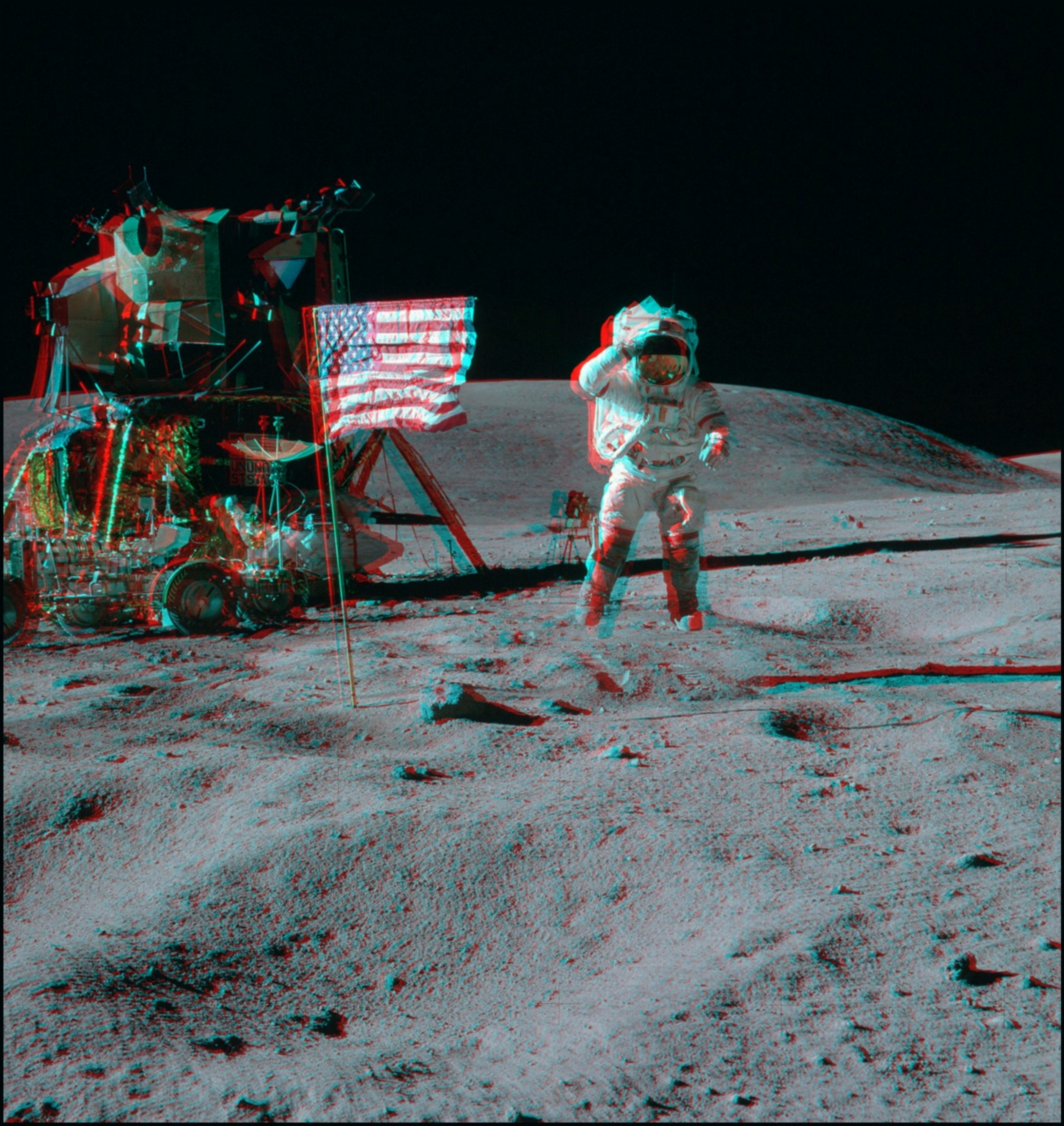
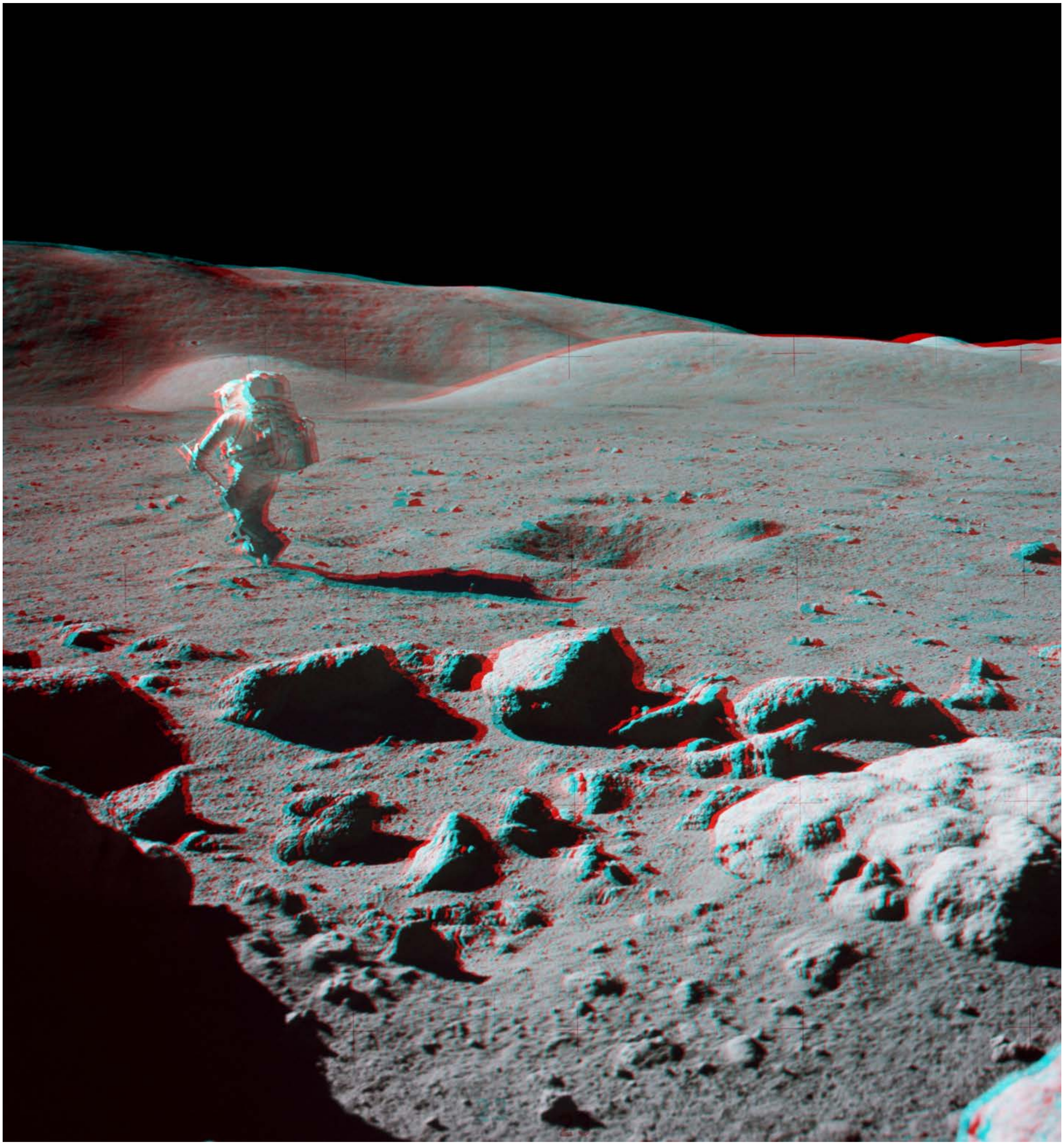
Apollo on the Moon in Perspective



3D Anaglyph Composites by Ronald A. Wells



Frontispiece: Apollo 17 Lunar Module Pilot (**LMP**) and geologist Harrison H. (Jack) Schmitt running back to the rover in lunar gravity at Station 5, Camelot Crater.

Cover Caption: Apollo 16 Commander (**CDR**) John Young in an “airborne” salute to the flag.

APOLLO ON THE MOON
IN PERSPECTIVE

Apollo on the Moon in Perspective

3D Anaglyph Composites

by

Dr. Ronald A. Wells

Vol. 1

Tranquillity Enterprises, s.p.
Abingdon, VA 24211

As described in the **Prologue**, all anaglyphs presented in this book are personal derivative works of art produced by the author from original NASA photos.

To the courageous Apollo astronauts,
who blazed the first trails to another world.
They personified American Exceptionalism at its finest;

And to the thousands of men and women,
who made their journeys possible.
They embodied “all mankind”.

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*****The Apollo 16 LM ***Orion*** was delayed in landing by 6 hours because of the need to overcome mechanical problems that occurred in both the **LM** and the **CSM** after they separated in lunar orbit. The title of the Apollo 16 section consequently also reflects the fact that without René Descartes, the French mathematician, there would have been no landing. The "Cartesian" coordinate system, named for Descartes, was used in the LM computer to reference the orientation of the spacecraft; analytical geometry developed by Descartes led to the formulation of calculus, which was "integral" to spacecraft guidance; and the general region chosen for the landing of the LM also bore the name of Descartes— all together a remarkable coincidence!

Acknowledgements

Few books ever see the light of day without the generous help of friends and colleagues, who provide needed advice, source material, proof reading and commentary, suggestions and encouragement. No less is this true for the current volume which has been a labor of love for a number of years. Although the book was assembled in a few short months, most of the anaglyph photos were created several years ago before I decided that a collection of them would be of interest to many people in demonstrating the rough nature of even the "smoothest" areas of the lunar surface.

The actual impetus to provide representative views from each of the six landed missions in book form was due to President George H. W. Bush, who saw only three or four of them during the summer of 2012 as section dividers in a book that I had sent him. Referring to the anaglyphs in a thank you note dated Sept. 24, 2012, he wrote: "They're fantastic and Barbara and I enjoyed them very much." During a speech at the *National Air & Space Museum* marking the 20th anniversary of the Apollo 11 Moon landing, President Bush called for the creation of a permanent lunar outpost. Had Congress embraced his 1989 *Space Exploration Initiative*, American astronauts might be living and working today at a base located in the Moon's south polar region.

I am indebted to Dr. Eric Jones, whose *Apollo Lunar Surface Journal* has served many space enthusiasts as the primary source for all things "Apollo" (http://www.hq.nasa.gov/alsj/). I am grateful for the long years' association as a co-editor along with a number of others far more knowledgeable than I in the intricacies of the Apollo Program. The *Journal*, of course, provided most of the high resolution photos that were used in the constructions of the anaglyphs. Many of those digitized scans were provided to the *Journal* by Kipp Teague, who maintains a very large collection of photos in his *Apollo Image Gallery* (http://www.apolloarchive.com/apollo_gallery.html).

I owe a huge debt to my friend and colleague William F. Mellberg, an aeronautics and space historian whose book *Moon Missions* was frequently consulted for "forgotten" facts. I have never met anyone who knows more about the aircraft of all nations, as well as the spacecraft of those few countries who have built them (not to mention ships and railroads). He is much better than a walking *Jane's*! I have appreciated the countless hours of conversations we have had on a variety of subjects. I am also deeply grateful for his proof reading and suggestions for the present book.

I also express my appreciation to Dr. Paul Spudis and his wife Anne for their many communications and for proof reading and suggestions for the book. Their knowledge of the Apollo program has proven invaluable. Dr. Spudis's two blogs offer perceptive and logical insights into lunar and deep space exploration: http://www.spudislunarresources.com, and http://blogs.airspacemag.com/moon/. Both should be required reading for all space enthusiasts.

I am grateful to Professor Mark S. Robinson, School of Earth and Space Exploration, Arizona State University, for advanced copies of the spectacular high resolution scans of the Earth and the Moon images used to make the anaglyphs given in the Epilogue, and for permission to use the EVA route maps for Apollos 15, 16 and 17. His direction of all aspects of the cameras on **LRO**, as well as the digital scanning of the prime Apollo metric, panorama, and Hasselblad films is providing a firm foundation for the continued exploration of the Moon.

Special thanks must be given to Colin Mackellar, my friend and colleague in Sydney (Merrylands West) Australia, for proofreading and comments, and for the long series of emails that culminated in our first meeting at the 40th anniversary of the Apollo 11 mission in Canberra in July, 2009. He designed and maintains the Honeysuckle Creek (**HSK**) Tracking Station website which provides the history of the radio telescope (**DSS-46**) station which played such an important role in the Apollo and other programs (http://www.honeysucklecreek.net/). He was instrumental in starting the search for the still missing Apollo 11 HSK tapes which recorded the first images of Neil Armstrong's steps down the LM ladder.

A very early version of these anaglyphs with only brief captions was seen by Apollo 7 Astronaut Walt Cunningham, whose 11-day mission with Wally Schirra and Donn Eisele performed the critical Earth orbital tests of the Apollo Command and Service Module after the disastrous Apollo 1 fire threatened to bring America's Moon program to an end. He shared them with his colleague Apollo 12 Astronaut Al Bean. I was gratified to learn from Walt that Al had remarked that he had wished he had seen them earlier in his career because they would have been an enormous help in producing his paintings. Walt later saw a full draft of this book, and in an email dated Nov. 4, 2013 he wrote: "I finally got the time to get into your Vol. 1 and am enjoying it a lot. As I was reviewing the pictures, I realized how much it was improving my perspective of the lunar surface."

Finally, I owe a deep debt of gratitude to Dr. Harrison H. (Jack) Schmitt, geologist and Apollo 17 Astronaut— the only scientist to walk on the Moon. He organized NASA's Energy Office after his Moon mission and was its first administrator before serving as U.S. Senator from New Mexico. A previous chair of the NASA Advisory Council, an ongoing consultant and a corporate board director, he has given me the privilege to serve as the co-Editor, along with Bill Mellberg, of his website, http://americasuncommonsense.com/, and as the Editor of his three books published there. His knowledge of the U.S. Constitution rivals any Supreme Court judge and has served him well in the production of the essays and the books on his website. His writings, both geopolitical and scientific, are articulate, erudite, thought-provoking, visionary, and grounded in wide ranging experience. I am grateful for his permission to have the PDF version of this book posted on his website, for comments on the book, and for the suggestion to include anaglyphs of his stereo pairs of the important rock sample 70019 which he brought back from the Moon (**Fig. 28** et seq. in the Apollo 17 chapter).

Mission Title Page Photo Credits

The 3D anaglyphs used on the Apollo J-mission (A15, A16, A17) title pages were produced from the metric cameras (medium resolution) carried in the Scientific Instrument Module (**SIM**) bays of the Service Modules. On the return journey of each of those missions, the Command Module Pilot (**CMP**) had the task of recovering the film canisters from both the metric camera and the narrow angle panorama camera by exiting the Command Module (**CM**) on a tether and moving down to the SIM bay to retrieve the film (see A15 **Fig. 1** as an example of the distance involved). The metric camera canister contained 460 m of film, whereas the panorama canister contained 2 km of film! The latter weighed 25 kg. The high resolution scans of these films produced by the Arizona State University is a testament to the quality of the images, which have only recently been surpassed by those of the Lunar Reconnaissance Orbiter (**LRO**).

The three anaglyphs presented here were produced from the PNG-formatted images which had a scanner resolution of 7.6 m/pixel. About 3-4 pixels are required to resolve a 25 m object. These images were converted to 600 dpi jpeg frames before processing with the StereoPhoto Maker program. The final anaglyphs were reduced to 300 dpi for this book to ensure significant enlargement in the reader's viewer. The surface anaglyphs, however, are only 200 dpi to keep the PDF file size manageable because of their large number. There are no metric images of the Apollos 11, 12, and 14 landing areas because those missions had no **SIM** bay cameras, and the J-mission orbits did not pass over them.

Apollo 11: From NASA photos AS11-40-5961, and -62 with modifications because 5961 was taken ca. 60 m from *Eagle* whereas 5962 was taken at about half that distance.

Apollo 12: From NASA photos AS12-46-6746, -47, -48, and -49.

Apollo 14: From NASA photos AS14-66-9277, -78, and -79.

Apollo 15: From NASA/ASU photos A15-M-0414, and -0415, Rev. 16.

Apollo 16: From NASA/ASU photos AS16-M-0162, and -0440, Revs. 17-18, respectively.

Apollo 17: From NASA/ASU photos AS17-M-0447, and -0596, Revs. 14-15, respectively.

Acronyms

ALSEP: Apollo Lunar Surface Experiments Package. Several scientific instruments bundled together in the SEQ (scientific equipment) bay and carried out to a site far enough away from the LM so as not to be disturbed. The instruments were fitted to either end of a carrying pole, which the astronaut carried like a dumbbell to the site where he then deployed the various experiments.

ALSSCC: Apollo Lunar Surface Stereo Closeup Camera (sometimes also ALSCC, with "stereo" omitted). A twin lens 35 mm stereo camera placed at the end of a walking stick-carrying device containing batteries, film, and mechanism for winding the film. The astronaut could make direct stereograms of the lunar soil in an area about 3" (7.6 cm) square. The camera was only carried on the Apollo 11, 12, and 14 missions. A total of 100 images were obtained from them.

ASU: Arizona State University.

CDR: Commander. The mission leader's title. From Apollo 14 onwards, the mission commander had red stripes on his helmet, arms, and legs to distinguish him from the LMP in TV scenes and photographs.

CM: Command Module. The cone shaped part of the spacecraft containing the three astronauts which was the only part of the giant Apollo-Saturn vehicle that returned to Earth.

CMP: Command Module Pilot. The astronaut who stayed behind in lunar orbit while the CDR and LMP landed on the surface. He normally sat in the middle seat of the CM because the CDR flew in the left hand seat as commercial airline captains do. During critical operations such as turning the CSM around and linking with the LM, or changing spacecraft orientations, the CMP flew in the left seat to perform his assigned tasks.

CSM: Command and Service Module. The CM attached to the Service Module, the latter of which contained the engine, fuel, oxygen, water, batteries, the SIM bay, antennae, and the like.

DSS-46: The designation given to the 26 m radio telescope first constructed at Honeysuckle Creek Tracking Station officially opened on March 17, 1967 in support of the Apollo missions, but later used for other space missions until 1981 when the antenna was moved to Tidbinbilla (see http://www.honeysucklecreek.net for further details).

EASEP: Early Apollo Surface Experiments Package. The first version of the ALSEP which had fewer experiments. It was flown only on Apollo 11.

EVA: Extra Vehicular Activity. Any operation conducted outside the spacecraft.

FDO: Pronounced "Fido". The Flight Dynamics Officer whose responsibility is the computation of all aspects of the spacecraft trajectories.

fov: Field of View. The angular dimension of a camera scene. The angle of view of such a scene subtended by the camera lens.

GOES: Geostationary Operational Environmental Satellite. A continuing series of weather satellites first launched in October 1975.

GSFC: Goddard Space Flight Center.

HFE: Heat Flow Experiment. One of the scientific instruments carried in the ALSEP which measured the thermal gradient or rate of heat flow from the interior of the Moon through the regolith.

HSK: The designation given to Honeysuckle Creek Tracking Station where **DSS-46** operated.

HTC: Hand Tool Carrier. The small portable device carried by the Apollo 12 astronauts during their two EVAs. It contained geological tools and the "Dixie cup" dispenser— a cylindrical container that dispensed plastic bags for holding small geological samples. The HTC can be seen at the right of **Fig. 11** in the Apollo 12 section. The Dixie cup dispenser is mounted on the extreme right, outer part of the HTC.

LO: Lunar Orbiter. The first lunar reconnaissance spacecraft whose principal purpose was to obtain high-resolution photos of possible landing sites for the Apollo program. Five orbiters were successfully launched between 1966 and 1967. The cameras used film which was developed on board the spacecraft and then electronically scanned before data transmission to the Earth.

LM: Lunar Module. The bug-like spacecraft that landed astronauts on the lunar surface during the Apollo missions. It consisted of a lower descent stage on top of which was mounted an upper ascent stage. The first contained a large throttleable engine for the landing. It also formed the launch platform for the ascent stage. The latter is the part of the LM visible in LRO photos of the landing sites. The ascent stage contained its own engine with fixed thrust.

LMP: Lunar Module Pilot. The third Apollo crew member who landed on the lunar surface with the CDR. The LMP did not actually fly the LM although he was trained to be able to do so in case of an emergency. The CDR actually flew the LM. Some of the tasks of the LMP were to perform operations to support the CDR, such as calling out altitude and descent rates during the landing and entering data into the guidance computer.

LRO: Lunar Reconnaissance Orbiter. A lunar orbiting satellite launched in June 2009 and still in operation as of 01/01/2015. The LRO Cameras, LROC WAC and NAC, consist of a wide angle camera and a narrow angle high resolution camera.

LRRR: Lunar Ranging Retro Reflector. A planar arrangement of corner reflecting cube-shaped prisms which will reflect incident light directly back to the source no matter what the angle of incidence happens to be. Three were carried to the Moon on Apollos 11, 14, and 15. The first two contained a hundred 3.8 cm cubes; but the Apollo 15 device was three times larger, having 300 prisms arranged in a hexagonal pattern. The arrays are still used today to provide precise measurements of the lunar distance.

LRV: Lunar Roving Vehicle. The small dune buggy that carried the astronauts across the lunar surface on Apollos 15, 16, and 17. It was folded in half into one of the LM equipment bays at launch. When lowered to the surface by the astronauts, it automatically unfolded to 5 × 10 feet with the seatback tops 5 feet off the ground. The bottom clearance was 14 inches. The unloaded weight of 460 lbs increased to 1500 lbs when fully loaded with the two astronauts and their equipment. Four 1/4 horsepower motors on each of its wheels provided front or rear wheel steering, or both. The top speed of 12 kph on level ground was broken by Gene Cernan at 18 kph on the drive down the slope from Lara Crater at Station 3 towards Shorty Crater at Station 4.

NOAA: National Oceanic and Atmospheric Administration. A federal agency charged with observations and conditions of the oceans and atmosphere, a part of the U.S. Department of Commerce.

MESA: Modularized Equipment Stowage Assembly. A stowage bin near the foot and to the left of the LM ladder beneath the LMP's window. It contained, among other items, the TV camera that was deployed to take pictures of the initial steps on the Moon. It opened automatically when a D-ring was pulled by the astronaut as he descended.

