A Beginner's Guide to Low-Cost Astrophotography: How to Photograph the Moon in an "Astronomical" Way (Part 2)

Last time, we introduced how to photograph the lunar surface using astrophotography, starting from scratch with equipment selection, setup, planning, and capturing raw footage. To address any questions that may have arisen from the previous content or minor issues that may occur during practical operation, I will provide supplementary explanations here:

1. **To reiterate the importance of a motorized mount (electric theodolite or equatorial mount).** We don't necessarily need it to track with extreme precision, but rather the hand controller and the motor itself. Because astronomical telescopes are essentially like super telephoto lenses, even the slightest movement can cause severe image jitter. It's difficult to achieve a stable image through purely manual adjustments, while the image obtained using a handle and motor will be far, far smoother.

2. If the planetary camera still fails to focus even when the focusing travel is extended to its limit, you can reinstall the 90-degree refracting eyepiece assembly (usually included with the original refractive lens). This assembly can effectively shorten the focusing travel, but be sure to secure it firmly.

3. For beginners, the built-in calibration of the controller is rather cumbersome and the operating conditions are quite demanding (for example, finding a bright star to calibrate in a city with severe light pollution may be difficult). However, it is advisable to perform calibration if possible; if calibration is not available, manual tracking will be necessary to keep the moon centered in the frame.

4. When you feel the moon is about to enter the frame, remember to lower the motor speed using the controller (usually the maximum speed is 9, adjusting it to around 5 is more suitable) to ensure the moon can slowly enter the frame.

Image: Scene from the day of the footage shoot, before the actual filming. The shoot took place right outside a brightly lit apartment building. Lunar photography has very low requirements for light pollution, so the shooting location was very flexible.

Next, we'll begin the main content of this episode: **post-production processing of the footage.**

Last time, we mentioned that the post-processing workflow for astrophotography mainly revolves around the core step of overlay. Next, let's understand in the simplest way why overlay is so important in astrophotography, and the principles behind the three basic steps of color grading: " **alignment-overlay-sharpening"** .

Take lunar photography as an example. When you obtain a single image of the lunar surface, even with proper operation and accurate focus, it's often not very clear. This is because the moon is far from the camera, separated by the atmosphere, and atmospheric disturbances severely interfere with image sharpness. Naturally, we want to sharpen the image to improve detail clarity. However, in practice, we find that

sharpening a single photo results in a lot of unnatural textures, and the entire image becomes very noisy, leading to a poor visual experience.

Image: The effect of sharpening a single image, which can be compared with the effect of sharpening after overlaying.

This is because a single blurry image cannot provide enough accurate information for graphics calculations, resulting in inaccurate sharpening calculations and making errors more apparent. **An effective solution is to take multiple images of the same object. Since each image will inevitably have data discrepancies, this provides the computer with a large amount of additional information for calibration, "neutralizing" errors and improving image quality.** This is the basic principle of "noise reduction through overlay" in photography. It is also because of this principle that I recommend using a high frame rate planetary camera for photographing planetary and lunar surfaces, as its efficiency is far superior to that of ordinary cameras.

Tips: Why is there noise?

Noise, or more professionally, noise, is indeed an anomaly in an image. The causes of noise are varied, but fundamentally, it stems from unavoidable errors in the "light signal-to-electrical signal-to-light signal" conversion process during image processing. This leads to discrepancies between the final generated image and the ideal image data, resulting in brightness (color) deviations from normal visual perception—visible noise. The less light information available from the environment, the more prone to error. Furthermore, when the signal is amplified after digital processing, these errors are magnified exponentially. A macroscopic example is when using a mobile phone to take photos at night and then trying to brighten the image; this results in numerous "snowflakes" caused by computational errors.

In short, to better perform post-processing adjustments such as sharpening, we need to prepare a large amount of data through overlay techniques; and to ensure successful overlay, we first need to align all the images. Each step can be accomplished using

different software, but the general principle remains the same. The following describes a relatively simple and common workflow.

Tips: Although there are many illustrations below, don't be afraid, there are actually very few places where we need to operate.

1. Alignment - PIPP

If you watched the previous episode and tried shooting, you'll notice that the moon in the raw footage will inevitably move and shake; and the cheaper the equipment and the less skilled you are at shooting, the more noticeable this shaking/movement will be. The free software PIPP aims to remove these anomalies as much as possible, making the image more stable and easier to overlay in the next step.

