that we should like to know, and this is hardly affected by such surface changes as occur in an arid region. The diminution of aqueous vapor so frequently noted at night in arid and elevated situations is presumably due partly to diffusion of moisture into the upper air at a time of day when there is little replenishment by superficial evaporation, and in part to an excessive depletion of moisture in a shallow surface layer of air through deposition of dew, although the latter cannot have been an efficient cause with the low relative humidity found by the Lick observers. The total quantity of water vapor in the entire column is not much changed by redistribution through diffusion, and any great accuracy in the determination of surface humidity would be labor wasted for the present purpose. A mean diurnal, or possibly a mean monthly, humidity may be quite accurate enough. The great dryness of the region about Flagstaff, and the infrequency of storms, consequently the moderation of fluctuations in the absolute humidity at this favorable site, must be considered in approaching this question. Variations in the relative humidity, such as are found in a limited layer of air in which cloudy condensation is either imminent or incipient, will have small influence upon the little a group, because it lies outside the limits of the diffuse band of absorption produced in a saturated atmosphere. In the daytime, it is true, a tall column of ascending moist air, tending to the production of a cumulus cloud, and intervening between our instruments and the sun, may produce a notable increase in aqueous telluric absorption; but the slight variation in condensation in the comparatively shallow layers of the night clouds need not be further considered in this connection. If we were dealing with the broad aqueous bands in the extreme infra-red spectrum, the problem would be different, for in these regions of the spectrum I have found wide variations

* By altering the illumination, the spectral background at either a or C was made of the same intensity as that of the comparison spectrum. The omission of this preliminary equalization increases the probable error, even though the direction of relative intensification of the lines remains unchanged.

from the passage of quite invisible masses of aqueous vapor; but it would take exceedingly refined observations to detect such changes in the a group. For these reasons we may dismiss Prof. Campbell's suggestion that "Very's numerical results refer chiefly to the relative absorptions of the aqueous vapor in our own atmosphere when Mars was observed at dark and when the moon was observed from two to eight hours (average four and one-half hours) later."

CONCRETE IN PALESTINE.

DEPUTY-CONSUL John D. Whiting furnishes, in answer to an inquiry, the following report covering concrete in Palestine and its application in an uncommon way in a German sanatorium in Jerusalem:

Concrete, introduced into Palestine about twenty years ago, was first used only for making floor tiles. The materials used were sand and shells from Jaffa and cement from Germany. At first these tiles were made in wooden molds and pressed by wooden mauls, and without patterns, in either black or white. Some years ago a leading German merchant imported a European machine, and produces in his factory in Jaffa different sizes, colors, and designs of tiles, also concrete sewer and water pipes and railings, cornices, steps, and building blocks.

In Jerusalem the opportunity for selling floor tiles, steps, and perhaps cornices is quite large, especially the first mentioned. Little, if any, opening can be expected for using concrete building blocks, as stone is plentiful, and labor for quarrying and dressing it is cheap, while cement and sand are extremely high, since it costs \$4 a ton to bring them from Jaffa by rail, although the distance is only about 53 miles.

In Jaffa the conditions are reversed. Little stone is found in the vicinity, and much of modern Jaffa has been built from sandstone brought from the ruins of Cæsarea and other old towns. This source of supply is now exhausted, and as stone quarries are scarce and the material inferior, concrete building blocks are growing in use. An inexhaustible supply of sand and shells is right at hand.

These blocks are now used in building corners of houses and for sides, sills, and arches of windows and doors, the spaces between being filled with sandstone, sometimes plastered over. The houses are sometimes finished off with a concrete cornice; often an entire balcony is thus made, the top, brackets, slabs, and railing being molded separately and cemented into the building. Concrete steps are also quite often used, and generally the floors are paved with concrete tiles.

Reinforced concrete has just appeared, calling forth much interest and curiosity from natives, especially masons. When the German Emperor and Empress visited Jerusalem in 1898 a carriage road from the northern suburbs up and along the ridge of Mount Scopus to the summit of the Mount of Olives was built for them by the Turkish government. From the top of Mount Scopus there is an extensive view. Jerusalem lies near by, below to the west, and to the east the Dead Sea appears only a few miles off, while it is over 20 miles, and beyond it and the Jordan valley extends the range of Moab.

It was this sight that impressed the Empress, and on her return to Germany a large sum was collected for building a sanatorium at this place, which is to be ready for use this spring. The cost is about \$386,000, and it will be known as the Kaiserin Augusta Victoria Stiftung. It will be open to the German public. In this building concrete has been used in a different manner from that in general use.

The use of oil fuel is rapidly extending, and the time may be near when it will have an appreciable effect upon the demand for coal. In the United States a bill has been introduced into the Senate which provides for the creation of a reserve oil-fuel supply for naval purposes. It also authorizes the Secretary of the Navy to acquire suitable land adjacent to the oil fields of Oklahoma for the erection of tanks for the reserve oil supply, to establish buying agencies, and obtain all information necessary with regard to the cost per barrel of the oil required, and the cost per mile of pipes laid. The Secretary is authorized to purchase as fast as the market conditions will justify, 25,000,000 barrels of oil for the reserve supply of the United States navy. The British Admiralty has also given a big order for oil to be used in the navy amounting to 225,000 tons.

* Lowell Observatory Bulletin No. 43.