MET: Modular Equipment Transporter. A small wagon only flown on Apollo 14 that carried tools and equipment needed for sampling. A 16 mm film camera was also mounted on it to record various activities. It was supposed to be pulled by a handle, but the rubber tires made it very difficult to maneuver in the soft lunar soil so that the astronauts often had to carry it between them.

NASA: National Aeronautics and Space Administration. The federal space agency formed by President Eisenhower in 1958 for the purposes of carrying out the nation's exploration of space.

PDI: Powered descent initiation, the beginning of controlled descent to the lunar surface.

PSE: Passive Seismic Experiment. An ALSEP instrument designed to record natural seismic activity caused by moonquakes. The Active Seismic Experiment (ASE) measured seismic waves produced by the action of emplaced explosive charges detected by an array of geophones.

PSEP: A self-contained moonquake detector that had its own power source from an array of solar cells as well as its own radio transmitter. It was only carried on Apollo 11 (**Fig. 11**).

RTG: Radioisotope Thermal Generator. A radioactive power source that produced electricity by the decay of Plutonium 238. It provided power for the ALSEP experiments.

SCB: Sample Container Box. Containers in which geological samples were placed. They were stored on the rovers at each station visited by the astronauts during the last three missions.

SIM: Scientific Instrument Module. A bay in the Service Module which contained the metric, panorama, and stellar orientation cameras; a laser; and several spectrometers. On Apollos 15-16, small 80 lb subsatellites were also carried in the SIM bay, which were ejected into orbit just before the astronauts initiated the burn to return home.

SWC: Solar Wind Collector. A stand with an aluminum foil blind that collected high energy particles in the continuously streaming solar wind. The same wind carries helium-3, the helium isotope that could provide long duration, clean electric power. The terrestrial magnetic field deflects the solar wind from the Earth, a major reason for collecting samples of it on the Moon.

TEC: Trans Earth Coast. The portion of the homeward bound journey after TEI. "Coast" because no more power is required, apart from minor corrective thrusts.

TEI: Trans Earth Injection. The CSM engine burn that provides the energy for the spacecraft to break out of lunar orbit into the homeward bound trajectory. It always occurred on the lunar farside with respect to the Earth and, thus, out of communication with Houston.

TLC: Trans Lunar Coast. The portion of the outbound journey to the Moon after TLI. "Coast" because no more power is required, apart from minor corrective thrusts.

TLI: Trans Lunar Injection. The CSM engine burn that provides the energy for the spacecraft to break out of Earth orbit into the outbound trajectory to the Moon.

UV: Ultra Violet. That portion of the spectrum with wavelengths shorter than the violet end. A telescopic camera with UV sensitive film was carried only on Apollo 16. It was set up in the shadow of the LM to minimize sunlight scattered into the optics from the local surface. It can be seen in the cover photo and in A16 **Fig. 2**.

VIP: Very Important Person. Special parking spaces next to certain building entrances are often referred to as 'VIP parking'. That was the intent on using the term for the LRVs and for the fact that the world's population had front row seats to watch the lunar lift-off of the LM ascent stages through the TV cameras which were left on and operational until the batteries were depleted.

Apollo Crews of the Landed Missions

	Apollo 11: July 16-24, 1969	Apollo 12: November 14-24, 1969
CDR:	Neil A. Armstrong	Charles "Pete" Conrad, Jr.
LMP:	Edwin E. "Buzz" Aldrin, Jr.	Alan L. Bean
CMP:	Michael Collins,	Richard F. Gordon, Jr.

	Apollo 14: Jan. 31-Feb. 09, 1971	Apollo 15: July 26-Aug. 07, 1971
CDR:	Alan B. Shepard, Jr.,	David R. Scott
LMP:	Edgar D. Mitchell,	James B. Irwin
CMP:	Stuart A. Roosa,	Alfred M. Worden

	Apollo 16: April 16-27, 1972	Apollo 17: December 07-19, 1972
CDR:	John W. Young	Eugene A. Cernan
LMP:	Charles M. Duke, Jr.	Harrison H. "Jack" Schmitt
CMP:	Thomas K. Mattingly II	Ronald E. Evans

The **CDR** and **LMP** landed on the lunar surface while the **CMP** maintained the **CSM** in orbit.

Note

Many readers find that prolonged use of red-cyan glasses in viewing too many anaglyphs can cause eye strain. Therefore, the author recommends that the reader periodically relax the eyes by using normal vision for a few minutes. This point is critical for the normal non-3D photos in **Fig. 17** of the green soil in the Apollo 15 section and for **Fig. 24** of the orange soil in the Apollo 17 section. These colors will appear washed out until the eyes readjust to normal vision.

PROLOGUE

Between July 20, 1969, the first landing, and December 14, 1972, the last lift-off, twelve Americans explored the surface of the Moon culminating a decade of exceptionalism that is not likely to be repeated for many years, even now 43 years since Neil Armstrong took that first step off the Lunar Module's (**LM**) footpad onto the lunar surface. The six landed missions were characterized by extra-vehicular activity (**EVA**) time outside the spacecraft ranging from 2 hrs, 31 minutes in one EVA for the first mission to 22 hours, 4 minutes in three EVAs for the last mission. The total accumulated time outside on the surface was 80 hours, 56 minutes, and 40 seconds for the 12 explorers. During this period, the astronauts made thousands of photographs in color and in black & white of rocks and boulders, craters, and panorama views of their surroundings.

The Apollo lunar surface photos are a national treasure, scenes which should be seen by everyone through the eyes of the photographers. Fortunately, with the aid of modern computer software many of the photos can be so viewed in 3D.

The procedures that were used on the Moon with the Hasselblad cameras to make panorama photos and to document each sample by side-stepping between two photos of a site, both in the cross-sun and down-sun directions, were developed by Ray Batson, Tim Hail and Gordon Swann of the Astrogeology Branch of the U.S. Geological Survey. Of course, assembling the photos by hand in those days was like working with a jig-saw puzzle and left seams at the joins. But clearly Batson understood that at some point in the future, the digitization of the photos and their manipulation by computer would produce seamless, spectacular views of the lunar surface. The author, and others like him who have worked with these images, has carried it a step further by extracting the stereo from them using the techniques he describes below.

The astronauts frequently had the 60 mm Hasselblad cameras attached to their chests to keep their hands and arms free, especially when making the full 360° or partial panoramas. In order to guarantee overlaps of adjacent frames as they turned in circles, the astronauts often made the overlaps as much as a half frame, and sometimes more because their cameras did not have digital view screens like modern cameras. These overlaps, having slightly different angular fields of view because of the turn and small side-step, can thus serve as the left and right components of a stereo pair. The wider the overlaps, the easier to construct wider views. Some of the anaglyphic overlaps themselves overlap, making 3D panoramic views of scenes possible.

Other photos provide left-right components by accident, such as those of the front cover anaglyph of John Young's salute to the flag. Charlie Duke's successive photos of the lunar leap caught Young at almost the same height, and Young himself had nearly the same pose of his body and his salute. Consequently, it was relatively easy for a computer program to match the two photos as a stereo pair because Duke moved just enough between the photos to change the angles of the field of view. Still other stereo pairs were deliberately made by the astronauts photographing a scene, side-stepping a pace or two, and re-photographing the scene.

But a few of those depicted here had to be manually adjusted such as the famous **Frontispiece** of Jack Schmitt running in lunar gravity at Station 5, Camelot Crater— the left-right photos of the scene itself, taken by Gene Cernan, only had Schmitt and his shadow in one frame, but not in the other. Cernan had just taken the photo without Schmitt, but heard him speaking and approaching from his right. So he waited until Schmitt came into the scene and re-photographed it. Cernan's slight movement in preparing for the second shot was sufficient to provide a genuine stereo terrain scene. But the author had to cut Schmitt and his shadow manually from the one photo, and with computer-aided measuring tools merge it into the other photo with appropriate offset with respect to the first photo. The computer program could then produce a stereo photo with accurately perceived 3D of the whole scene using the original with Schmitt and the modified second photo with him added. The result worked beautifully as illustrated in the **Frontispiece**.

All of the surface photos have been published online in the extremely valuable *Apollo Lunar Surface Journal* (http://www.hq.nasa.gov/alsj/). High resolution jpeg versions of the single photos from this journal provided most of the source material for this book. Many of them have also been made into 3D anaglyphs for that journal by various contributing editors. Others have also used those anaglyphs in different publications. But all anaglyphs used in the present book were produced solely by the author using the Corel PhotoPaint program, and the Stereo PhotoMaker program by Masuji Suto and David Sykes (http://stereo.jpn.org/eng/index.html/), a program recommended to him by the makers of the Planar stereo monitors. This versatile freeware program produces either correctly adjusted anaglyph stereos or side-by-side pairs for use in Polaroid, other similar stereo monitor types, or crystal glasses. In some cases, it was possible to use Arcsoft's PanoramaMaker program to stitch together a number of anaglyph panels into a seamless whole. Some were also stitched manually using PhotoPaint when the overlaps in the resulting anaglyph panels were too small to allow triangulation. These show seams. A few panorama scenes having anaglyph panels without overlaps, however, were produced as hybrids, i.e., with original mono photo panels inserted into the gaps.

While the anaglyph views of the lunar surface provide astounding depths of the scenery, it has been the author's experience that these same 3D scenes rendered by various Polaroid stereo monitors are unmatched in their realism, especially with color photos. However, the purpose of this book is to try to bring as much realism to the user at the lowest possible cost.

Not all possible photos that could be made into anaglyphs by one technique or the other have been included here. A selection has been made for each of the six landed missions. For example, the stop at Station 9, Van Serg Crater, on the Apollo 17 mission provided almost 100 anaglyphs in color and b&w at that stop alone.

The first few illustrations in each mission section are 2D non-stereo images, generally from the Lunar Reconnaissance Orbiter (**LRO**), or maps providing overhead views of the landing sites. A few of these from the early missions will contain numbers corresponding to the locations of ensuing anaglyph photos. Locations from the later missions, which have a number of stops or stations, are identified only by the station number. Other 2D photos have been included to illustrate a particular point or a location in a subsequent anaglyph.

April 20, 2015

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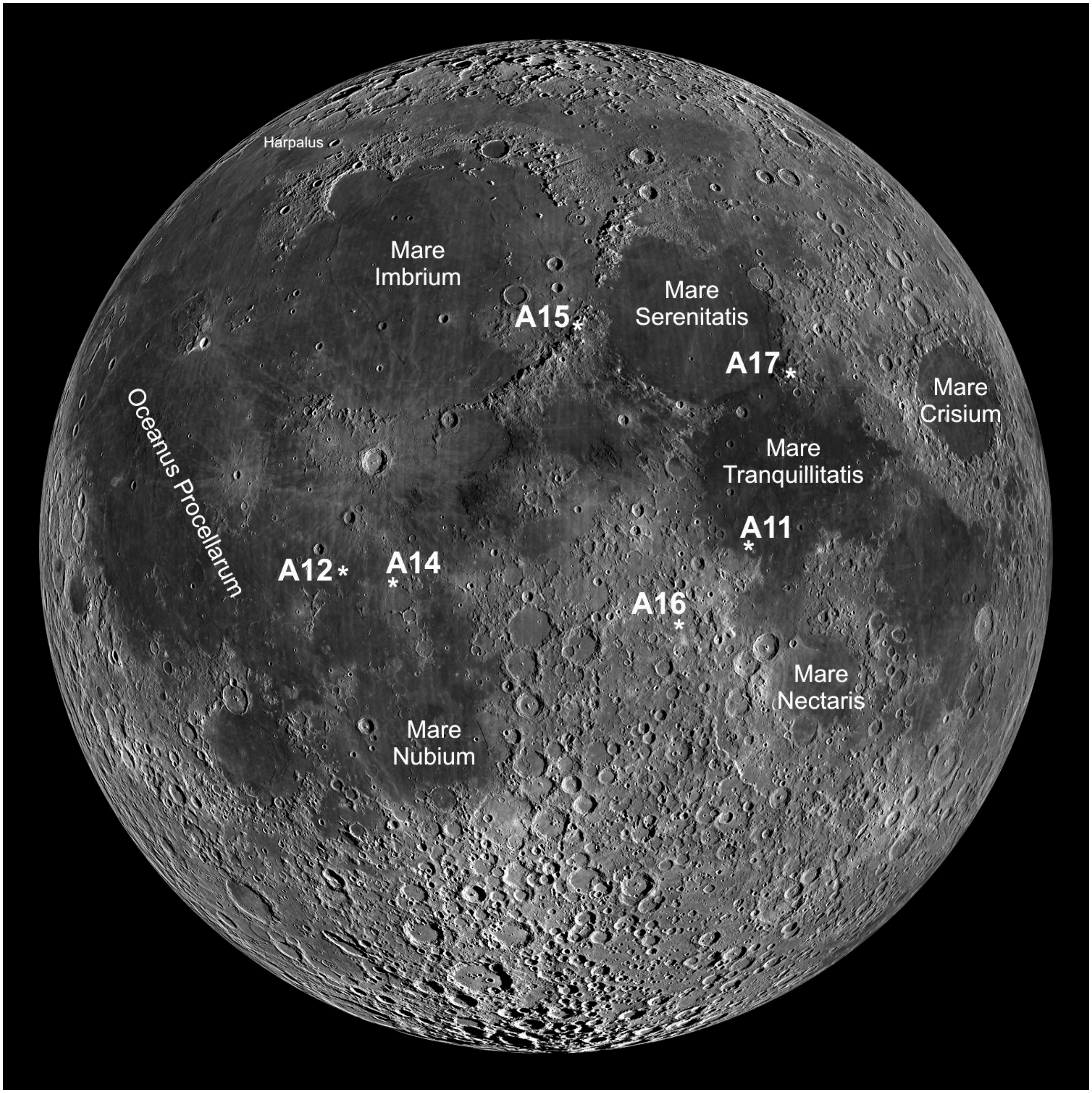
USA

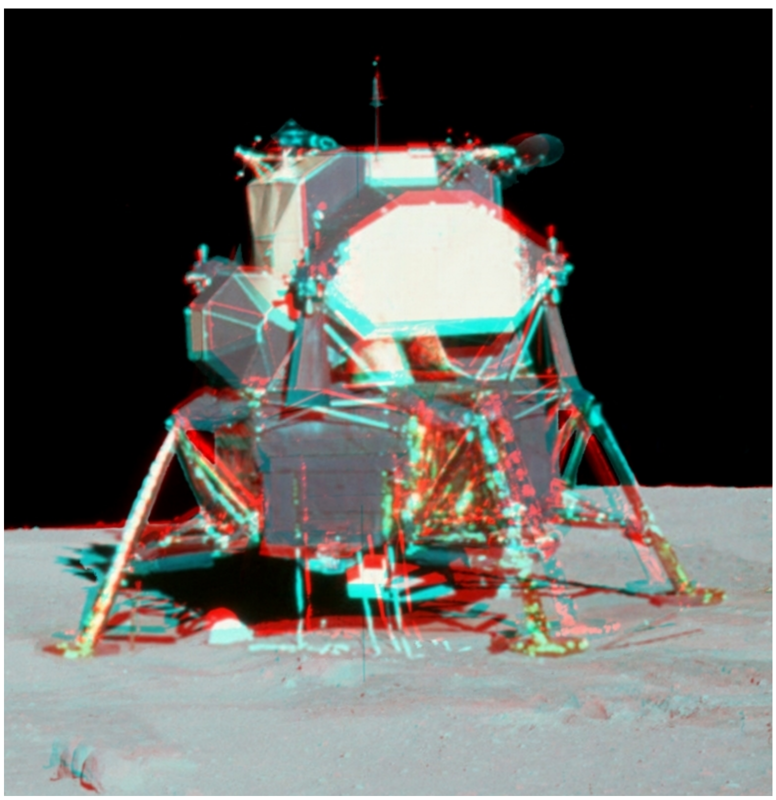


Apollo Landing Sites. The stars with adjacent lettered numbers mark the landing sites of the various Apollo missions. The Apollo 12 **LM** landed within a crater diameter of ***Surveyor III*** 2 years, 7 months later. ***Surveyor V*** was the only other unmanned landing near an Apollo site. Apollo 11 landed 2 years, 2 months later a little less than 100 km to the South of it. (Base map, NASA/ASU/GSFC photomosaic from **LROC** **WAC**).

APOLLO 11

***Eagle*, The First Landing**

July 20, 1969



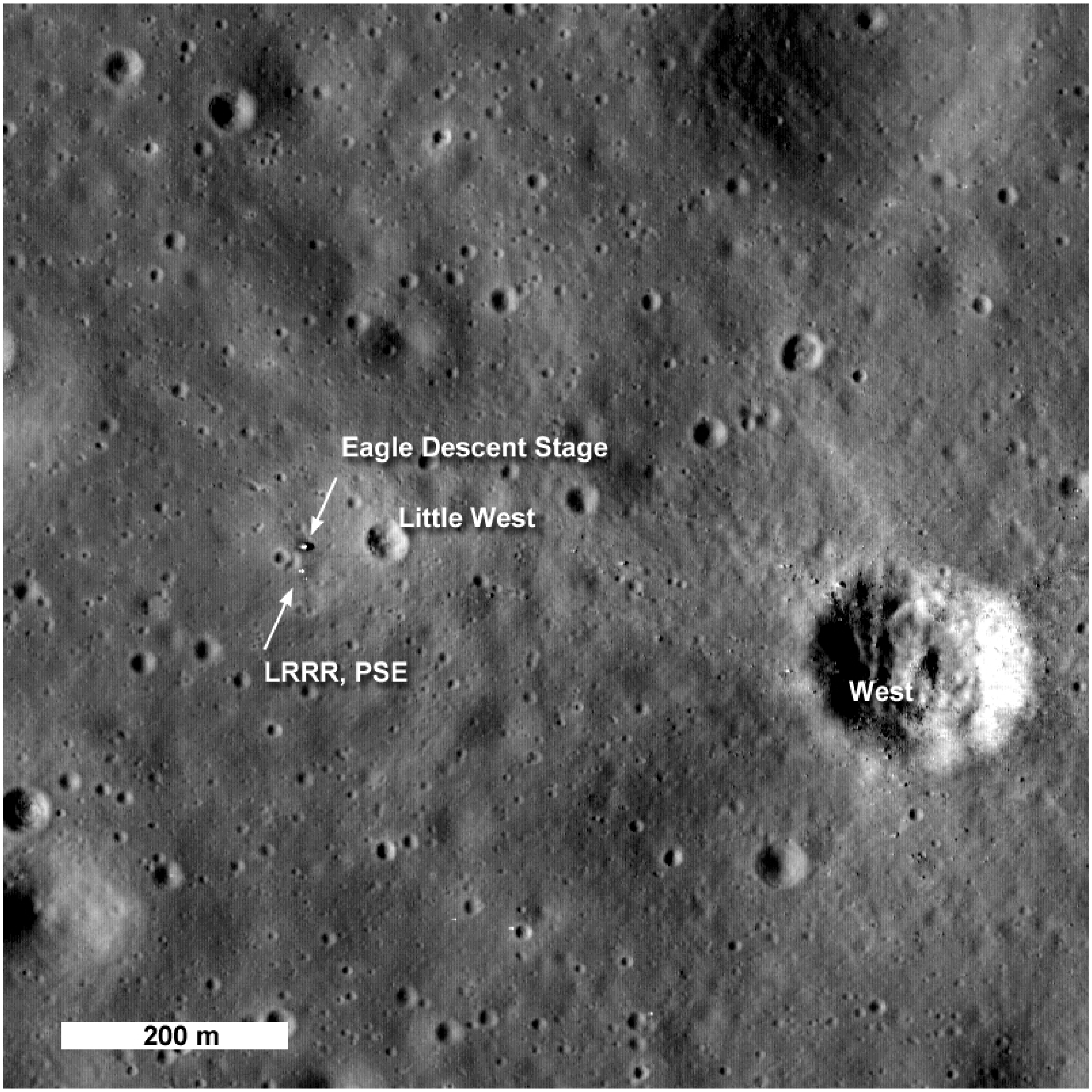


Fig. 1. The Apollo 11 landing area as seen by the Lunar Reconnaissance Orbiter. West Crater at right was the target selected by the **LM** computer. Had Neil Armstrong not taken manual control of the landing, the spacecraft would have crashed there or in the rubble field of boulders surrounding the crater (these are better seen in **Fig. 2**). Armstrong flew the spacecraft beyond and past Little West Crater before finally finding a spot safe enough to land. **LRRR** = Lunar Ranging Retro Reflector, a target which reflects laser beams back to the Earth. **PSE** = Passive Seismic Experiment, placed to detect Moon quakes (This actually should have been labeled **PSEP** = Passive Seismic Experimental Package, a design unique to Apollo 11). (NASA/ASU/GSFC photo).