Open PIPP and drag in the footage you just shot. Except for the settings mentioned below, which are essential, the rest can be ignored for now.

- **Determine the material type**

In the "Source files" section, select the necessary options under "Optimize Options For" in the lower right corner. If you photographed the entire moon, select "Solar/Lunar Full Distance"; if you only photographed a portion, select "Solar/Lunar Colse-up".

- **Determine the output color**

In the Processing Options section, note the green option "Convert Color To Monochrome". This option is checked by default, and when checked, the final image will inevitably be black and white. We will keep this option checked by default. If you want to process the moon in color, remember to uncheck this option.
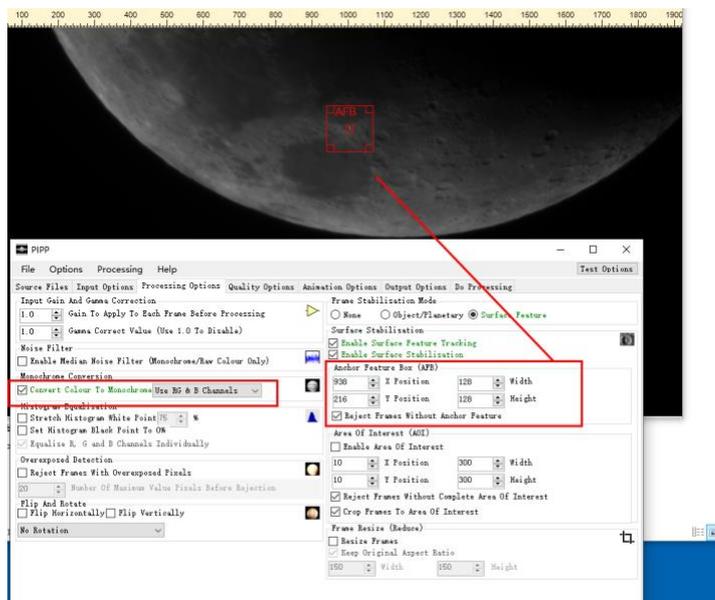

- **Determine the calibration area (AFB).**

After determining the source material type, a red Anchor Feature Box (AFB) will pop up in the source image area. Drag this red box to an area in the image with more texture details or stronger contrast to facilitate program alignment. You can also adjust the AFB area size in the right-hand sidebar of the "Processing Settings," but the default settings are usually sufficient.

- **Export and save as**

After confirming the above options, simply click "Start" under the "Do Processing" section. After processing is complete using the default options, the system will generate a video with a "pipp" extension and automatically open the folder containing the saved AVI video. Open this video, and you'll find that the moon in the frame is no longer moving, but is firmly fixed in a certain position on the screen.
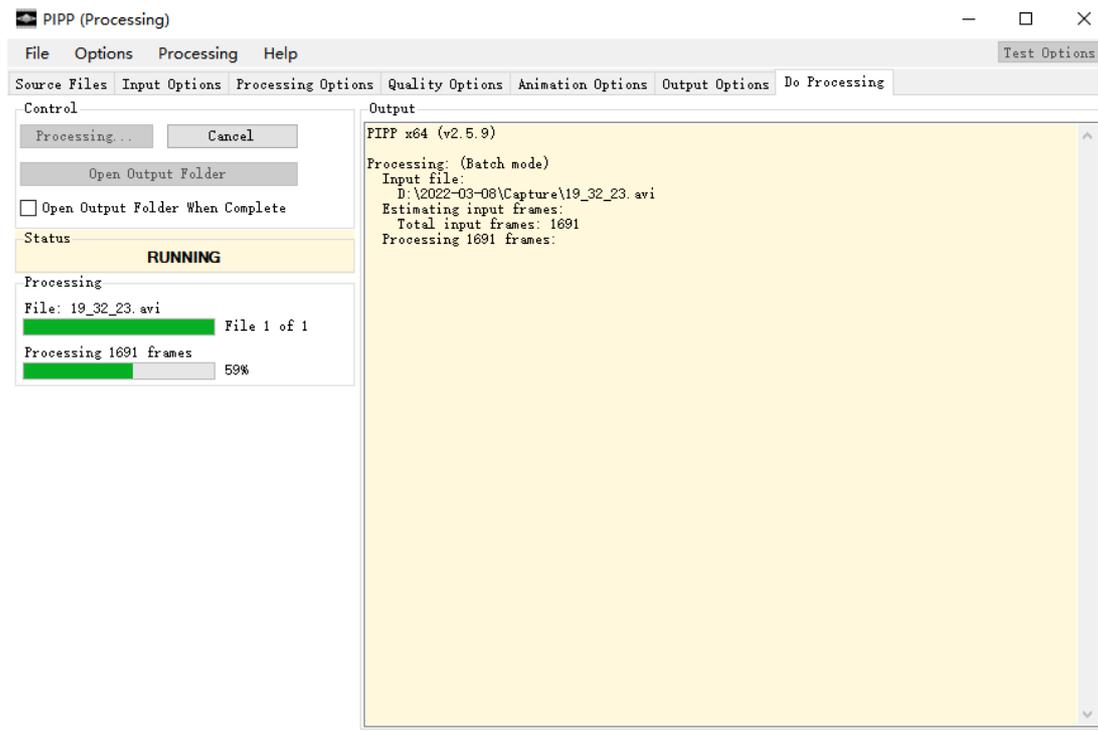
2. Overlay - AutoStakkert! (AS!)