(For landing site location, click **here**)

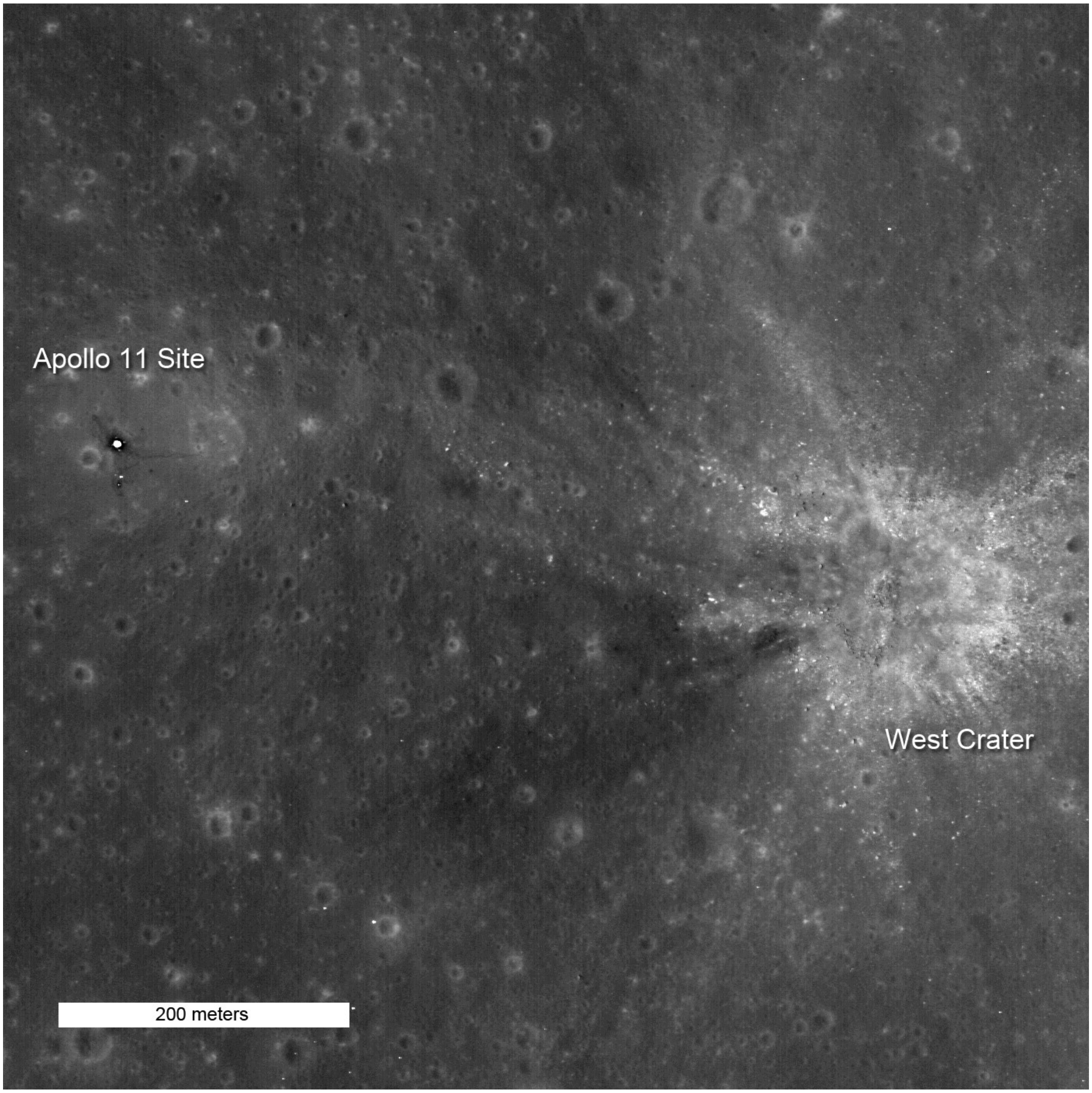


Fig. 2. Apollo 11 landing area as seen by the Lunar Reconnaissance Orbiter. The boulder field surrounding West Crater is easier to see in this photo taken at high sun, early afternoon elevation. The activities and tracks of the astronauts can be seen around the descent stage at left. This area is enlarged in **Fig. 3** under different lighting conditions. (NASA/ASU/GSFC photo).

(For landing site location, click **here**)

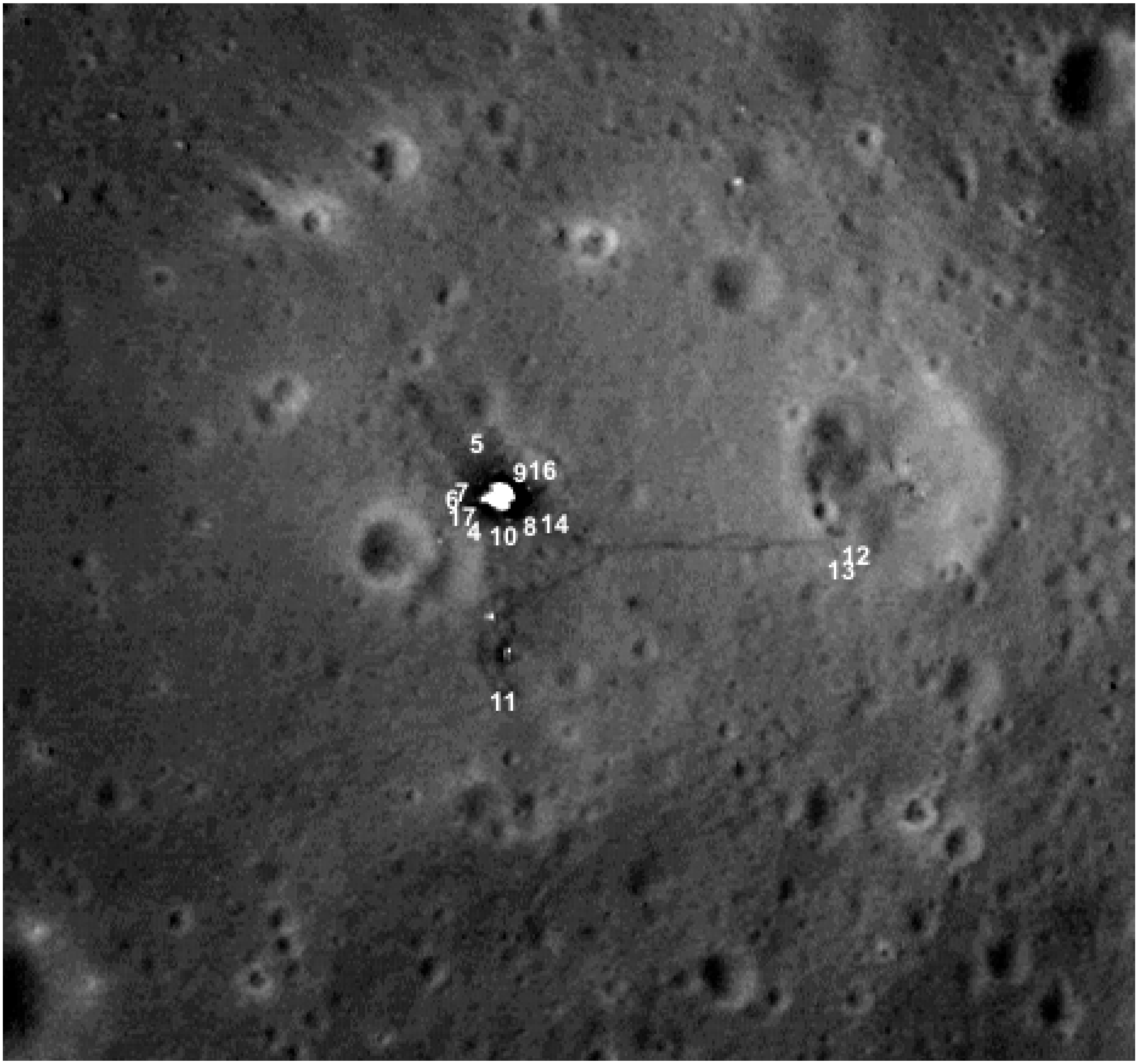


Fig. 3. The Apollo 11 descent stage with the porch and ladder above the 4th footpad (on the left) can be easily seen in this enlargement of **LRO** photo M122054682. The tracks towards the NNW end at the position of the TV camera. The **PSEP** and the **LRRR** can be seen south of the descent stage. Neil Armstrong's tracks from the **PSEP** area out to Little West Crater and back to the vicinity of the descent stage can be followed. The distance covered in the latter trek is about 60 m. The numbers mark the approximate locations of the following figures beginning with "4" for **Fig. 4** ("approximate" is used here, for example, because 6,7,17 are photos from the same pan made somewhat to the left of the ladder in the shade of the **LM**). (NASA/ASU/GSFC photo).

(For landing site location, click **here**)

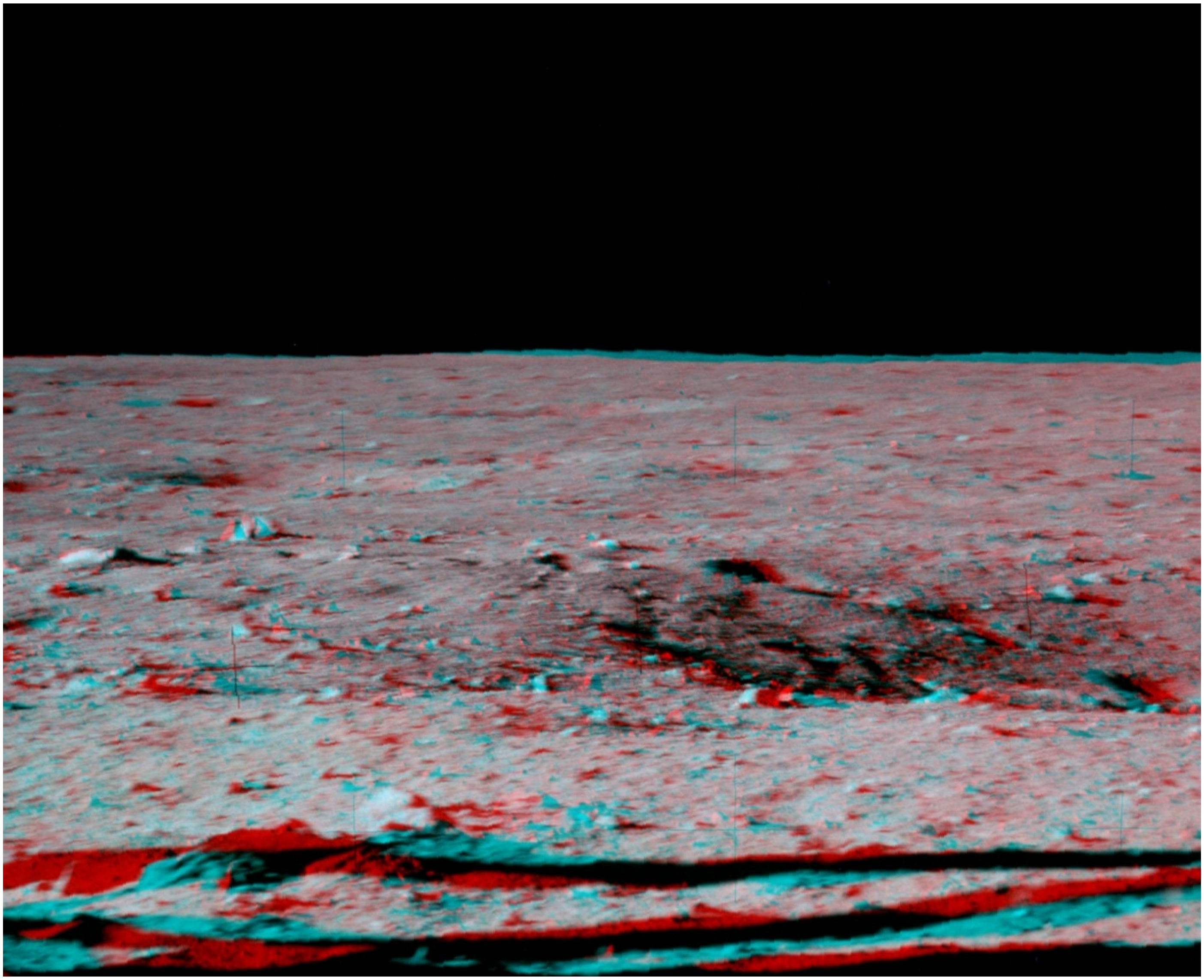


Fig. 4. Part of the double crater at right next to which Neil Armstrong set the **LM** down, seen from the lunar surface below Armstrong's window. Note the undulating terrain beyond ou to the horizon. (From NASA photos AS11-40-5861 and-5859).

(For photo location, click **here**)

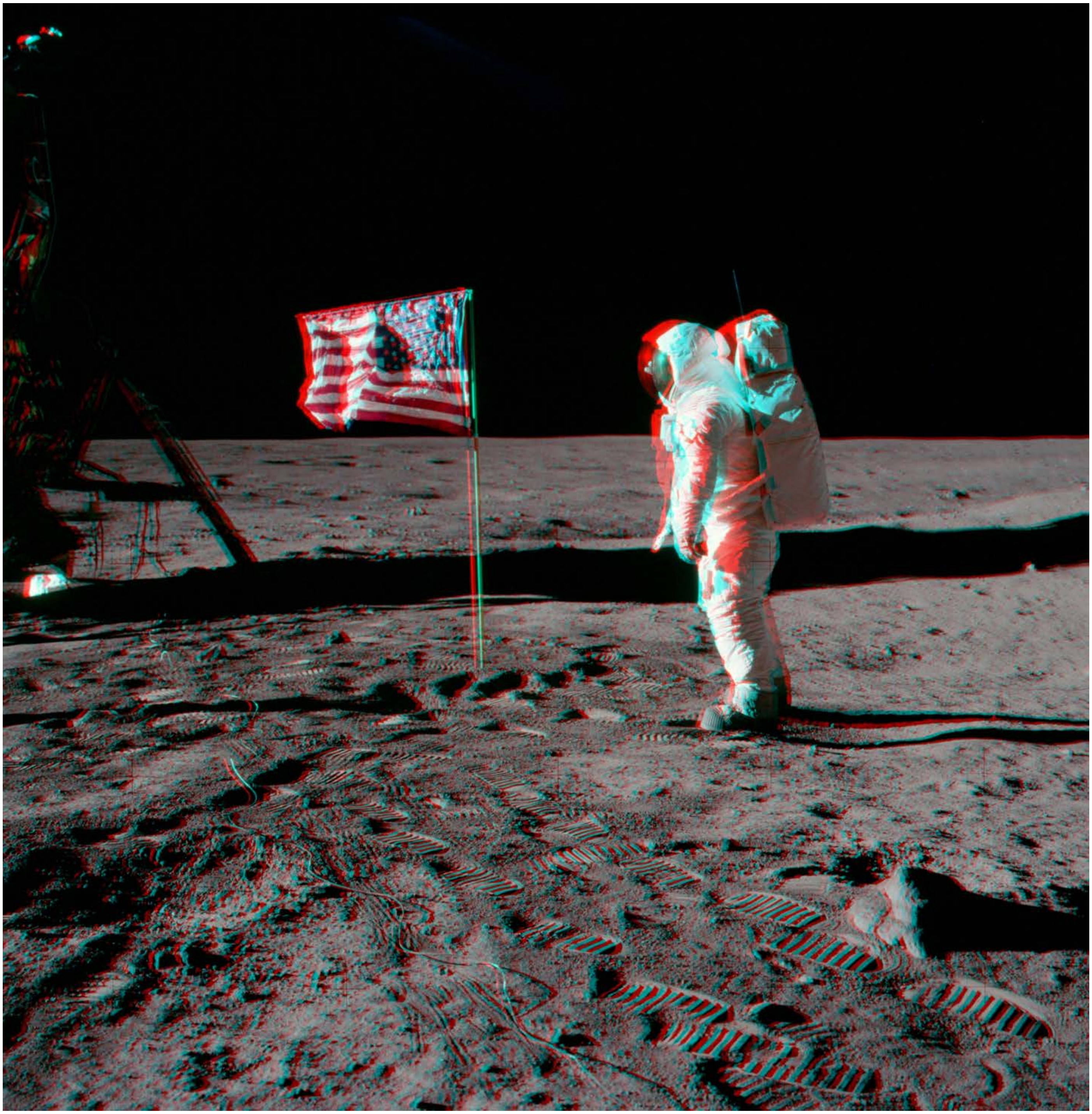


Fig. 5. Buzz Aldrin standing near the deployed American Flag before saluting. This profile view aptly demonstrates the normal upright posture caused by lunar gravity acting on the combined body weight and the heavy backpack. Although Aldrin is facing left towards the rising sun, a careful inspection of the faceplate will show that he is actually looking at Neil Armstrong and his camera. (From NASA photos AS11-40-5875, and -5874).

(For photo location, click **here**)

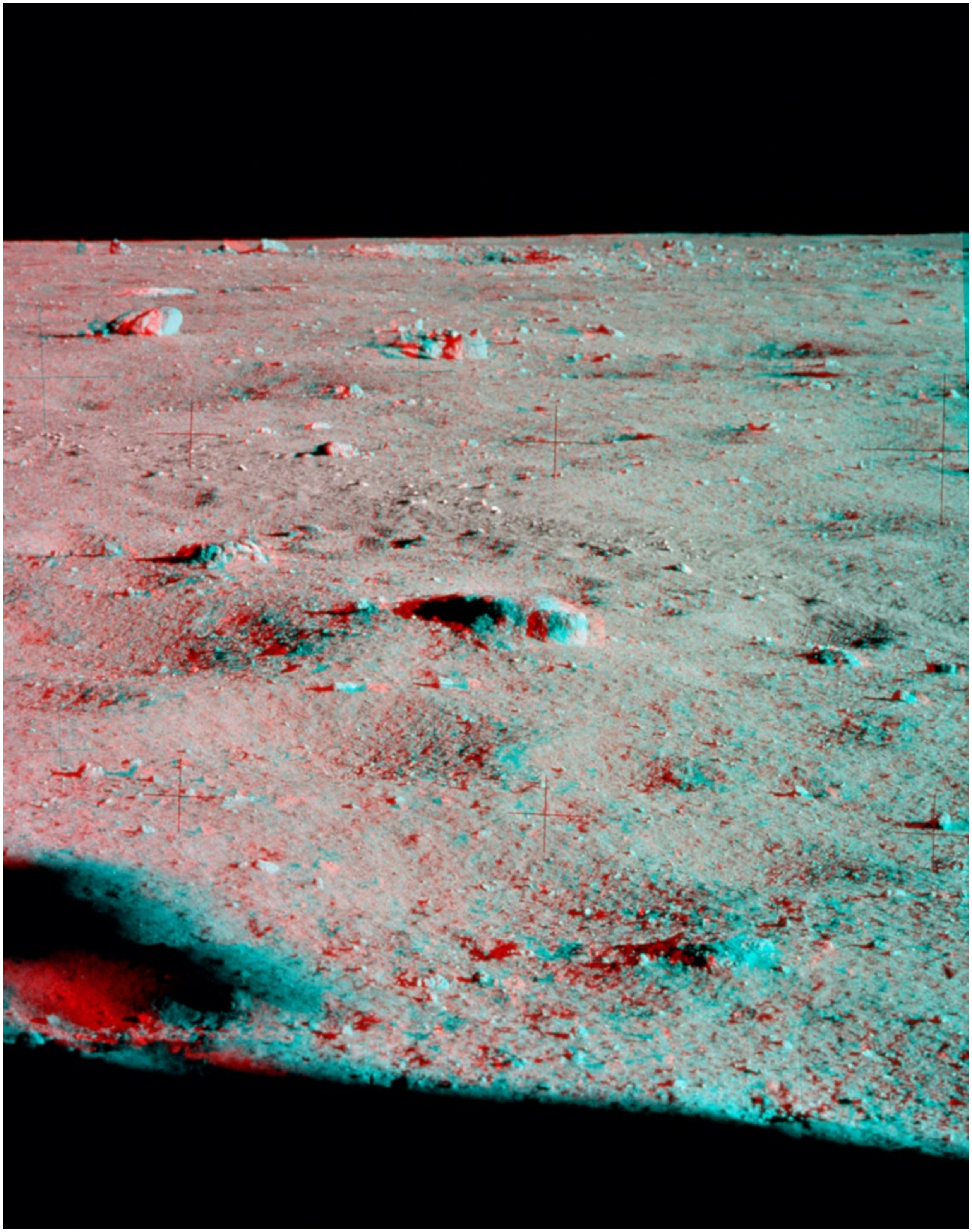


Fig. 6. View to the NW of the **LM** from a position below Aldrin's window demonstrating the rolling roughness of the surface. (From NASA photos AS11-40-5883, and -5884).

(For photo location, click **here**)

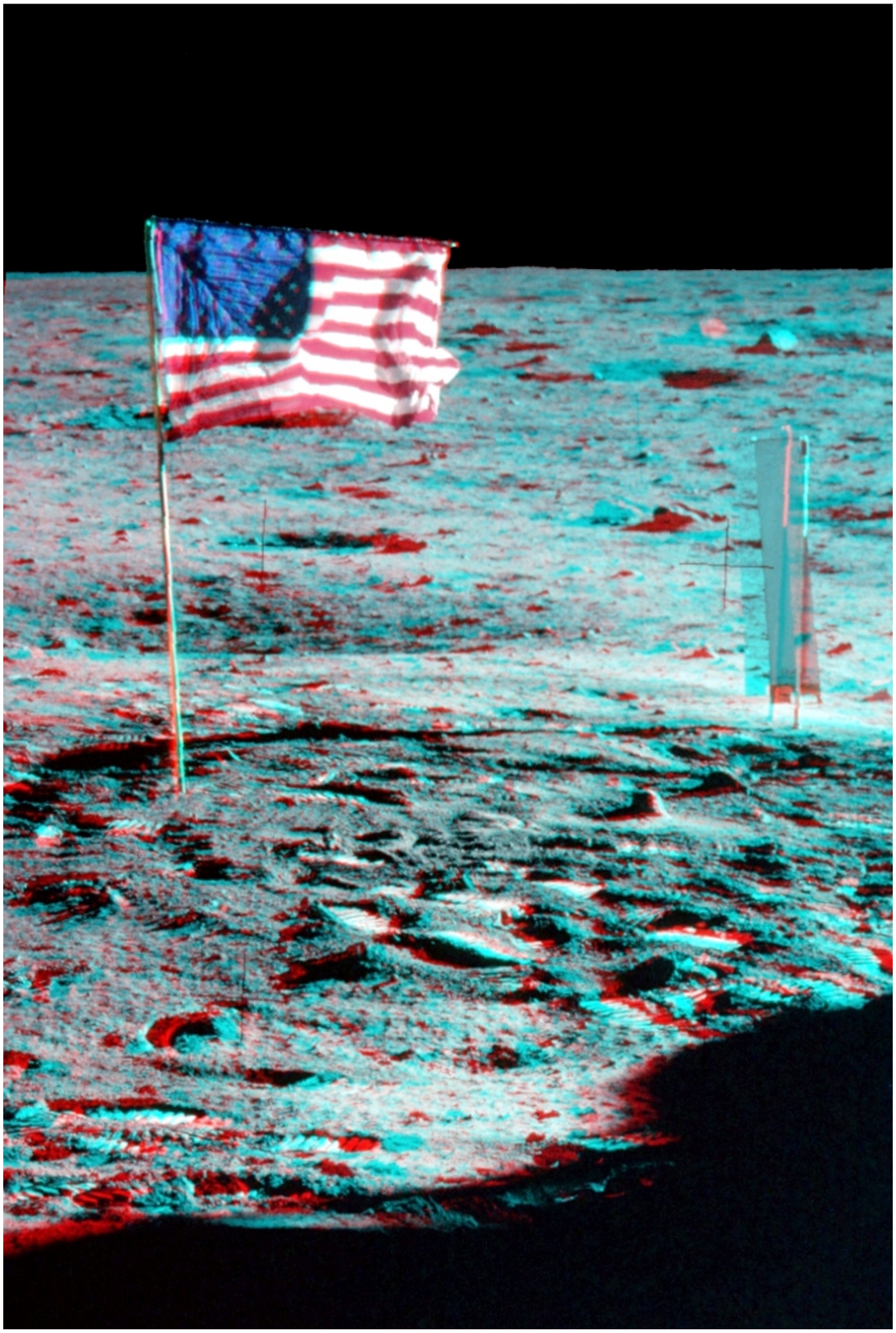


Fig. 7. Continuing right from **[Fig. 6](#)**, a view to the N of the **[LM](#)** showing the Flag, the Solar Wind Collector (**[SWC](#)**) at right, and the undulating terrain. (From NASA photos AS11-40-5885, and -5886).

(For photo location, click **[here](#)**)

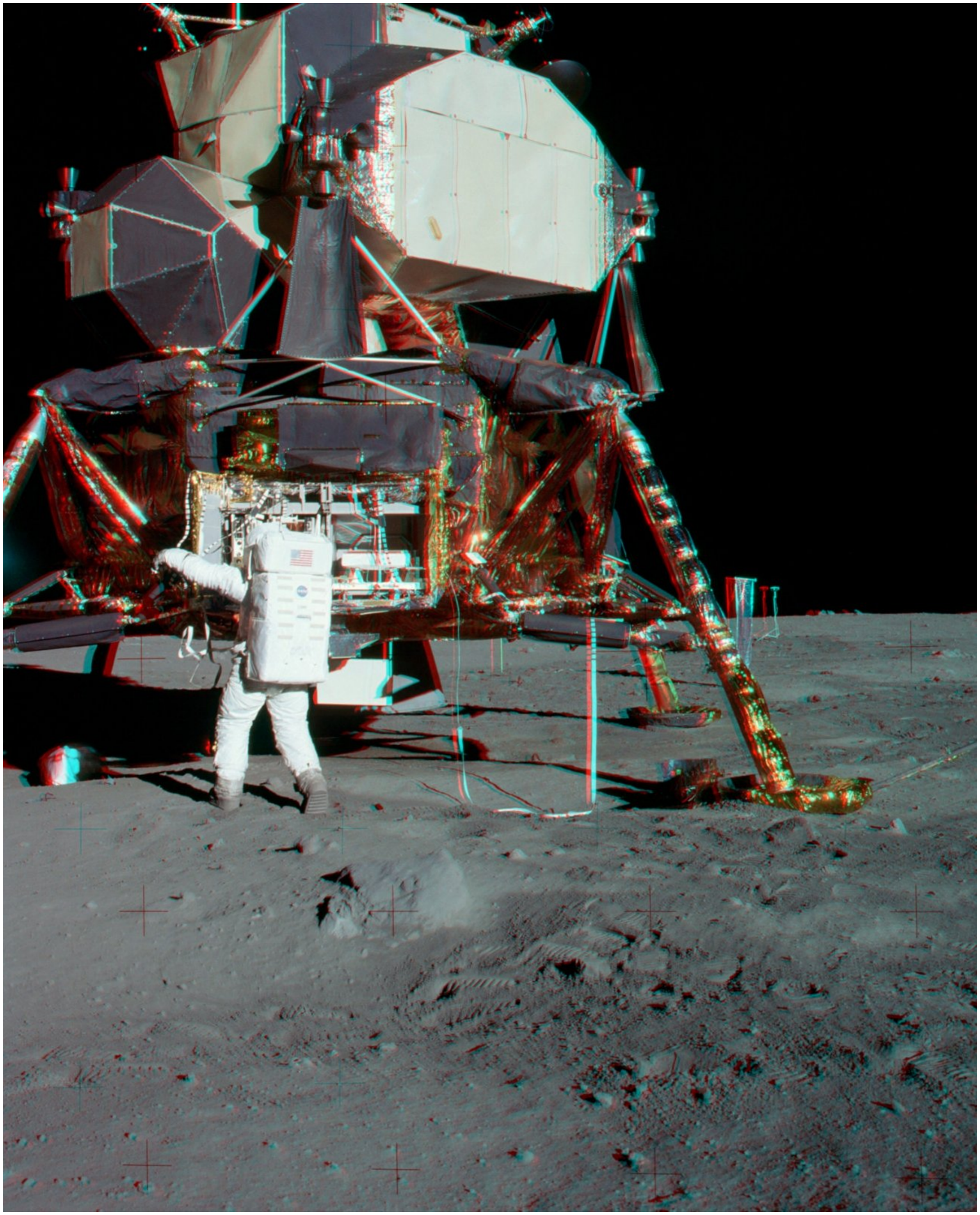


Fig. 8. Buzz Aldrin at the equipment bay of the **LM** pulling out the **EASEP** (Early Apollo Surface Experiment Package) to lower to the surface. To the immediate right of the LM leg is the **SWC** and to the right of that further to the NNW is the TV camera. The rod sticking out from the footpad at far right is part of the six foot contact probe that gave warning when the LM was close to touch down. (From NASA photos AS11-40-5927, and -5929).

(For photo location, click **here**)

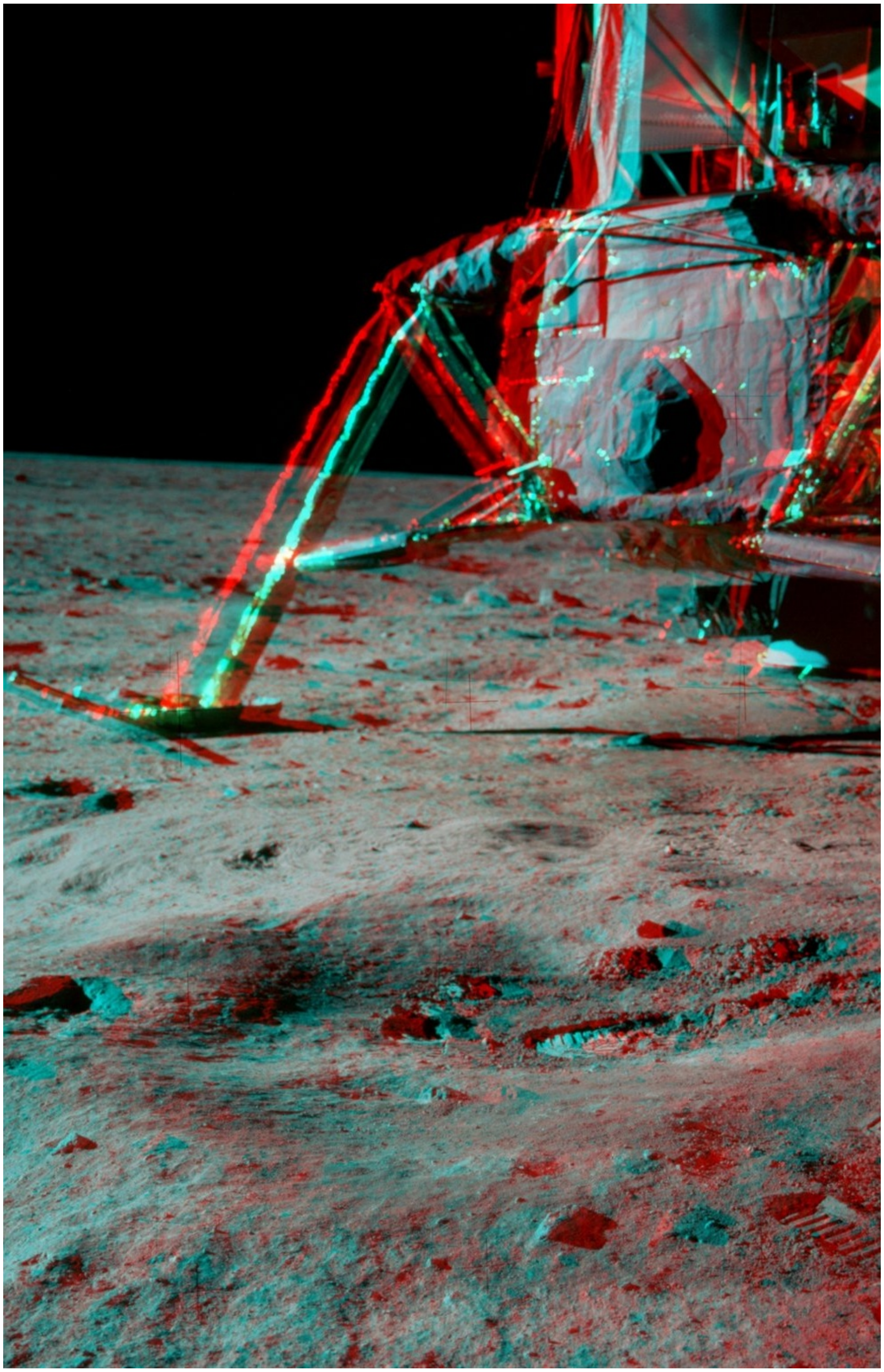


Fig. 9. View of the **LM** on its east side from the other side of the footpad with the probe sticking out, looking south. Note that the ground on which the LM rests is not smooth! (From NASA photos AS11-40-5915, and -5914).

(For photo location, click **here**)

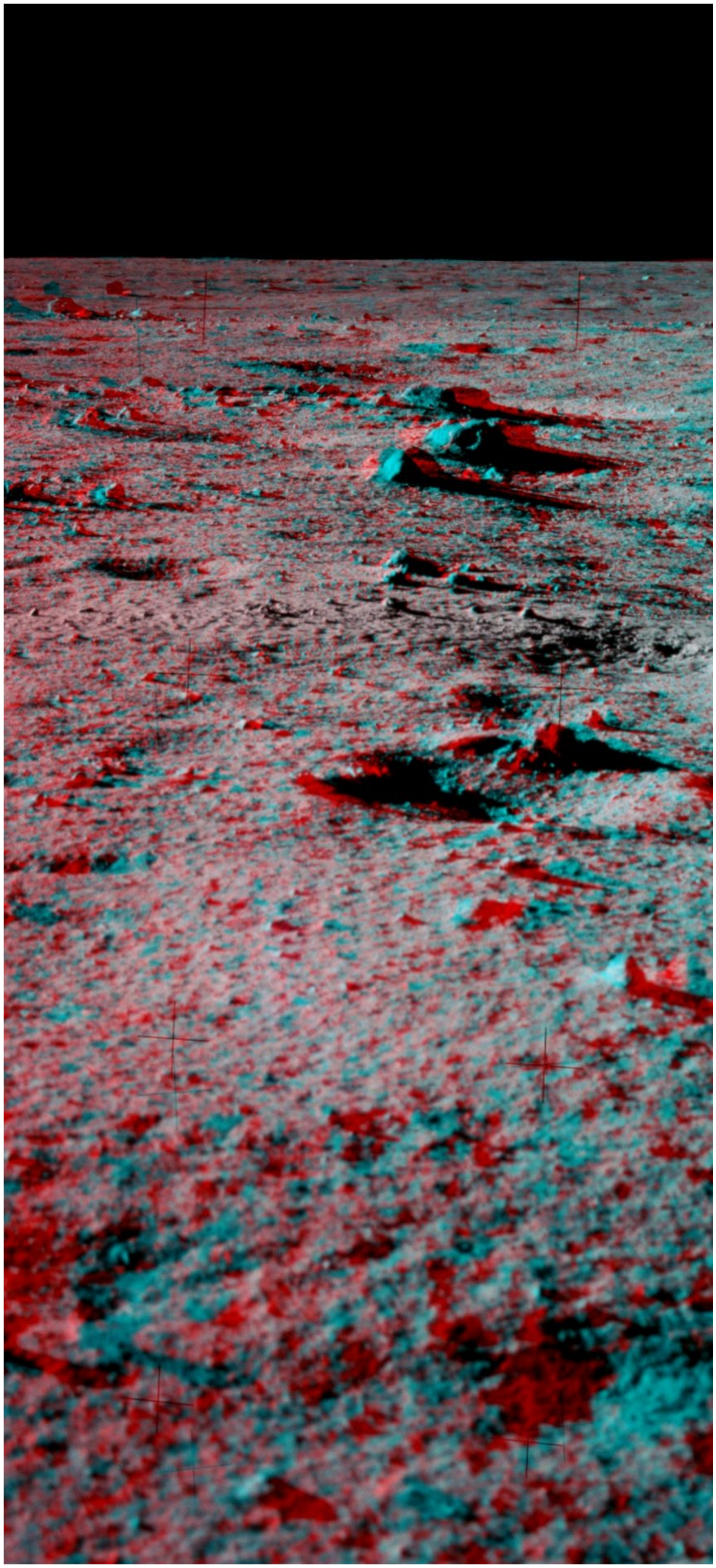


Fig. 10. At the LM looking south towards where the PSEP and LRRR will be set up by Buzz Aldrin. Note the undulating and rocky terrain. (From NASA photos AS11-40-5937, -5939).

(For photo location, click here)

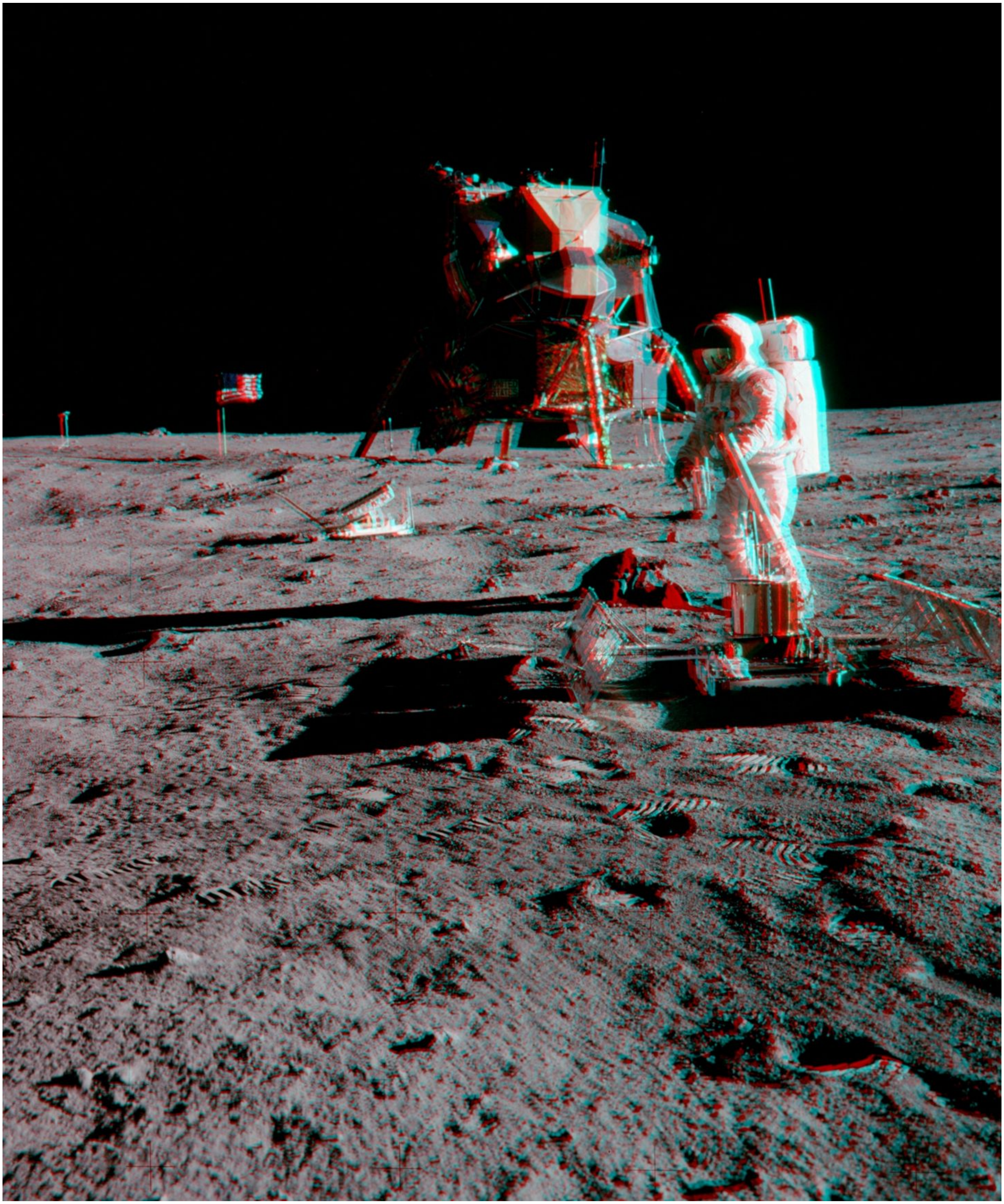


Fig. 11. Reverse direction from **Fig. 10**. Buzz Aldrin adjusting the antenna of the **PSEP**. To the left is the **LRRR**, the Flag beyond the **LM** and the TV camera in the distance. Aldrin appears only in one photo, but the compositing here was as described in the **Prologue** for the **Frontispiece**. (From NASA photos AS11-40-5950, and -5949). (For photo location, click **here**)

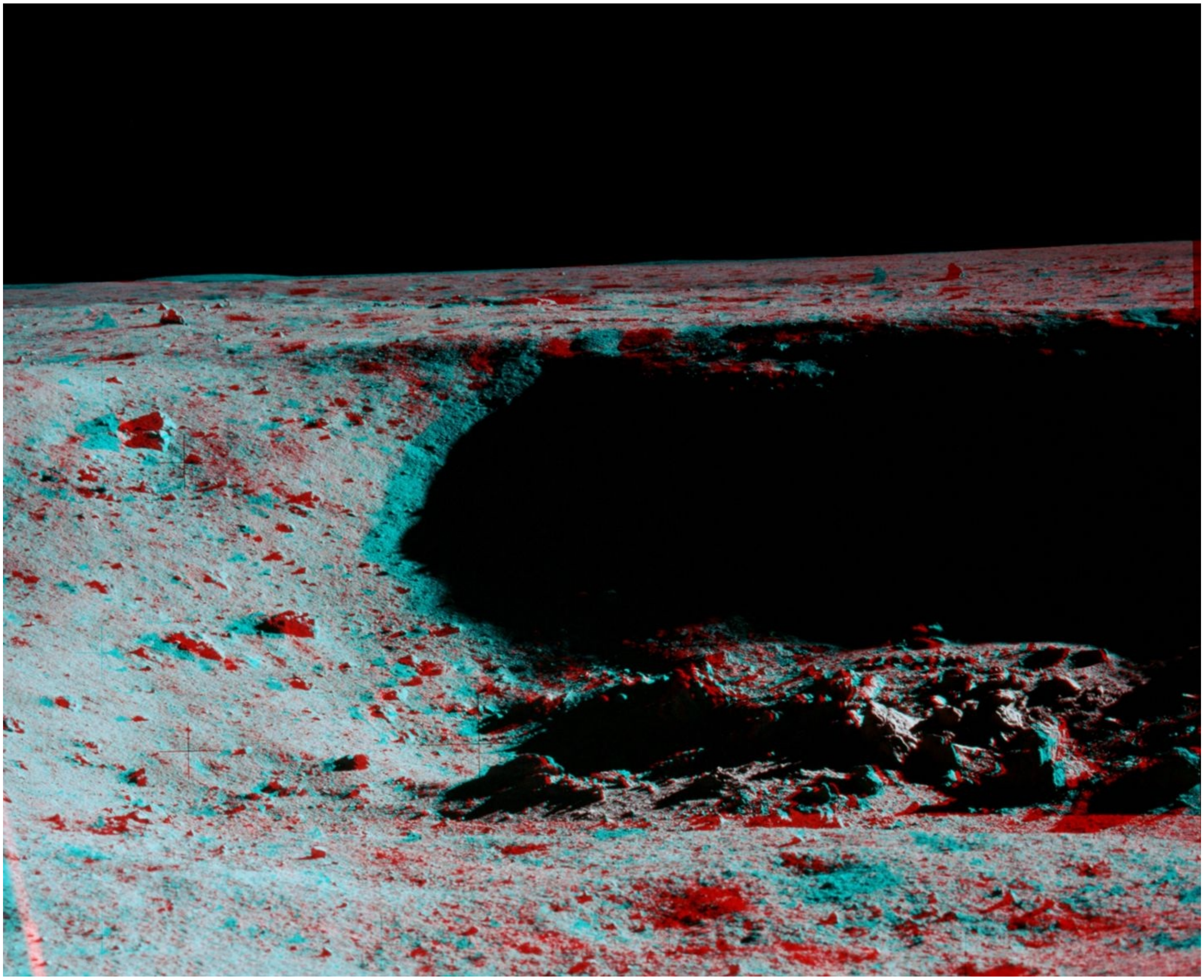


Fig. 12. Little West Crater, the farthest distance walked by Neil Armstrong who is taking the photos. The **LM** is located ca. 60 m to the left. (From NASA photos AS11-40-5954, and -5956).