Similar to PIPP, AS! is also a free software with a single purpose and simple operation. Furthermore, AS! and PIPP can be seamlessly integrated, which is one of the reasons I recommend these two programs. AVI files exported via PIPP can be directly dragged into AS! and subsequent operations can be performed immediately (if the footage hasn't been processed by PIPP, there's a chance of errors when dragged in).

Similarly, apart from the settings mentioned below that are required, the rest can be ignored for now.

- **Analyzing the quality of the materials**

Drag in the video file generated by PIPP, select "Surface" under "Image Stabilization" on the left, then use Ctrl+click to select the analytical area in the green box in the screen area, and then click "Analyse". The program will evaluate the quality of the material.
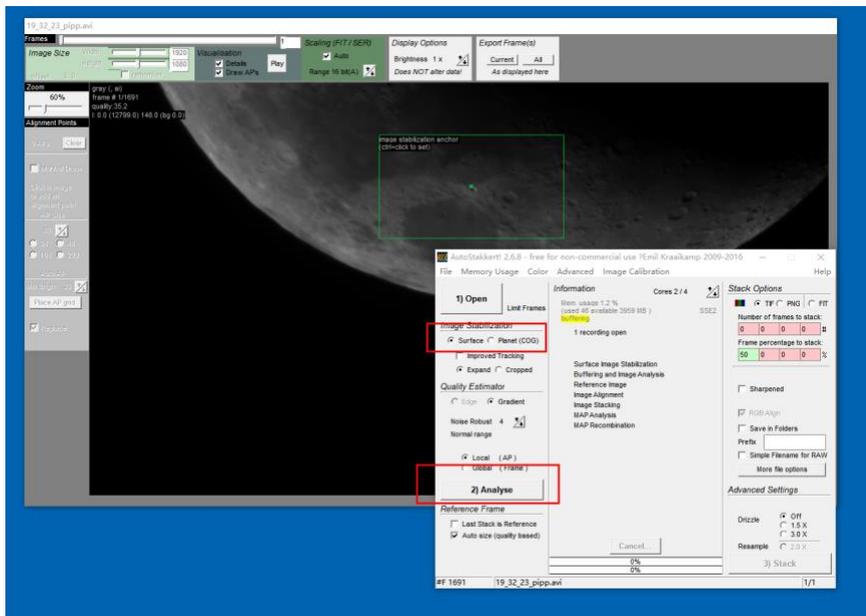
- **Selective overlay**