(For photo location, click **here**)

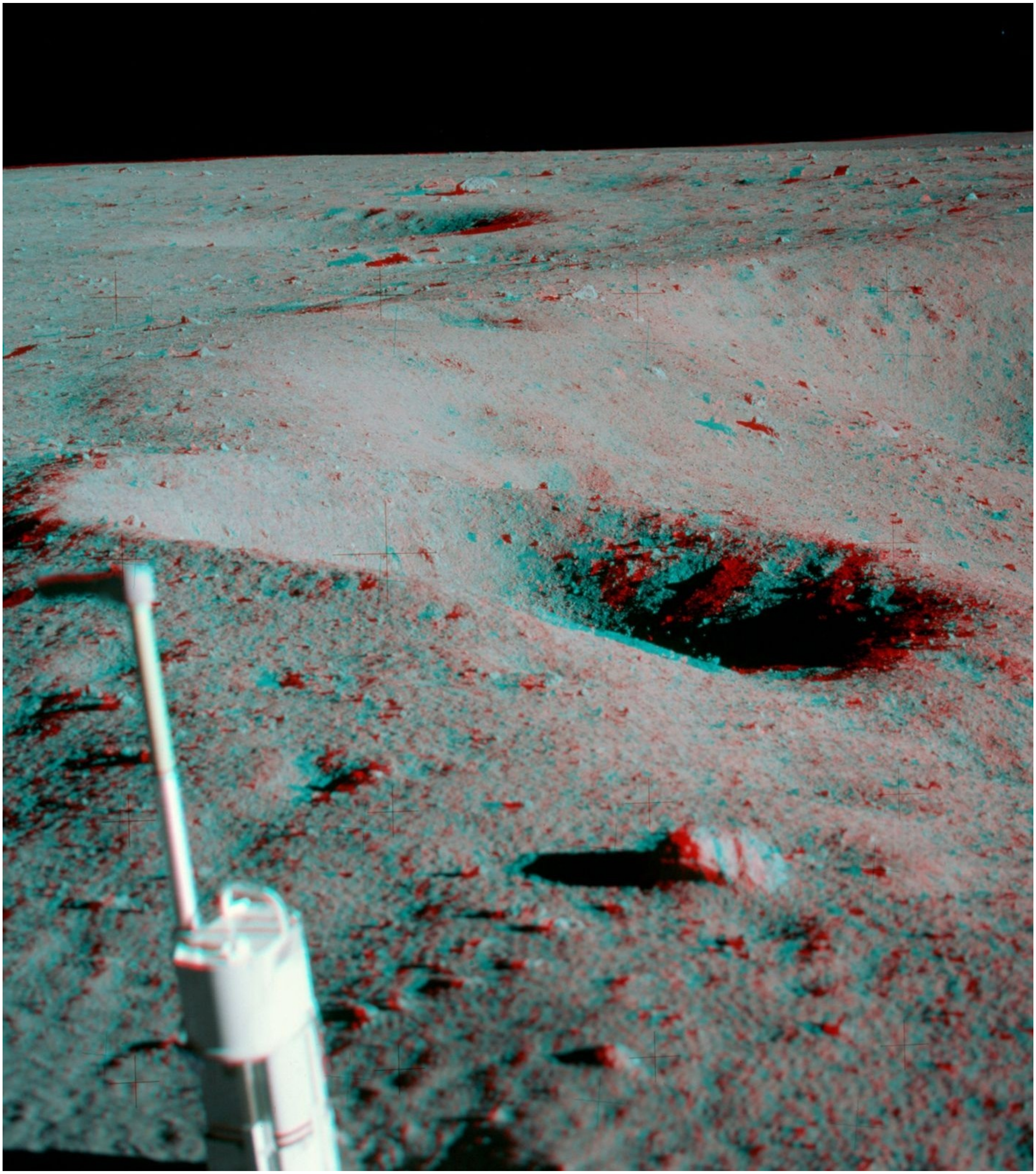


Fig. 13. To the left of **Fig. 12**, the west end of Little West Crater. The vacuum cleaner-looking device at left is the Apollo Lunar Surface Stereo Close Up Camera (**ALSSCC**), the only stereo camera taken to the Moon for making very close photos of the surface soil directly in stereo. (From NASA photos AS11-40-5958, and -5959

(For photo location, click **here**)

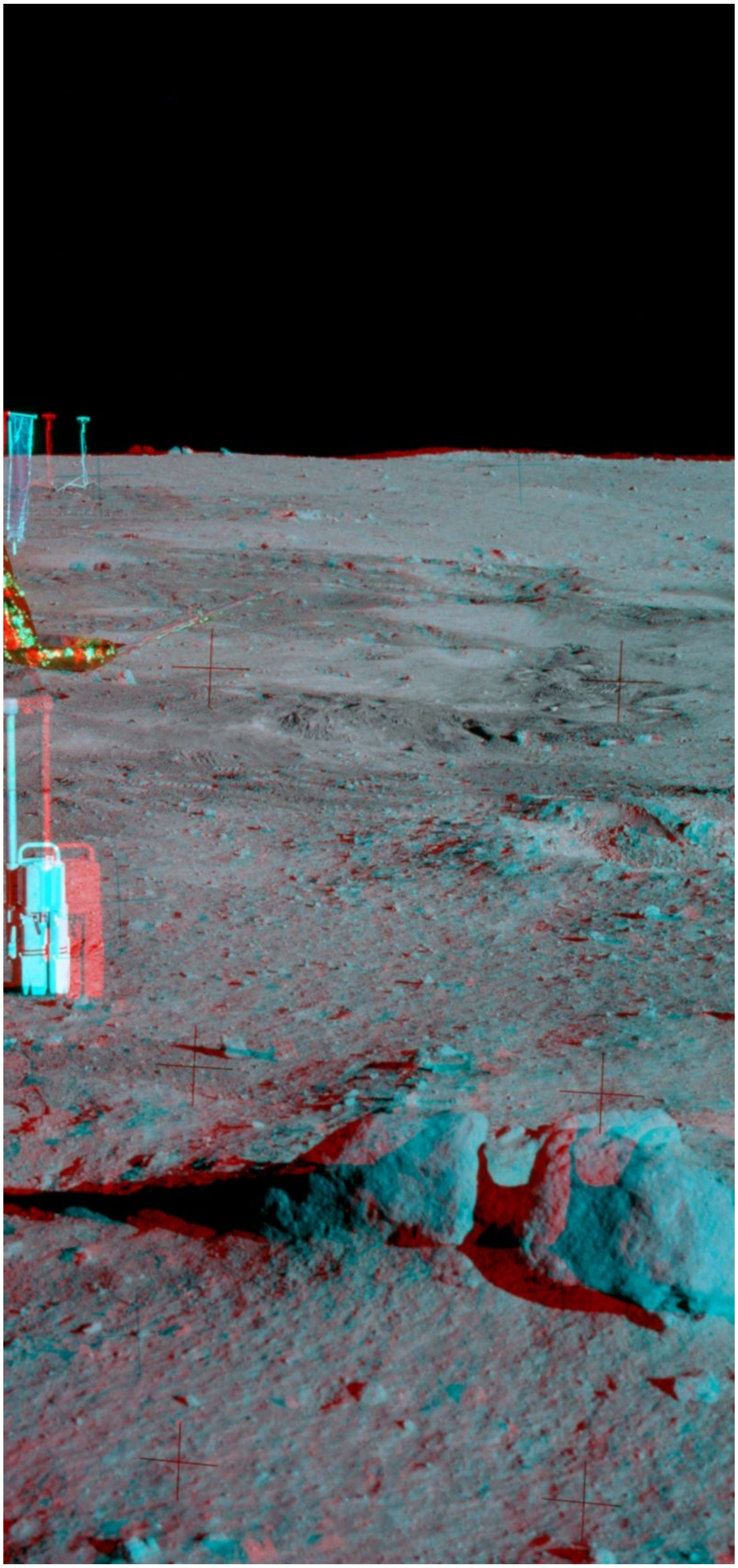


Fig. 14. East side of the **LM** with the **ALSSCC** and a split boulder in the foreground. The footpad with the contact probe in the middle ground, and the **SWC** and TV camera in the distance. The split boulder can also be seen in the lower left corner of the anaglyph on the mission title **page**. (From NASA photos AS11-40-5931, and -5932).

(For photo location, click **here**)

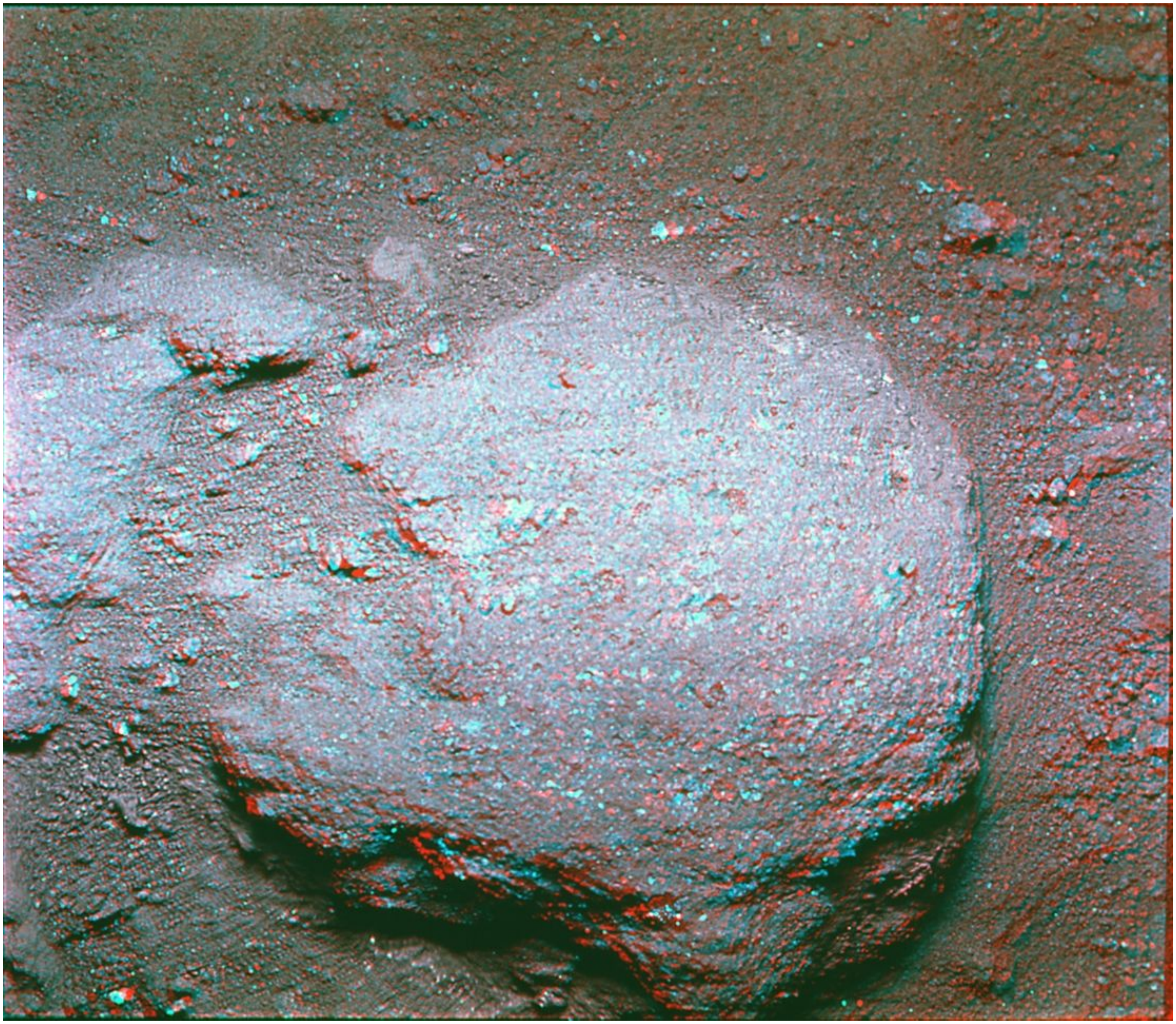


Fig. 15. A close up 3D look at the lunar soil. The "giant boulder" is actually a small piece of basalt about 2.5" × 2.0" in size. A characteristic of the lunar soil is revealed in this and similar **ALSSCC** microphotographs, namely, the high content of glassy material. Gene Cernan on Apollo 17 referred to it as "sparklies". Jack Schmitt, on the other hand, gave a rather more detailed geological description. Here is what they actually said (excerpted from the *Apollo Lunar Surface Journal*):

117:20:20 Cernan: Man, there's sparklies in the soil, Jack. You can just look at it. See them all over? Very fine-grained. It's sparkly, that's all. …

117:21:54 Schmitt: Looks like a vesicular, very-light-colored porphyry of some kind; it's about 10 or 15 percent vesicles. I'm right in front of the LM. …

(From NASA photos AS11-45-6712A and B).

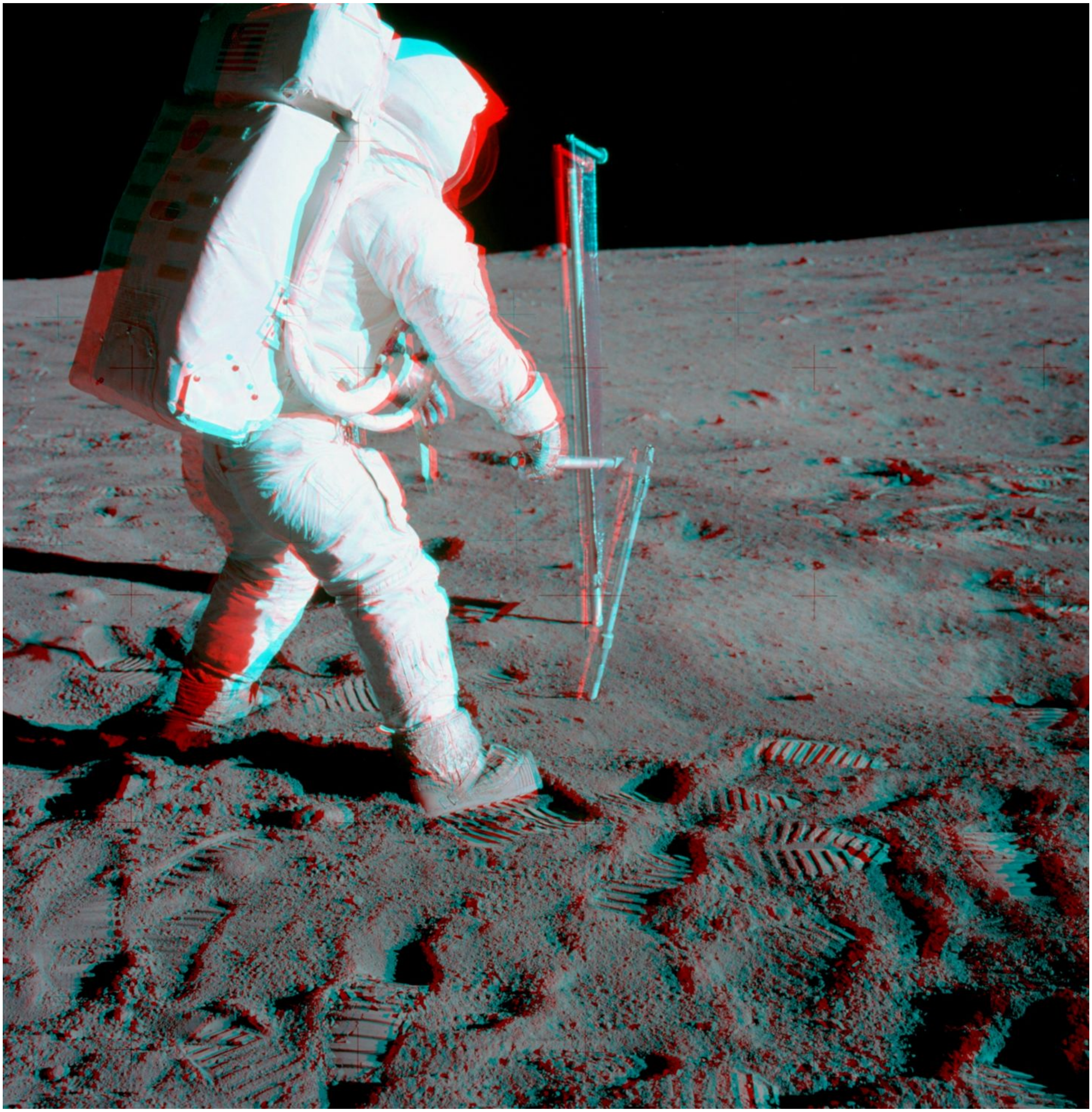


Fig. 16. In this final anaglyph selected for Apollo 11, Buzz Aldrin is driving a core tube into the ground near the **SWC** to obtain a sample showing the surface structure at depth. Unfortunately, he was only able to drive it down about 20 cm (From NASA photos AS11-40-5963, and -5964).

(Note: There is only one good Hasselblad photo of Neil Armstrong on the lunar surface. It is given as the non-3D photo in **Fig. 17**)

(For photo location, click **here**)

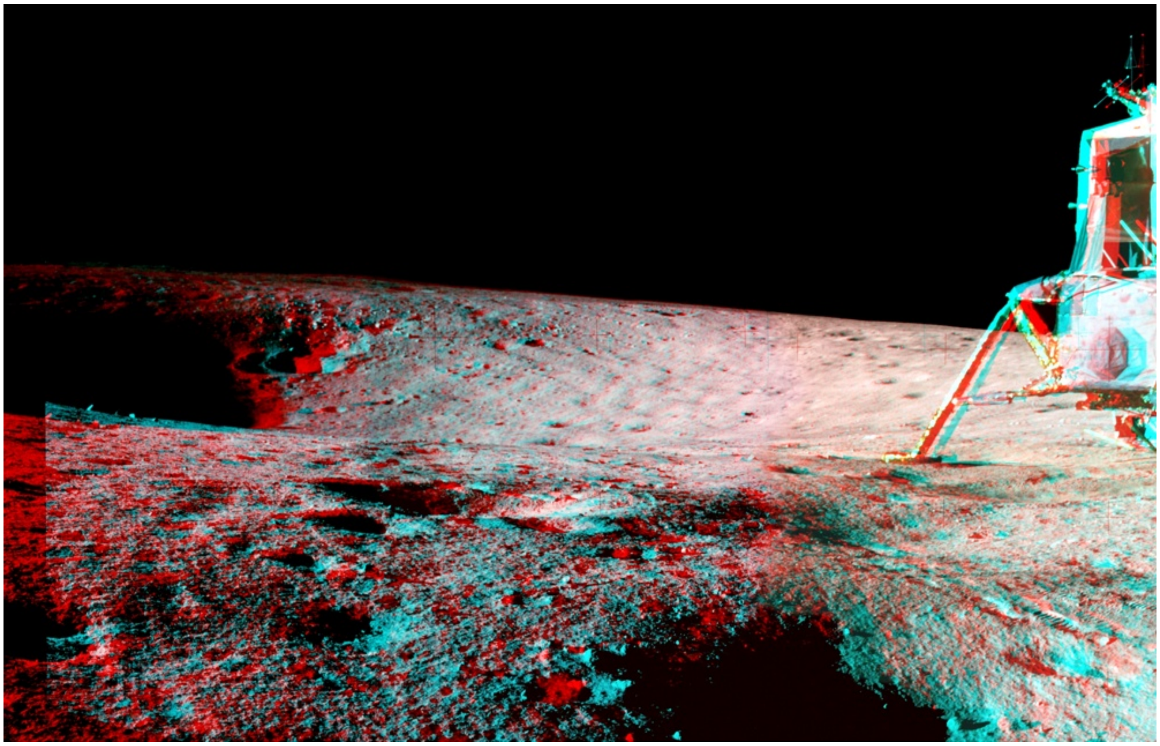
Fig. 17. The only good Hasselblad color photo of Neil Armstrong on the lunar surface, unfortunately not in 3D. According to the mission plan, Armstrong took most of the photos, which is why Buzz Aldrin appears in many of them. In this instance, Aldrin temporarily had the camera and made a panorama, of which this was one of the frames. The left portion of this frame appears in the stereo view of **Fig. 7**. In the above photo, Armstrong is packing a bulk lunar soil sample into a rock box that he has placed on the table of the Modularized Equipment Stowage Assembly (**MESA**). The rock box had been filled with a variety of rock samples. As a last sample (10084), Armstrong decided to fill the remainder of the box with about 17 scoops of lunar soil taken from a 3 × 5 m area below the right window of the LM. As Jack Schmitt has noted, this soil was the most important sample from all the missions returned from the Moon. (NASA photo AS11-40-5886).

(For photo location, click **here**)

APOLLO 12

***Intrepid*'s Precision Landing at the Snowman**

November 19, 1969



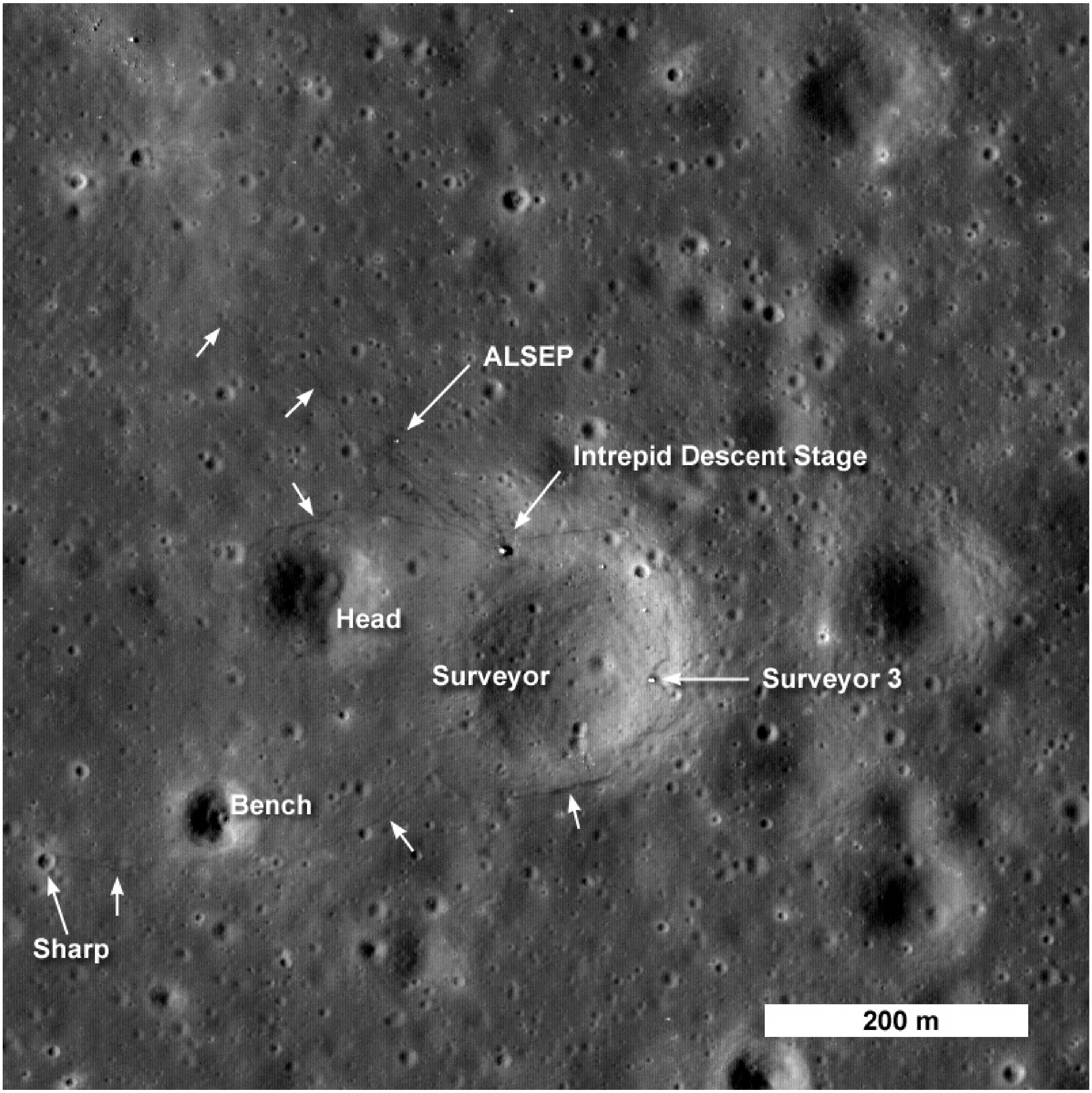


Fig. 1. The Apollo 12 landing site photographed by **LRO**. The principle goal of the mission was to land as closely as possible to Surveyor Crater so that the astronauts could pay a visit to the unmanned spacecraft *Surveyor III* which landed on the Moon more than two years earlier. The astronauts' tracks are denoted by the arrows. Head Crater, Surveyor Crater, and the two large craters at right were informally called "The Snowman" since these components looked like the balls forming a snowman (if the reader will turn the photo clockwise by 90°). (NASA/ASU/GSFC photo)

(For landing site location, click **here**)

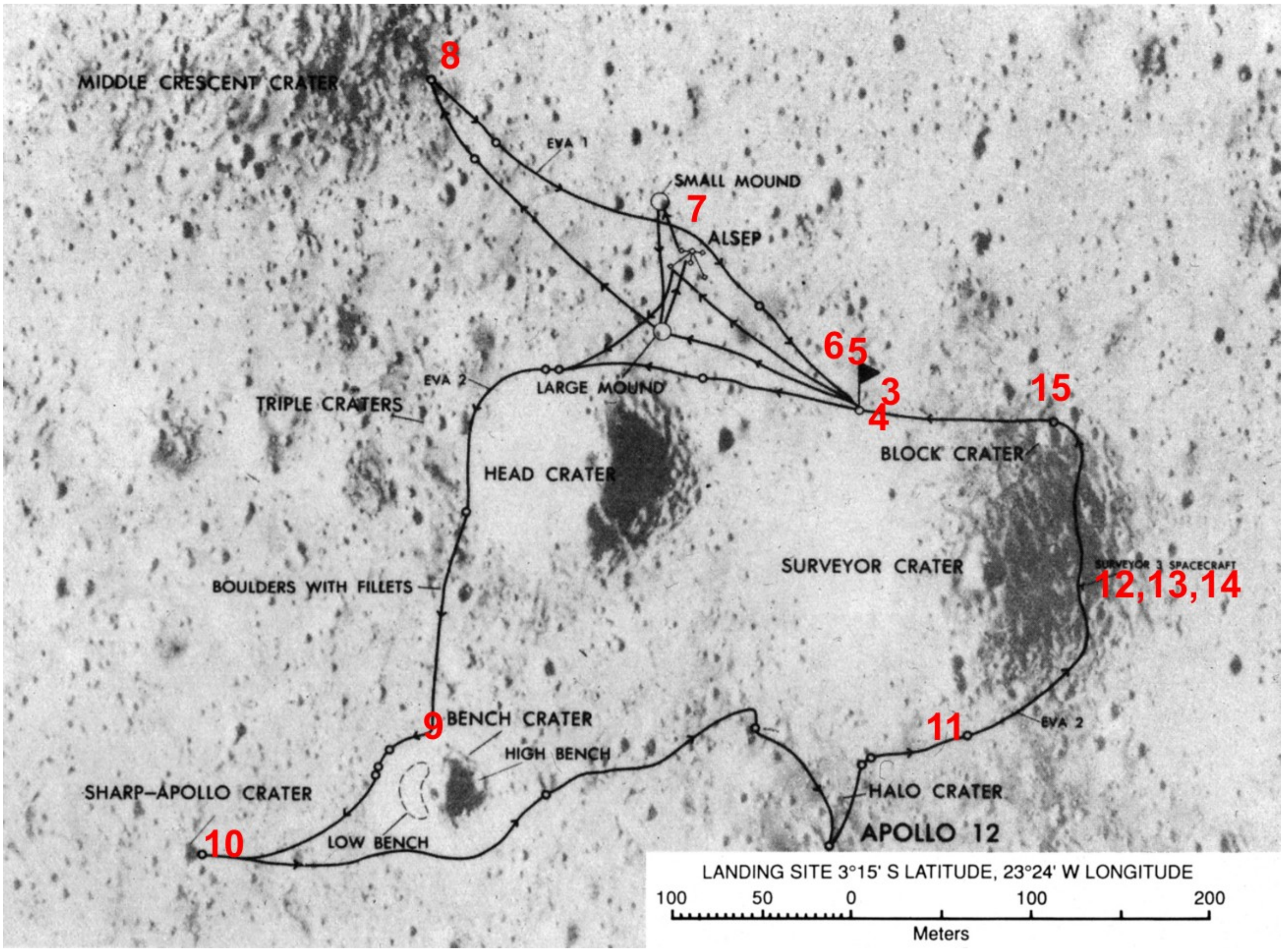


Fig. 2. Photo location map for the 15 photos selected for this mission. The first **EVA** was spent on the north side of Surveyor Crater (photos 3-8), and EVA 2 was spent on the counterclockwise circuit as indicated in the map (photos 9-15). Compare this chart with the **LRO** overhead photo in **Fig. 1**.

(For landing site location, click **here**)

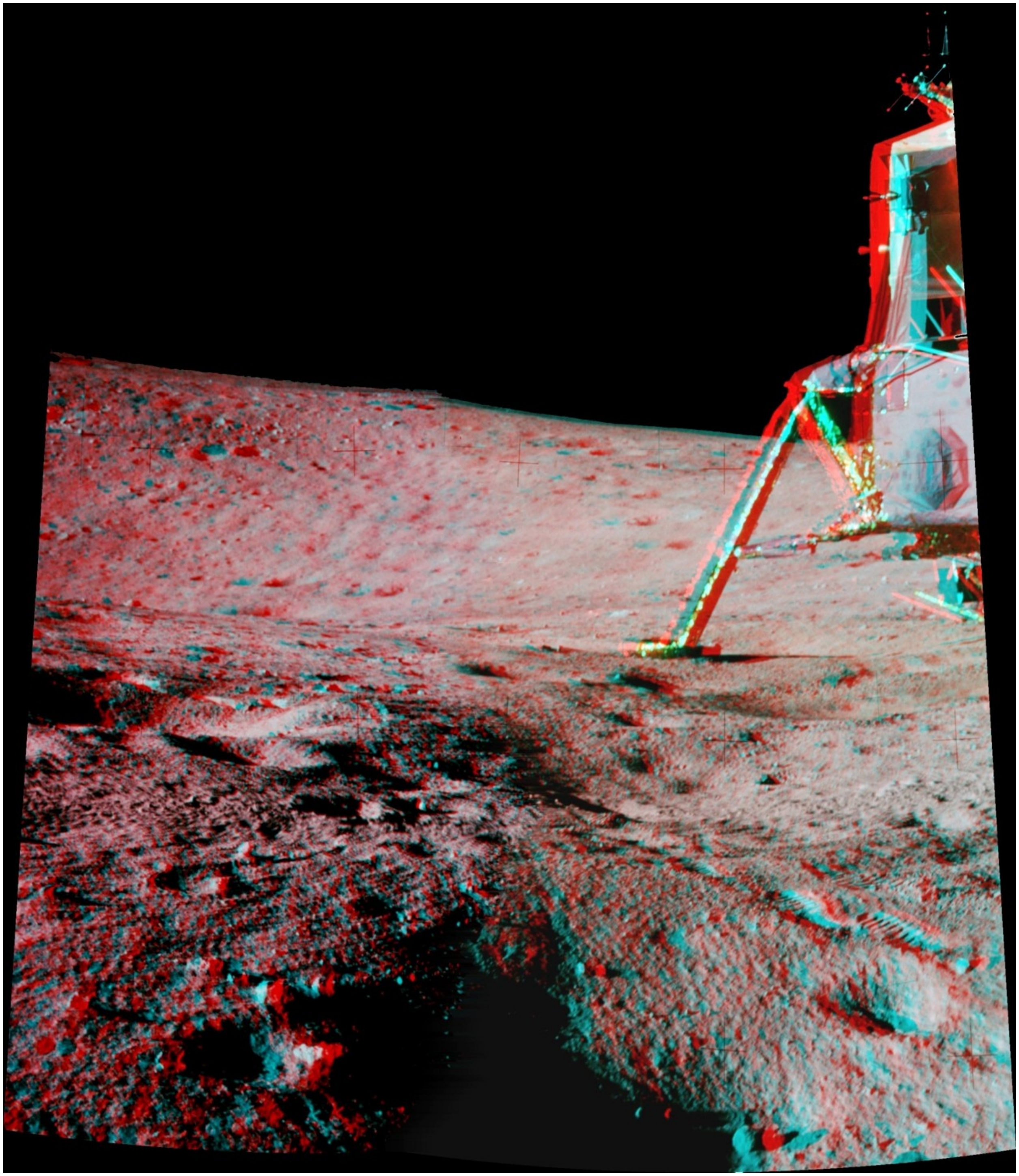


Fig. 3. The **LM** *Intrepid* sitting on the rim of Surveyor Crater. The small, but very deep craters in the foreground demonstrate how easily the spacecraft might have been affected had one of the footpads set down in such a hole. (From NASA photos AS12-46-6747, -6748, and -6749).

(For photo location, click **here**)

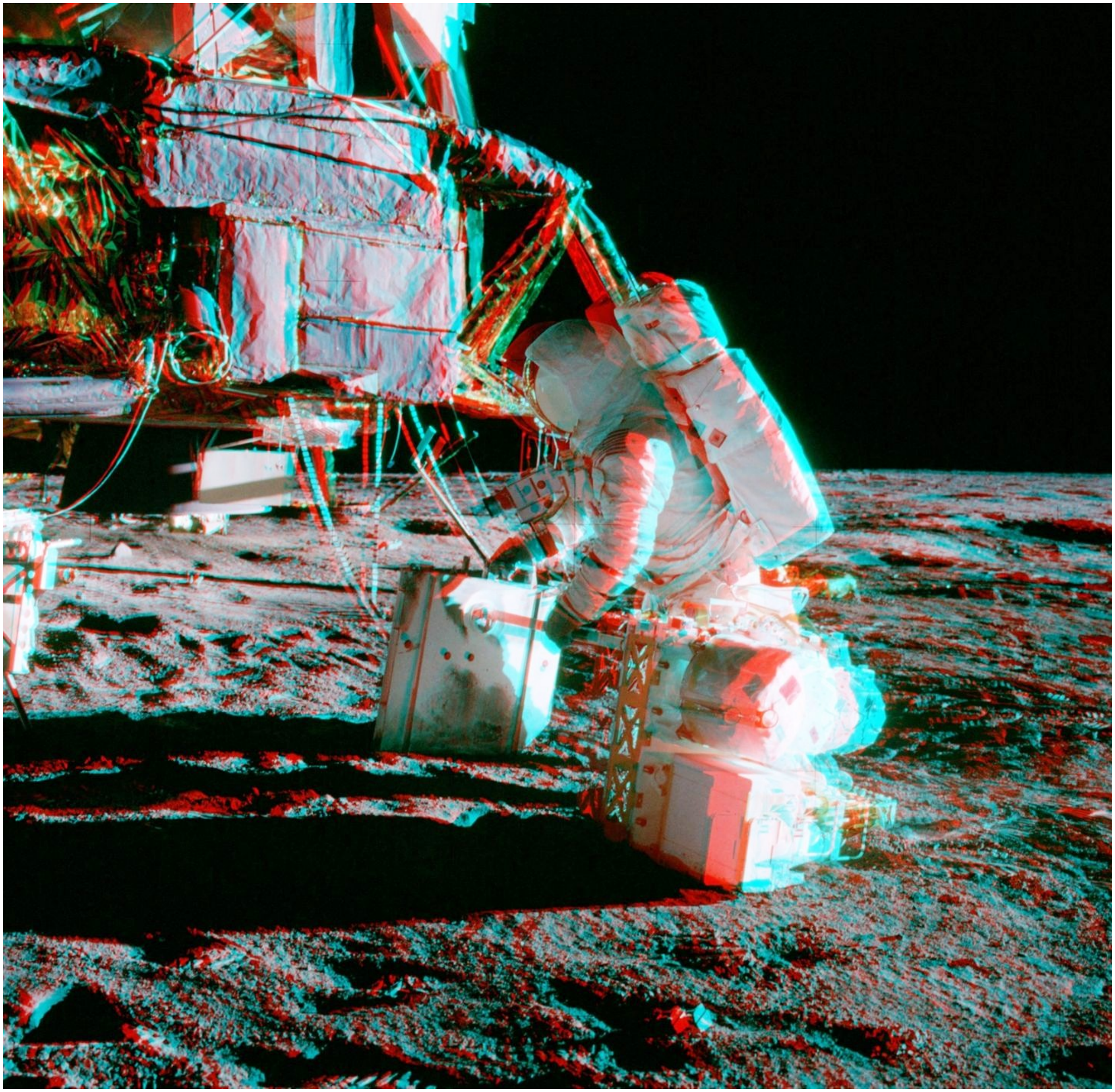


Fig. 4. Astronaut Al Bean is attaching a carry bar to several scientific instrument packages (**ALSEP**) which he will then carry to an area away from the **LM** to the northwest where they will be installed. (From NASA photos AS12-46-6791, and -6792).

(For photo location, click **here**)

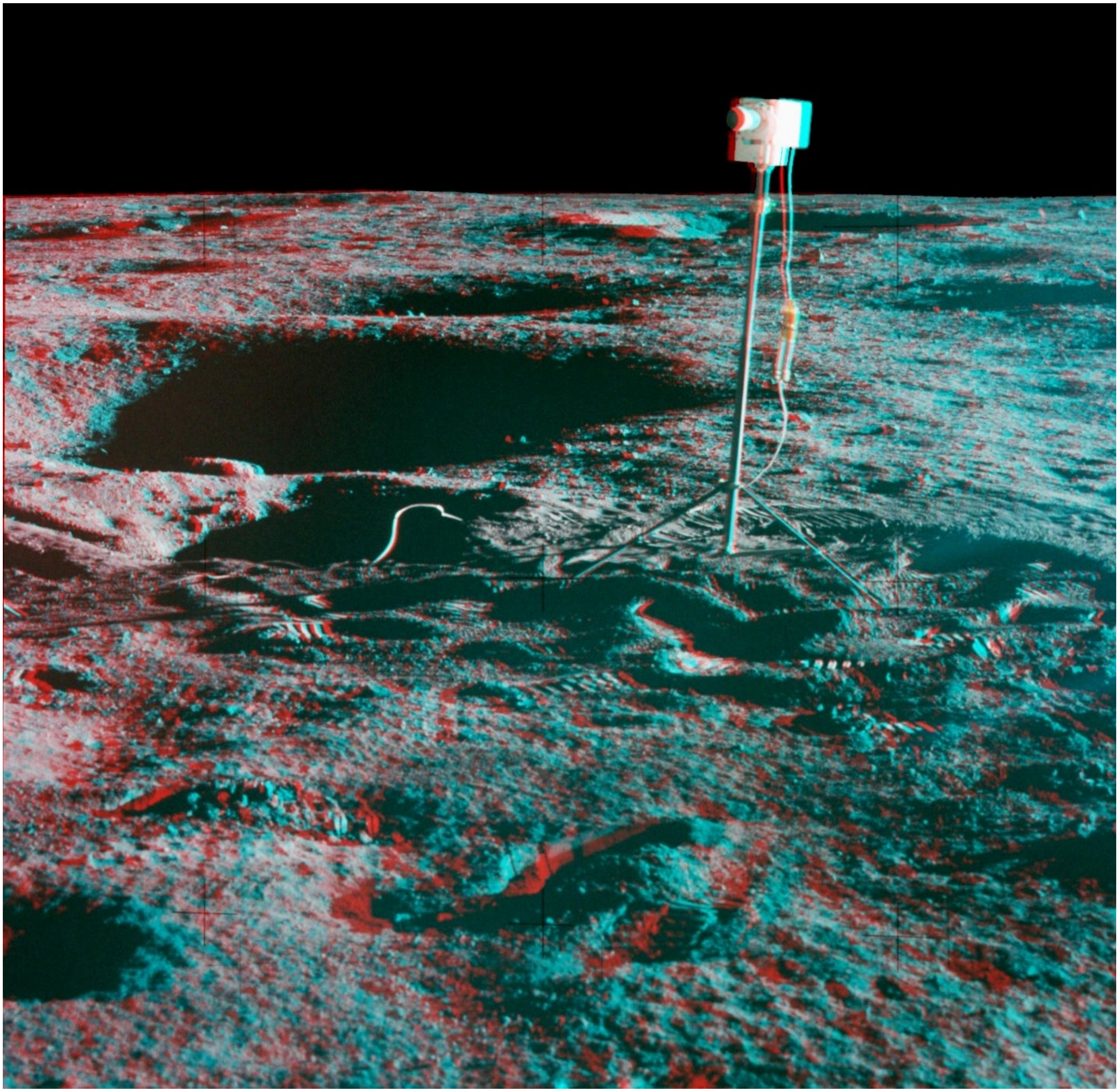


Fig. 5. The ill-fated TV camera abandoned on its mast. It was damaged when the uncapped lens was pointed directly at the sun for a few seconds while it was being mounted on the tripod. The camera was brought back to the Earth for detailed failure analysis. Note the raised-rim craters in the background. (From NASA photos AS12-47-7002, and -7001).

(For photo location, click **here**)

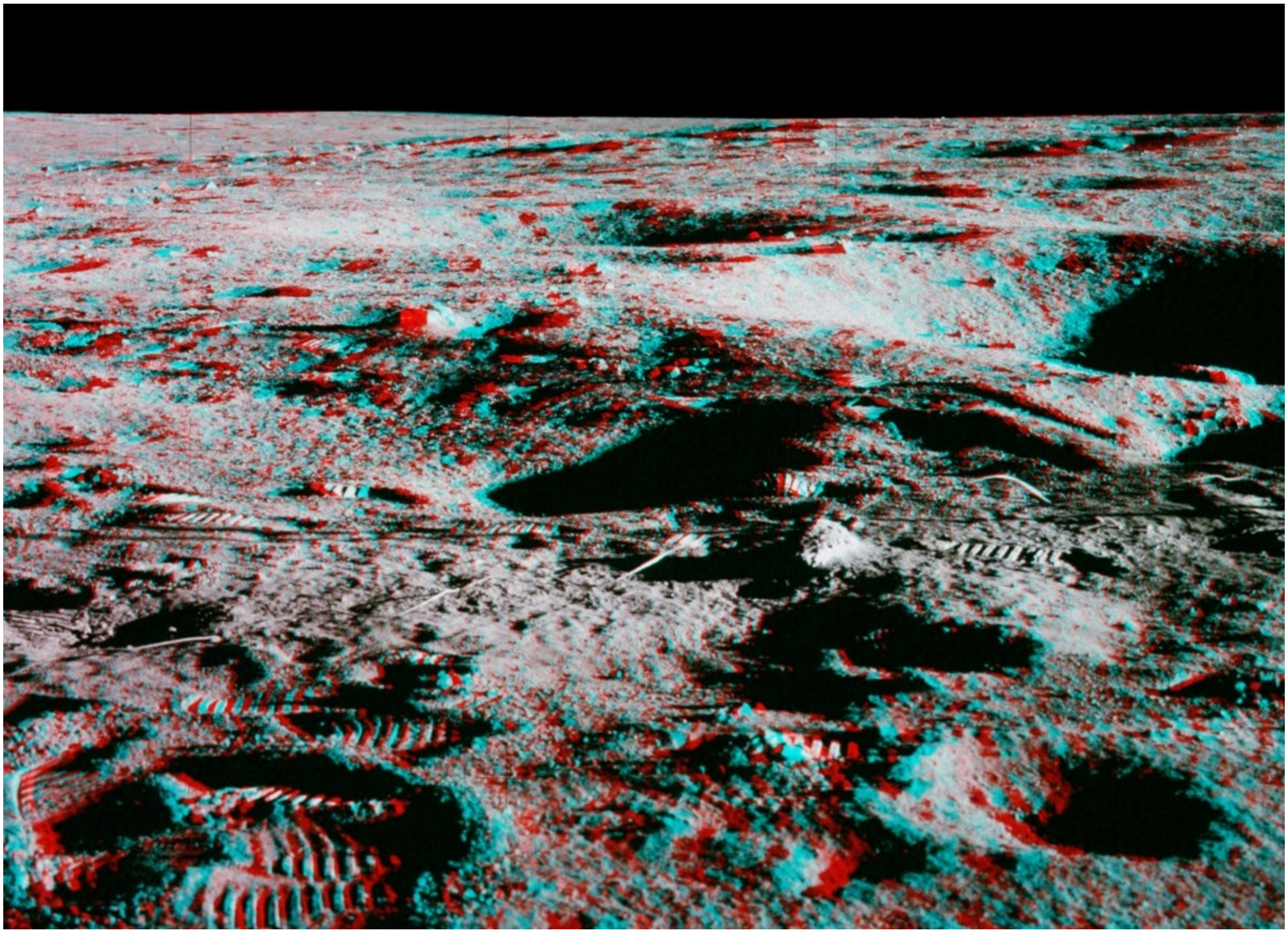


Fig. 6. A continuation of the scene in **Fig. 5** immediately to its left. The large crater at right is the large crater behind the TV camera. Also, cabling from the TV camera to the **LM** is visible in the bottom half of the photo. Incidentally, the number sequence in all credit captions indicates the left and right images used to construct the anaglyph, respectively. (From NASA photos AS12-47-7004, and -7003).