After the evaluation is complete, a quality graph will pop up in the center of the interface. Then, based on this graph, select the percentage of frames to stack in the "Stack Options" on the right: if the green curve is generally higher than the 50% horizontal line, you can choose to stack 50%-75%; if it is generally lower than the horizontal line, choose to stack 25%-30%, don't be greedy.
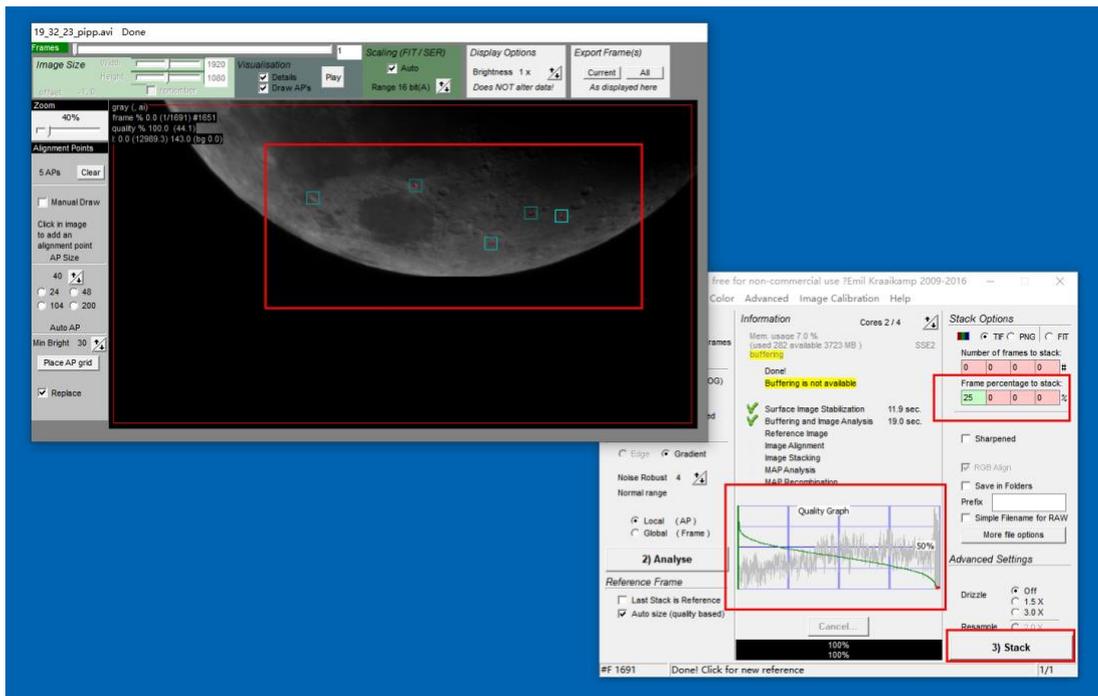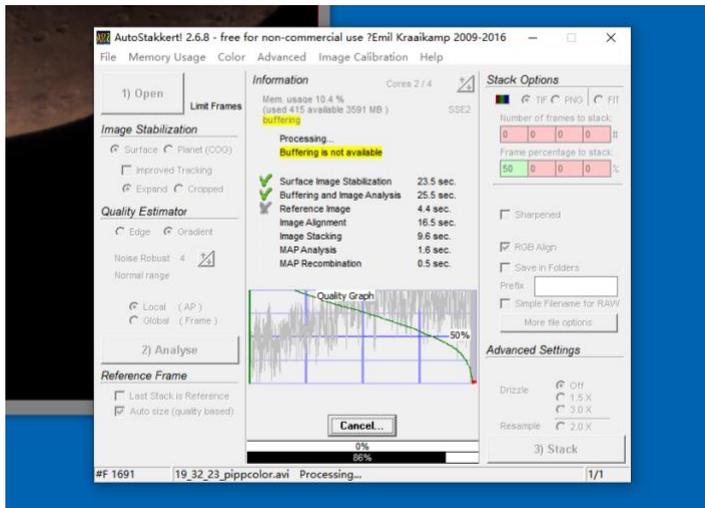
Image: The same source material may yield different results depending on the resolution region.

- Select the overlay anchor points and export.

Select 3-5 areas with abundant texture or high contrast on the screen as overlay anchor points, and then click "Stack" in the lower right corner. The system will then generate a TIFF image file, which will be saved in the same folder as the video exported by PIPP by default.
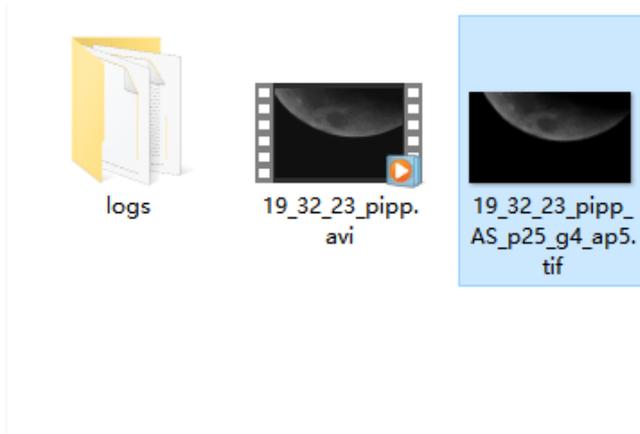

3. Sharpening and other post-processing - Photoshop

If you don't have Photoshop, you can choose any other similar software that can open TIFF files and perform sharpening.