(For photo location, click **here**)

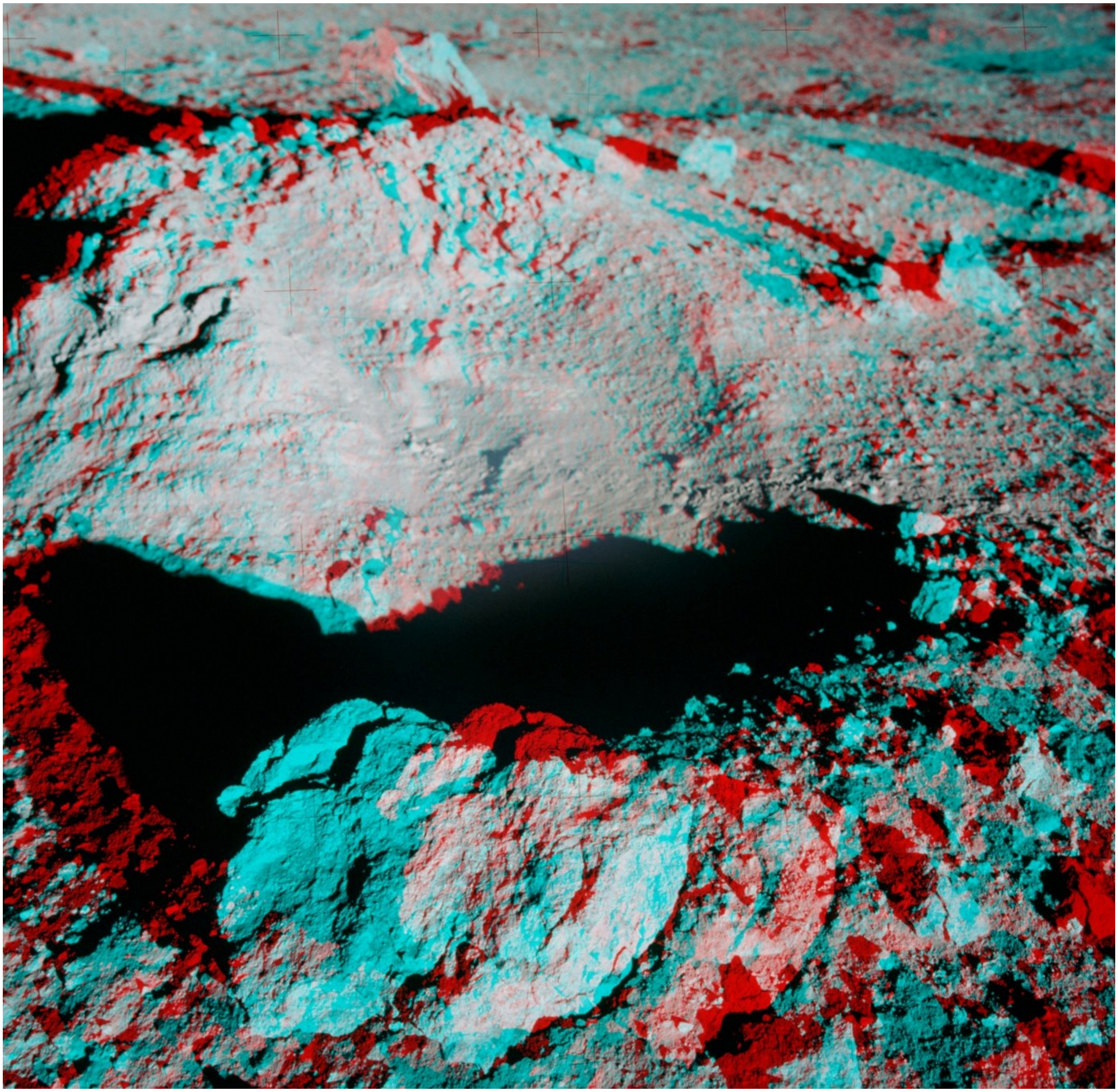


Fig. 7. A small mound of material, probably ejecta from a nearby secondary crater, which has been impacted by a smaller boulder that left the small crater beside it. The mound is located about 40 m beyond the site where the **ALSEP** was deployed in the direction of Middle Crescent Crater. The latter crater was the furthest distance to the NW walked by the astronauts (**Fig. 2**).

(For photo location, click **here**)

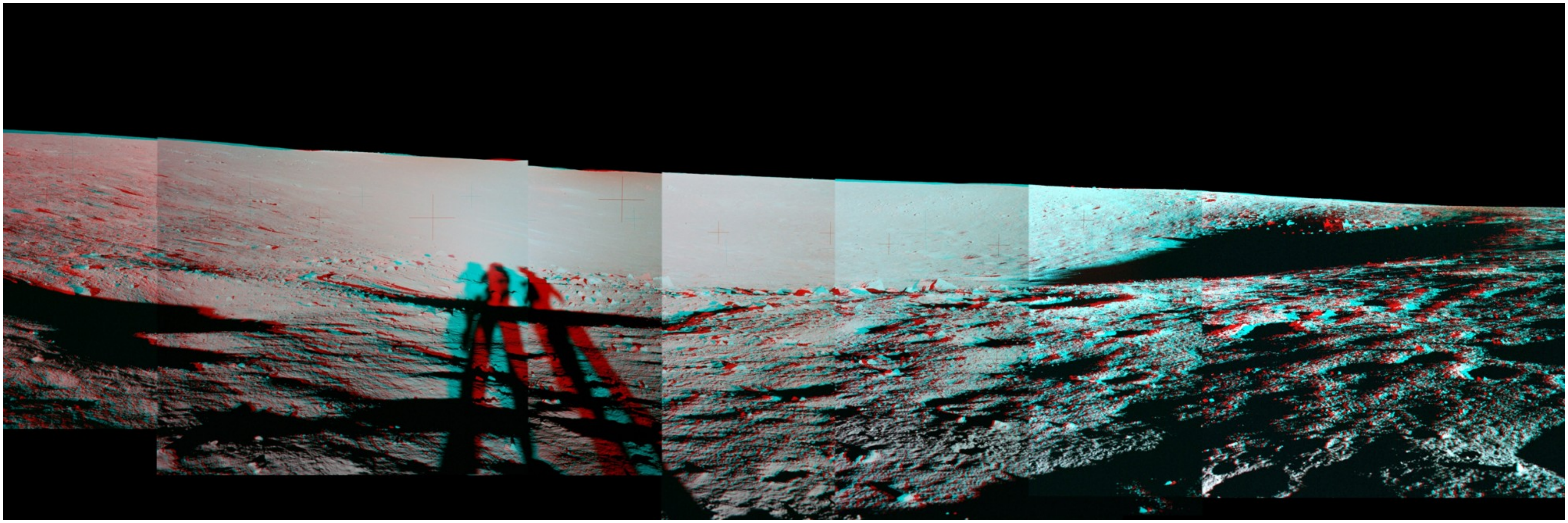


Fig. 8. A composite of seven overlap panels from a pan of Middle Crescent Crater made by Pete Conrad. Overlapping the anaglyphs is difficult because the red-blue displacements are not usually the same between panel edges. Conrad made this pan starting at the right side of the crater and moving counterclockwise. He then made a second pan returning clockwise to the right. The crater is located about 300 m northwest of the **LM**, and about 175 m beyond the **ALSEP**. (From NASA photos AS12-46-6844 through -6836, inclusive).

(For photo location, click **here**)

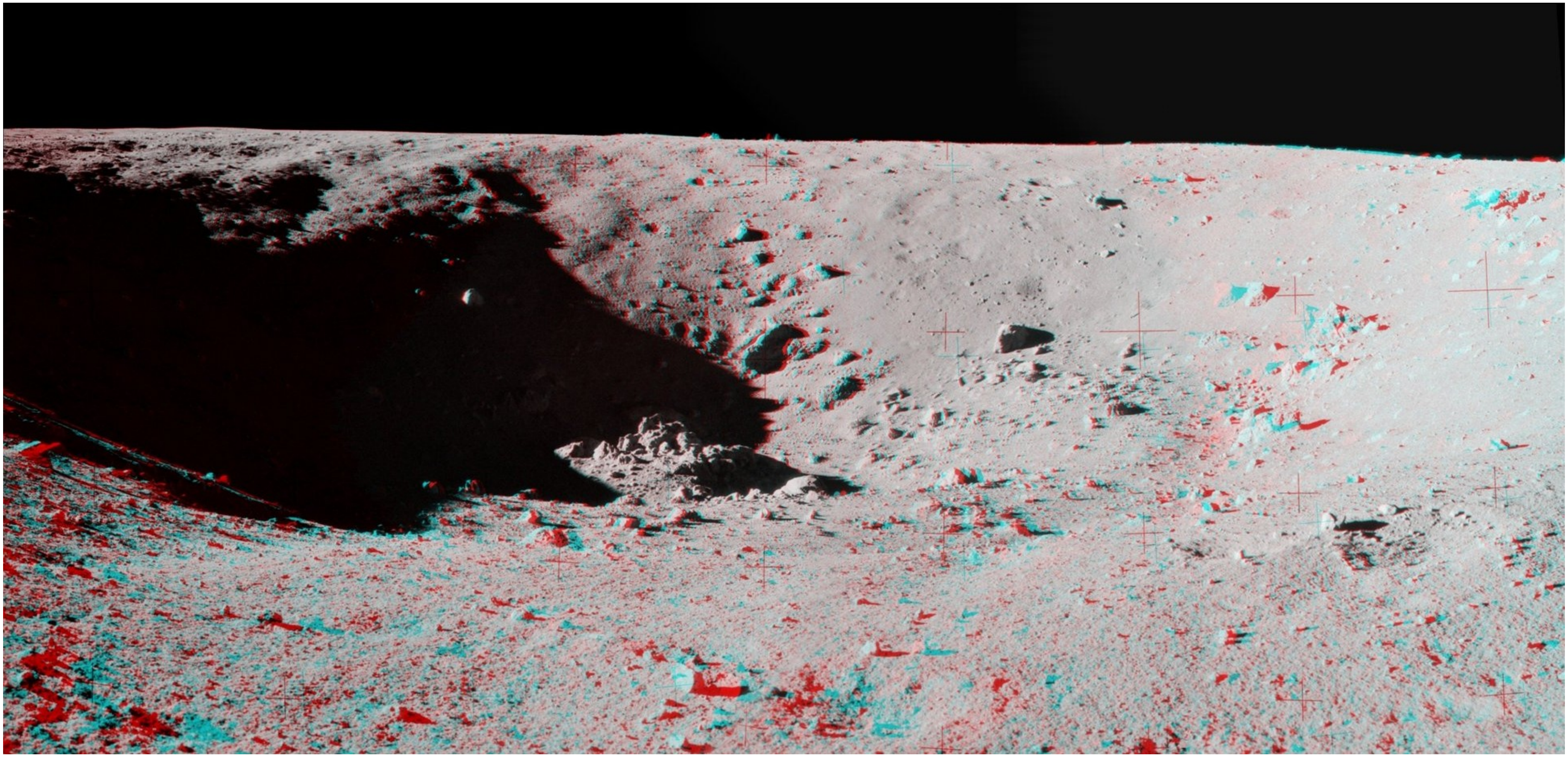


Fig. 9. A composite of four anaglyph panels from Pete Conrad's panorama of Bench Crater standing on the northwest rim. In this instance the panorama maker program was able to join the panels seamlessly. (From NASA photos AS12-49-7223 through -7227 inclusive).

(For photo location, click **here**)

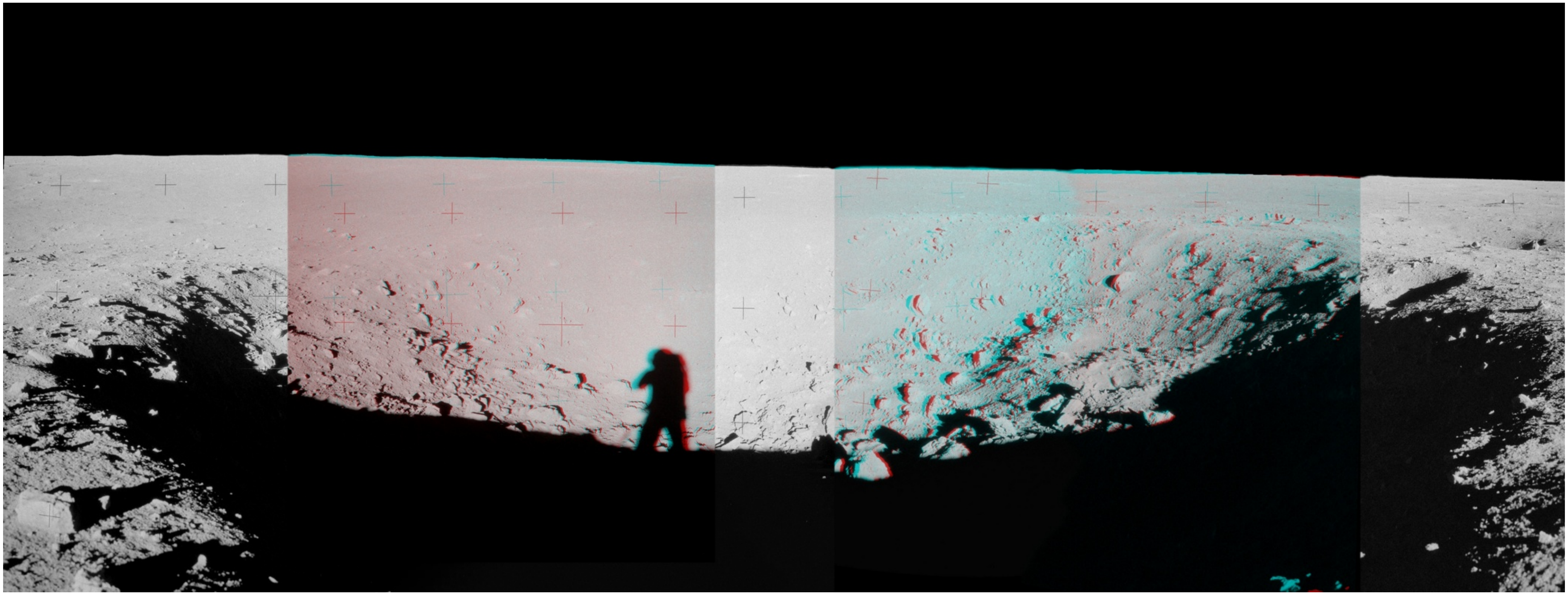


Fig. 10. Anaglyph hybrid from Pete Conrad's pan looking west across Sharp Crater. There were anaglyph gaps in the center and at the ends which have been filled in with the original pan. (From NASA frames AS12-49-7270, -71, -72, -73, -74, and -75 inclusive).

(For photo location, click **here**)

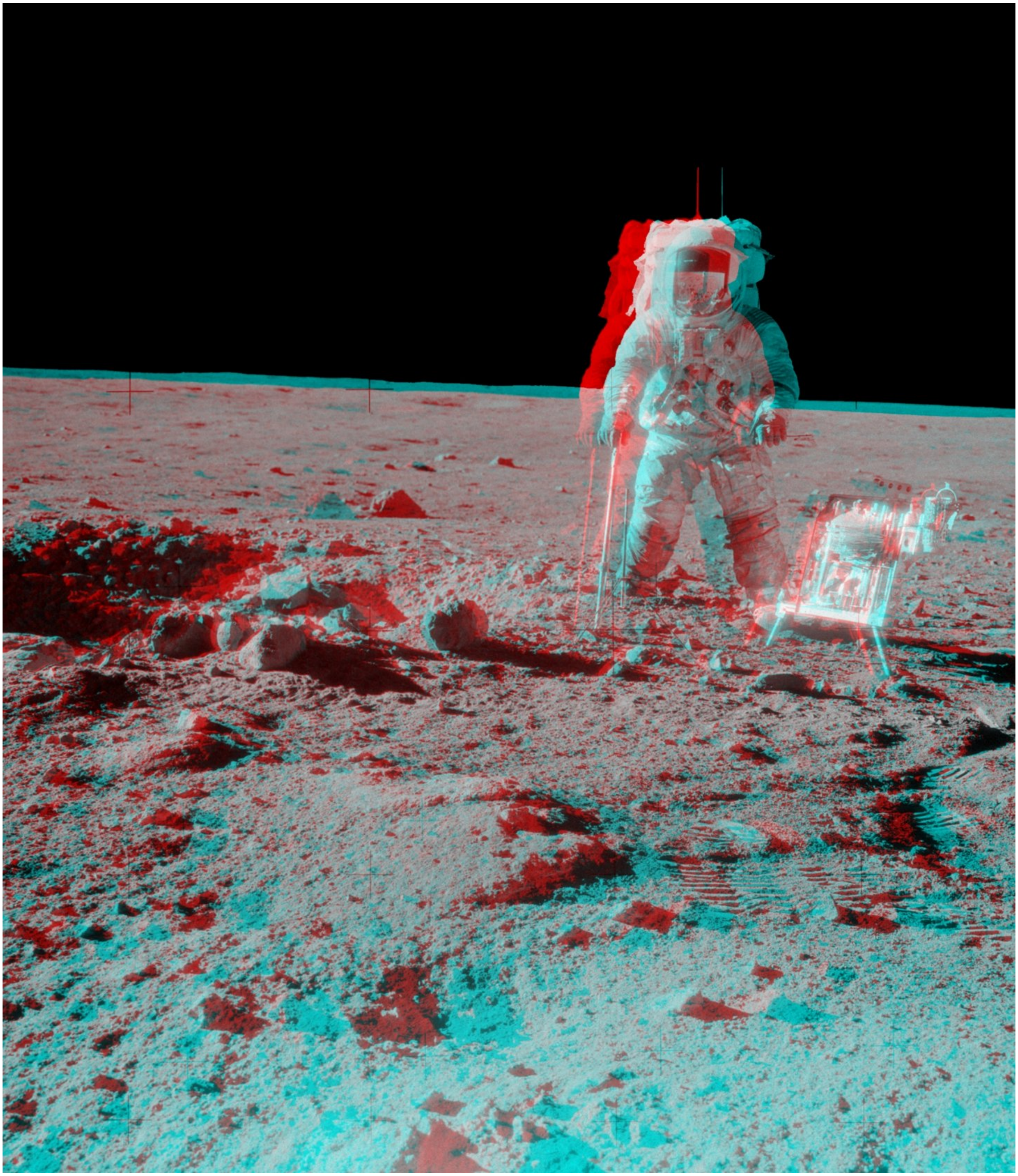


Fig. 11. Al Bean's photo of Pete Conrad on the south rim of Surveyor Crater. The hand tool carrier (**HTC**) is at right. Conrad is holding a scoop, and the gnomon is near his foot. This anaglyph has excellent depth, especially with Conrad who did not move between the two exposures. Bean also stepped apart just the right amount to allow this exceptional 3D view to be made 40 years later! (From NASA photos AS12-49-7318, and -7319).

(For photo location, click **here**)

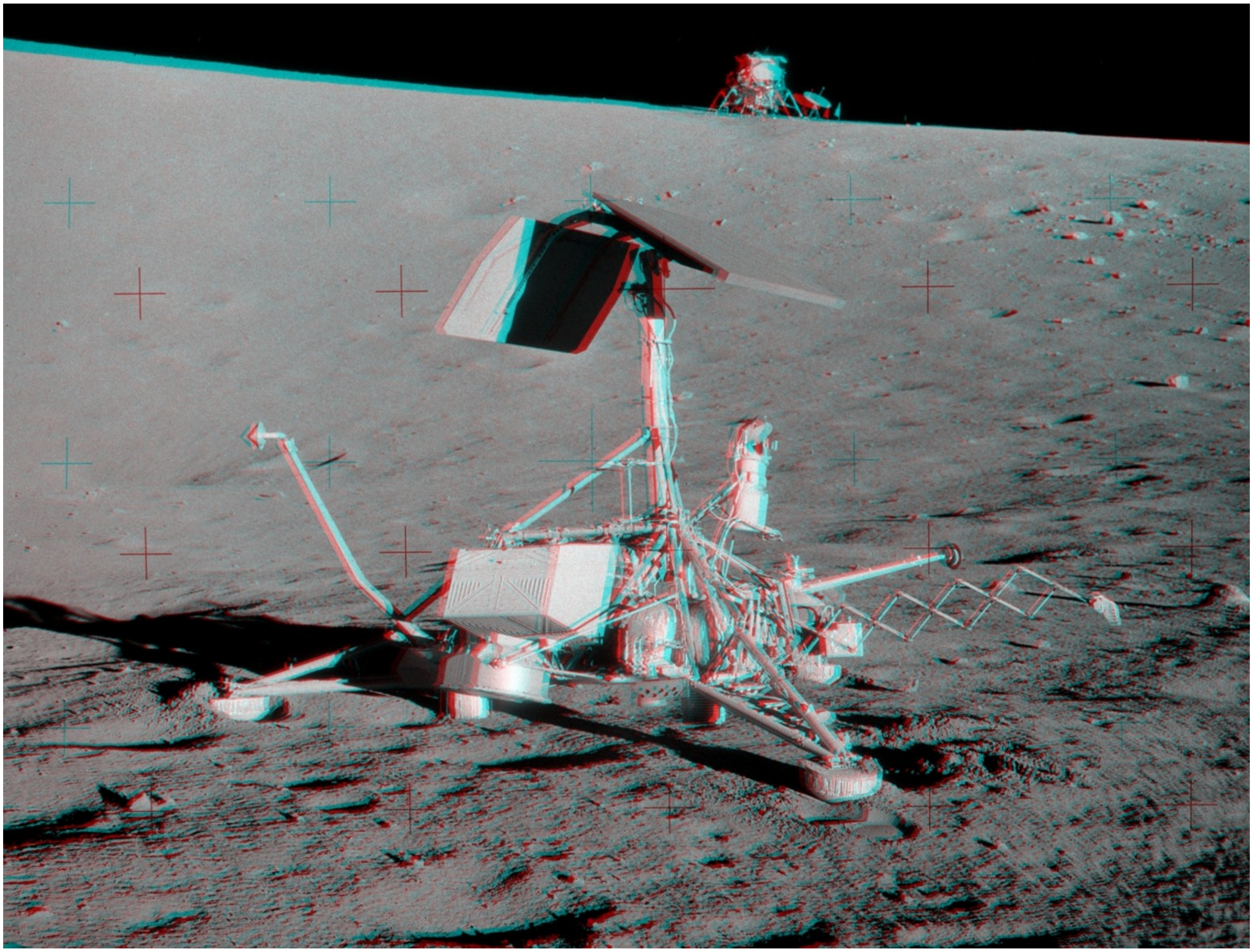


Fig. 12. The *Surveyor III* spacecraft which landed on the Moon on April 17, 1967 ca. 2.5 years earlier than Apollo 12. Principal components of the spacecraft are the mast with the planar high gain antenna at right and the solar panel on the other side; the two omni-directional antennae (with cone-shaped ends) sticking out to the left and right near the bottom of the spacecraft; the extendable arm with surface scoop at the end; and the cylindrical upright camera system. The astronauts cut the arm with its scoop and the TV camera from the spacecraft and returned them to the Earth for analysis. In the distance ca. 175 m away are the LM *Intrepid*; the high gain communications antenna; and the American Flag (the horizontal bar of the flag mount was broken, so the Flag appears limp against the vertical mast). (From NASA photos AS12-48-7099, and -7100).