Open the file and select Filter - Camera Raw Filter. Although we didn't import a Raw file, this module integrates many adjustment functions, making it easy for beginners to find what they're looking for. Those with Photoshop experience can also choose other methods.
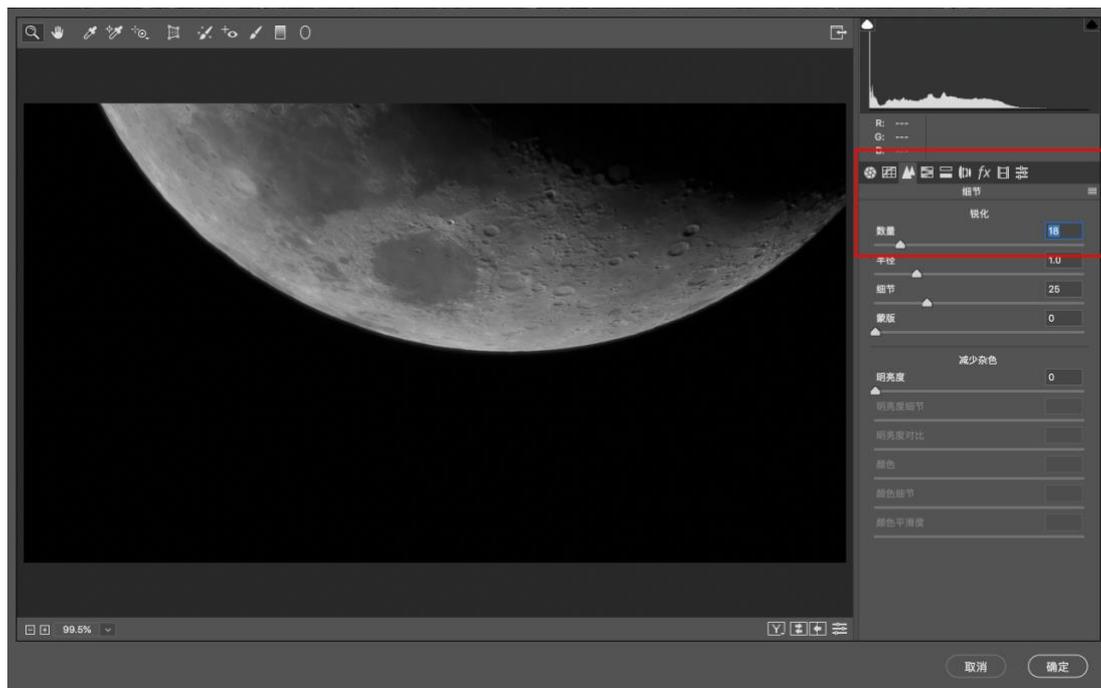
In the Camera Raw filter, find "Sharpen," and then drag the "Amount" slider under Sharpen directly to the right. If you've followed the standard procedure before, you'll find that even if we simply drag the sharpening slider to the limit, there won't be any obvious graininess or color banding.

Image: Detail comparison between overlay sharpening (top) and single-image sharpening (bottom). It can be seen that after the same significant sharpening, the latter exhibits severe graininess. The higher the quality of the overlay material, the more pronounced this difference becomes.

We can even perform another round of sharpening after saving this round of operations, but this time it's more likely to produce graininess. We can zoom in on the image to 200% and continue sharpening until no image abnormalities appear. For the remaining steps, we can adjust brightness, contrast, etc., according to our own preferences, but remember to do so moderately and try to keep the image as smooth and natural as possible.

- **Composition, Refinement and Preservation**

Now we've reached the final stage! You can use the built-in cropping tool in Photoshop to recompose the image; you can also use the text tool to add your own name, the shooting time (for lunar photography, recording the shooting time is relatively important information, as it helps in learning and understanding lunar phases), and add your own designed signature or watermark. Then select " Save As " to save the result as a JPG or PNG file, setting the image quality to the highest level. This will output a standard image format that we can use for sharing on social media.
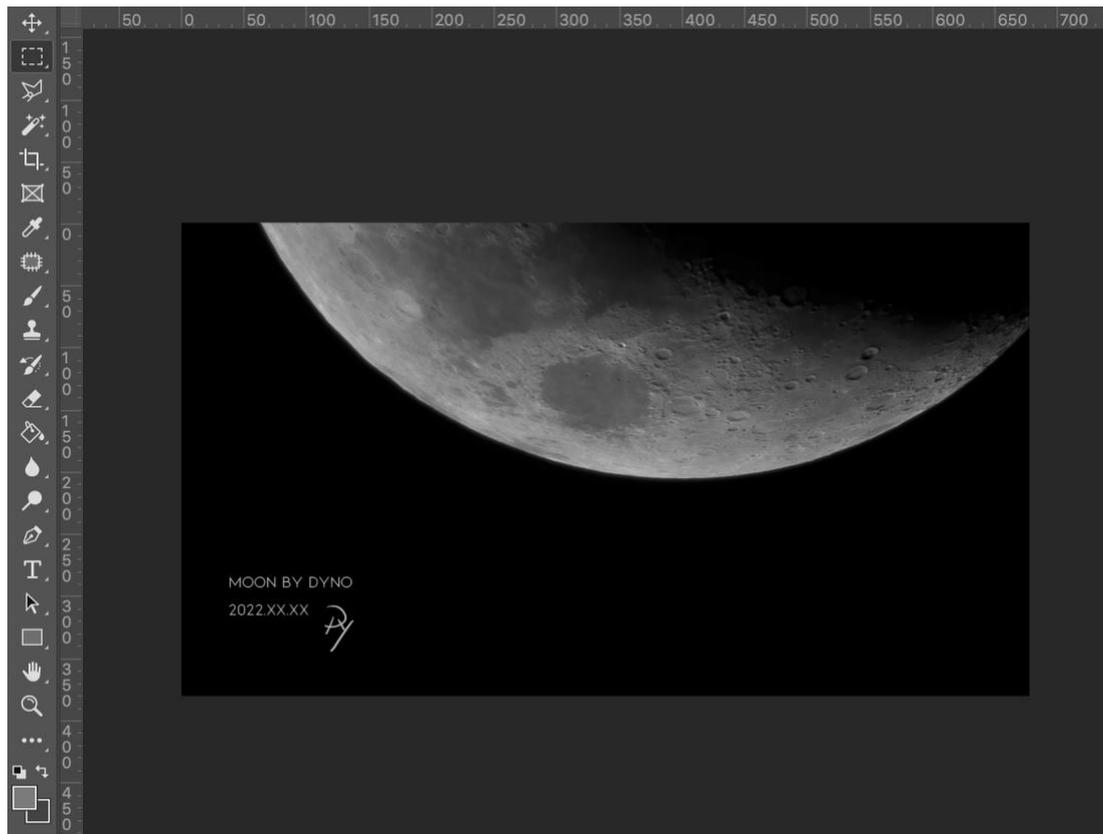
Tips: Sometimes a signature watermark can also help with composition. In the example image, the focus is on the upper right, so I placed the signature, date, and other information on the lower left side of the image to balance the composition.

summary

This concludes our most basic attempt at astrophotography. Of course, it has many shortcomings: for example, the telescope we chose in this example had a relatively small field of view, making it difficult to capture the entire moon; the lack of proper calibration resulted in a limited number of frames for overlay (around 1500 frames in this example, while achieving a good effect might require 10,000 or even more); and due to a lack of experience in adjusting white balance, we directly chose black and white photos, etc. However, setting aside these non-core elements, we have been able to complete a genuine "astrophotography" session with minimal cost and have mastered the most core shooting principles and techniques.

Compared to the highly controversial "AI-powered moon photography," our methods are very realistic and rigorous. And if photographing the moon ignites your interest in exploring the stars, then even more exciting subjects await you — high-resolution

images of lunar craters, Saturn, Jupiter, sunspots, galaxies, nebulae⋯ all beckoning you from afar, waiting to be discovered.