(For photo location, click **here**)

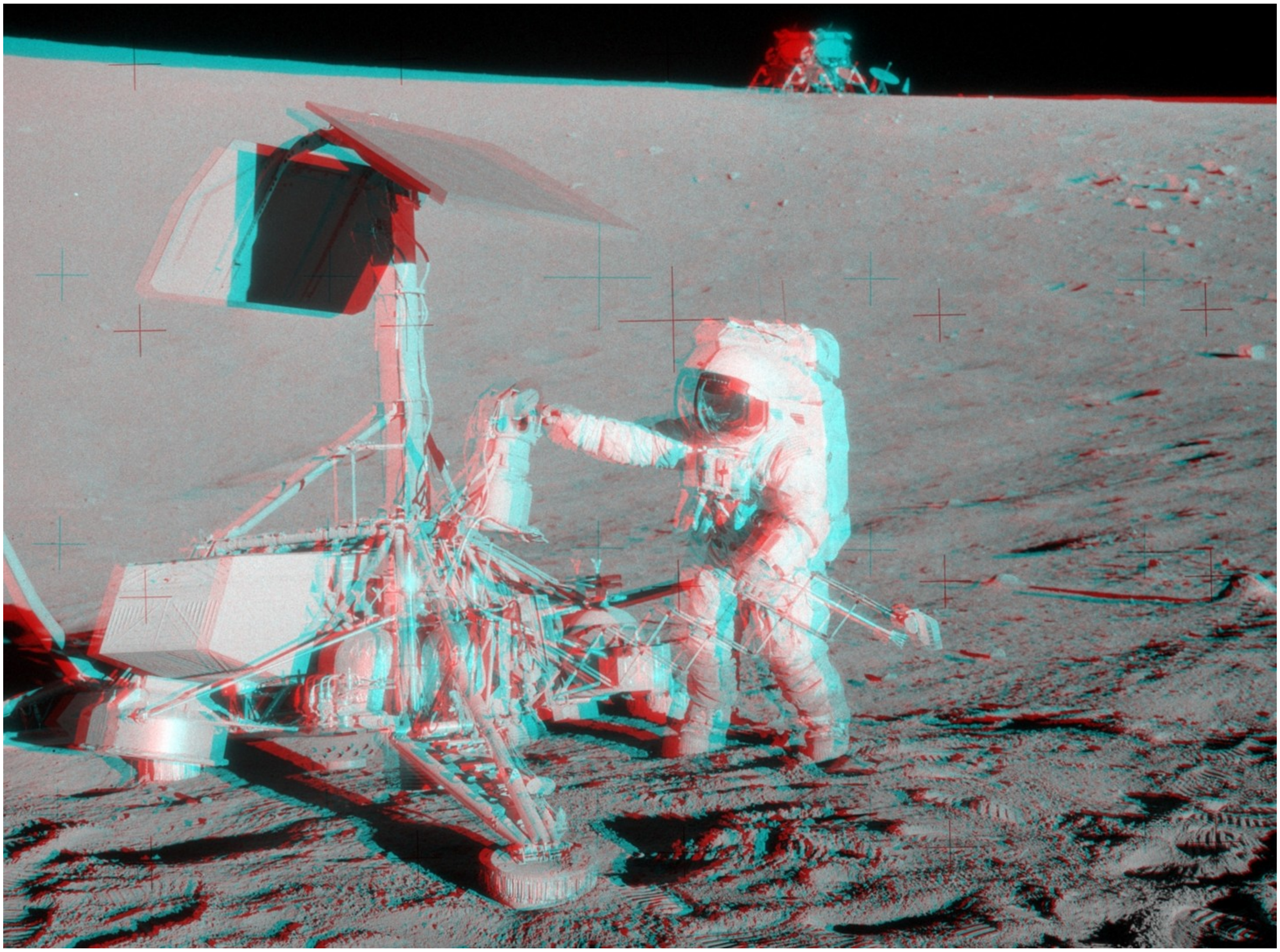


Fig. 13. Anaglyph of Pete Conrad pointing to the place where he swiped his forefinger across the dusty mirror of the camera. The streak he made indicated that the amount of dust raised by ***Intrepid*** as it flew along the north rim of the crater before setting down was substantial. (From NASA photos AS12-48-7133, and -7134).

(For photo location, click **here**)

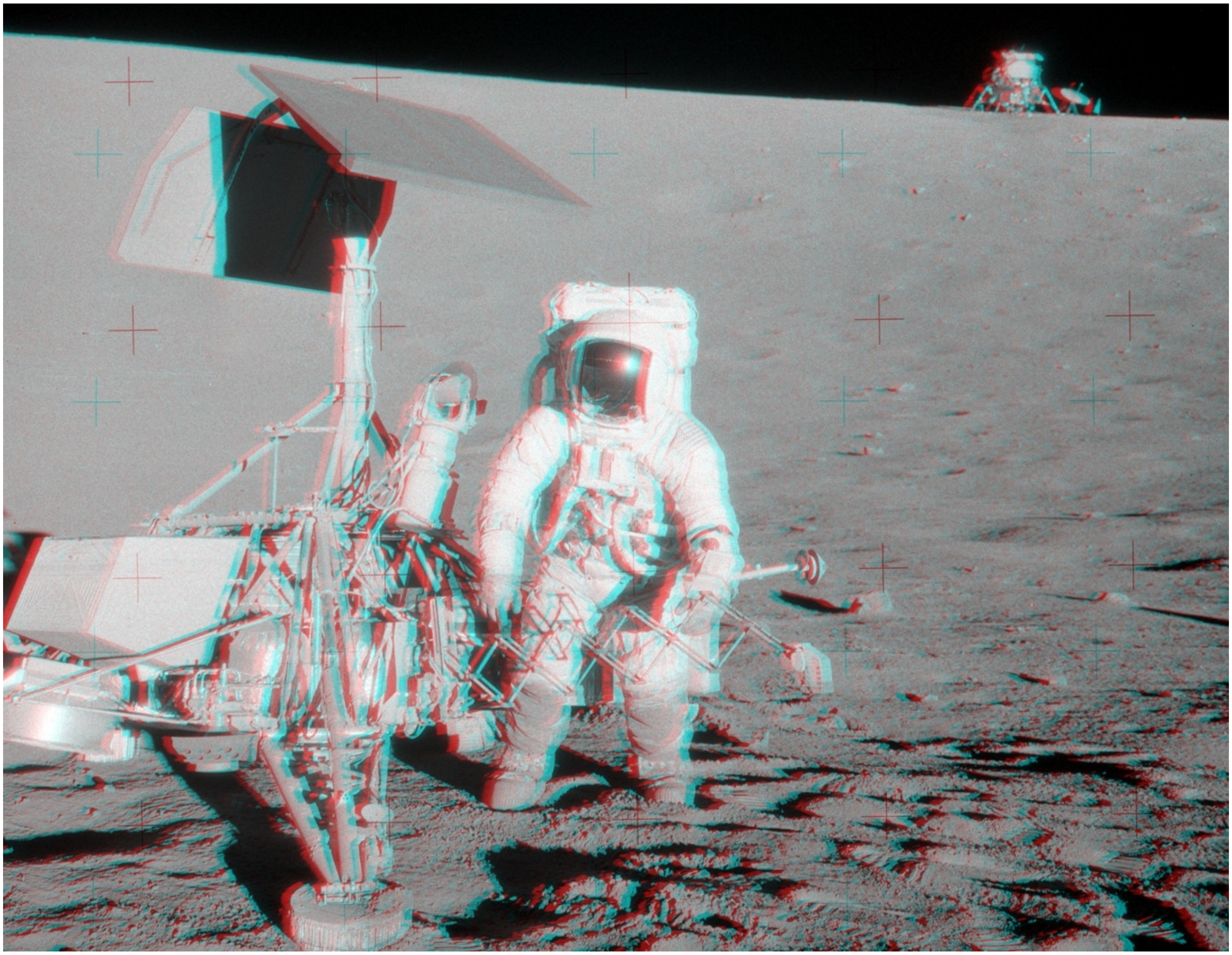


Fig. 14. Al Bean at the Surveyor spacecraft (completing the so-called tourist shots). (From NASA photos AS12-48-7135, and -7136).

(For photo location, click **here**)

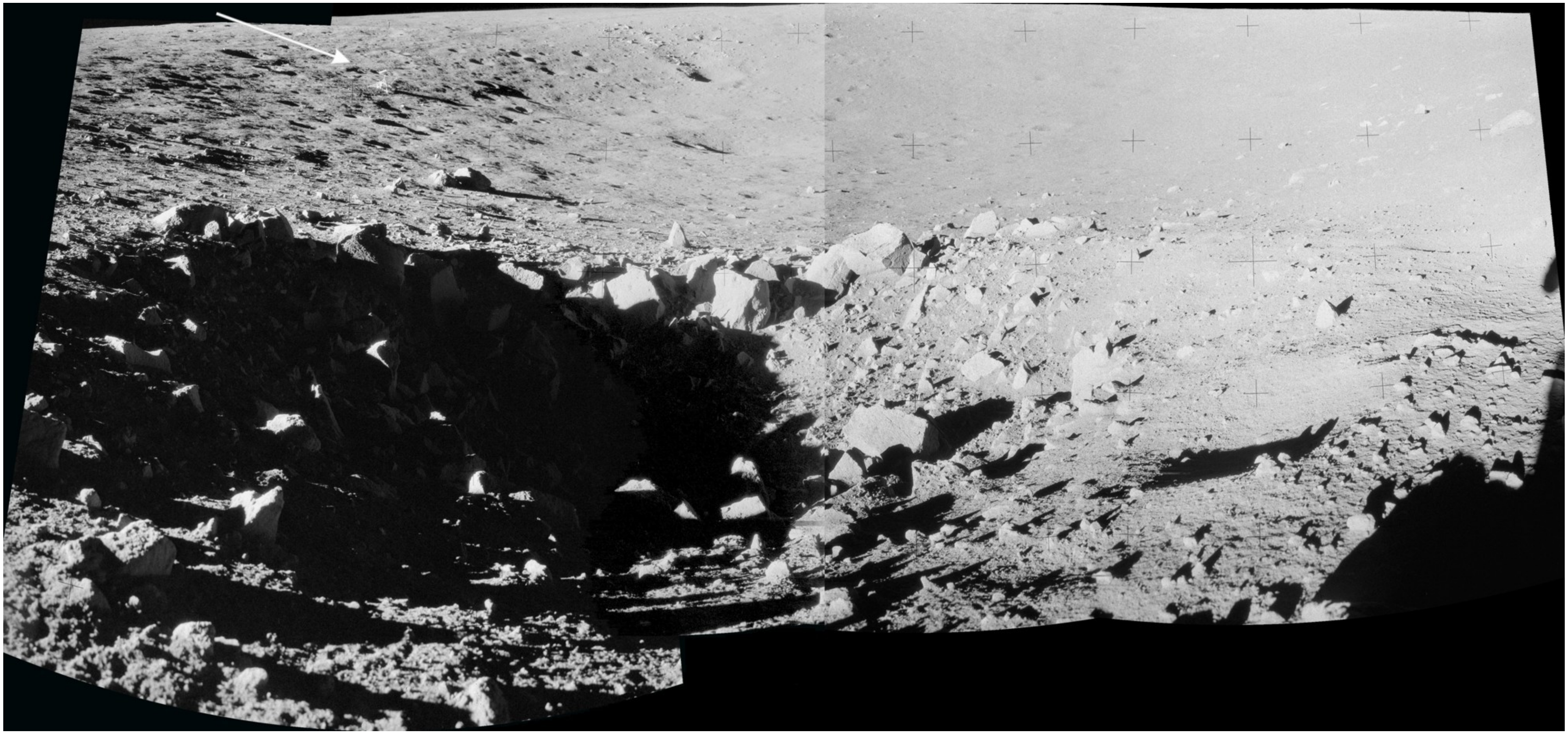


Fig. 15. A plain, non-3D view of Block Crater in the foreground, looking across Surveyor Crater to the south rim. *Surveyor III* is at left just beyond the arrow. The darkish streak curving down towards the spacecraft marks the track of the astronauts. This crater and the two large boulders between it and *Surveyor III* were instrumental in the final selection of this area as the mission target. Ewan Whitaker of the Lunar and Planetary Institute in Tucson, AZ found the Surveyor spacecraft from a Lunar Orbiter (**LO**) photo taken before the Apollo 12 mission flew by comparing the LO photo with the view from the spacecraft towards Block Crater taken by *Surveyor III*. The rocks seen in the foreground, including the triangular-shaped one left of center, were clearly imaged by *Surveyor III* in 1967. Block Crater, the two boulders, and Surveyor all lie on a straight line in **Fig. 1**. (From NASA photos AS12-48-7144, -7145, -7146, and -7147).

(For photo location, click **here**)

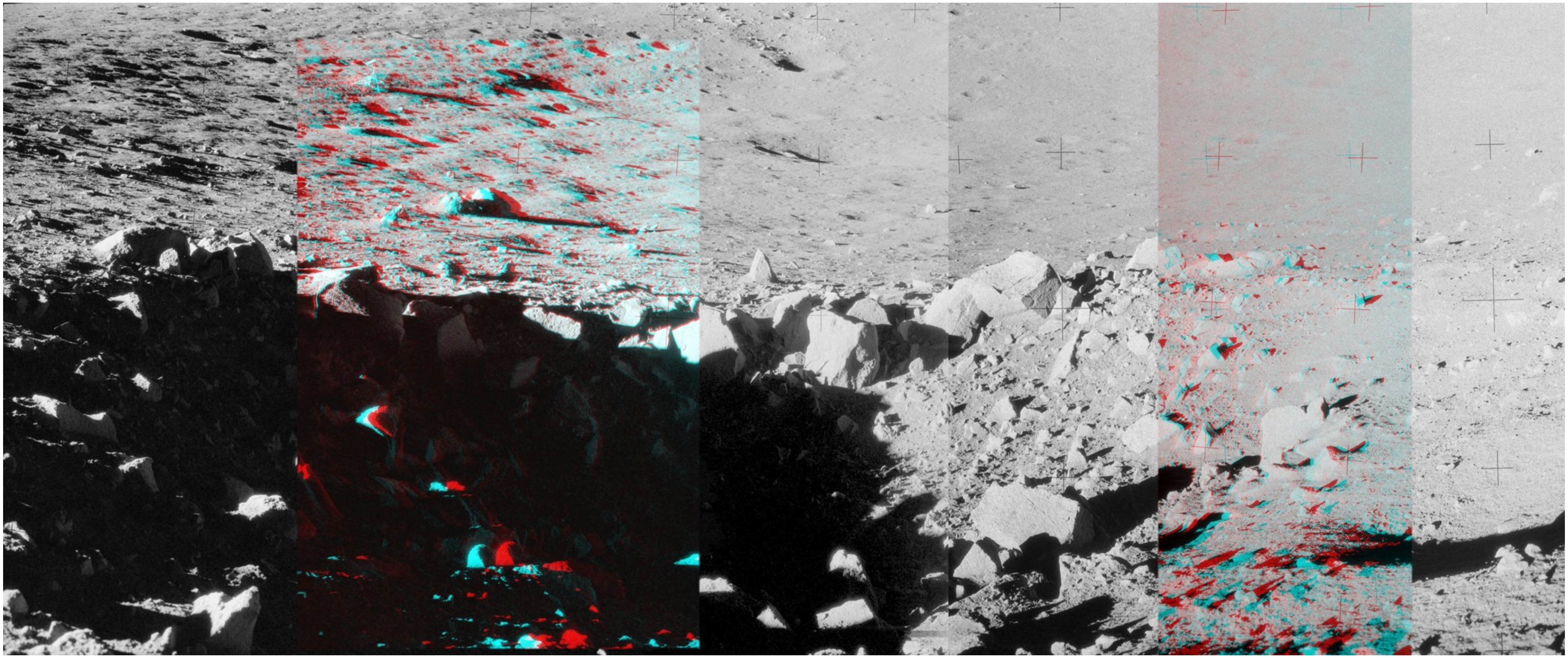


Fig. 16. Anaglyph views of portions of **Fig. 15**. Gaps in the anaglyph overlap panels have been filled in with regular photos for continuity. *Surveyor III* is in the top left corner of the left anaglyph panel. The large gaps resulted from poor matching of the interior anaglyph overlaps. (From NASA photos AS12-48-7144, -7145, -7146, and -7147).

(For photo location, click **here**)

APOLLO 14

***Antares* at *Fra Mauro* – Cone Crater**

February 5, 1971

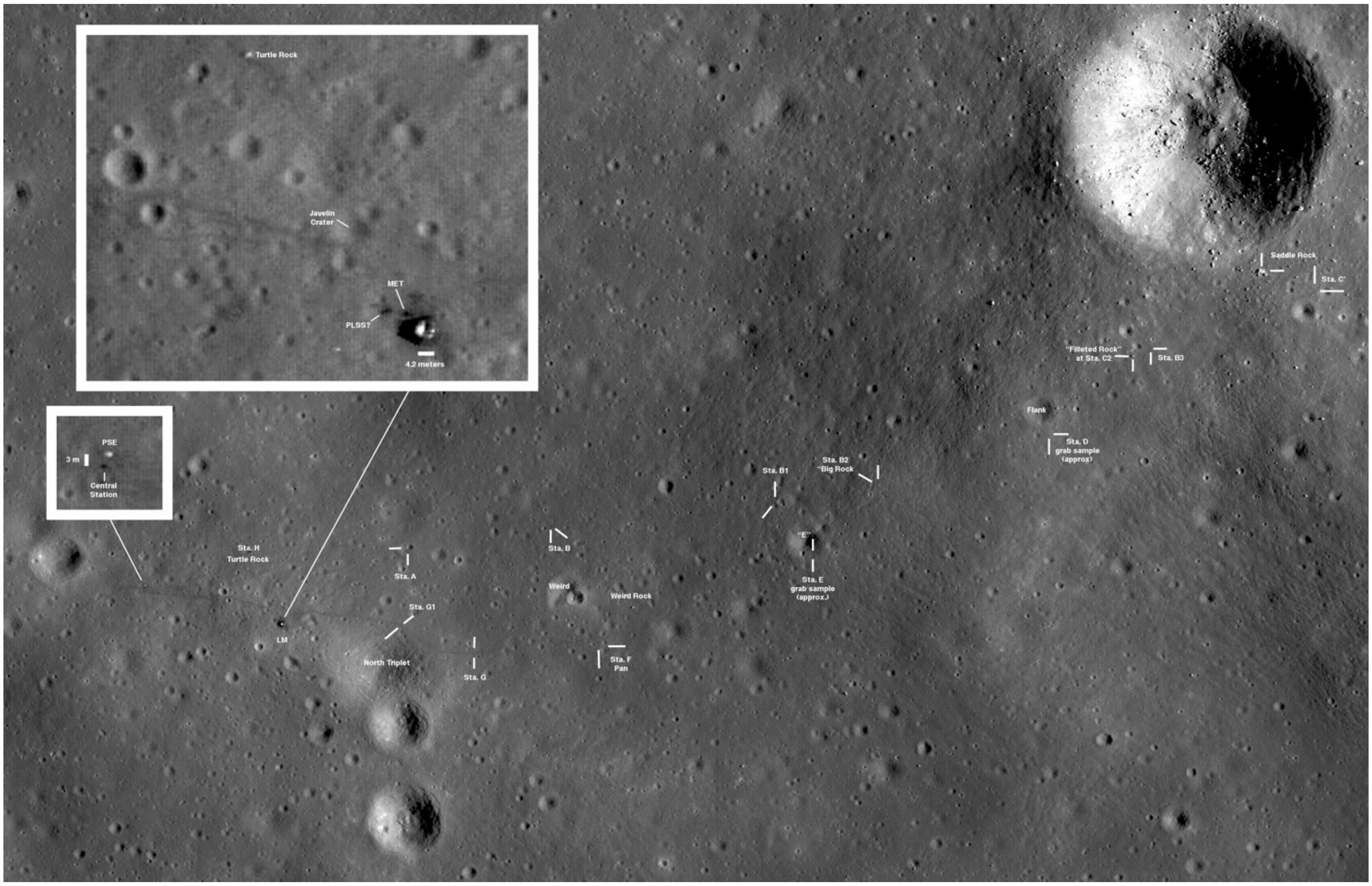


Fig. 1. **LRO** photo of the Apollo 14 landing site and Cone Crater (upper right). The upper left inset is an enlargement of the descent stage of the *Antares* **LM**. The smaller inset is the site of the **ALSEP** with the Passive Seismic Experiment (**PSE**) showing up as a white dot. The various labeled sites mark the stations where the astronauts stopped briefly for samples and photographs on their walk to the top of Cone Crater and back. Sometimes their tracks are visible. The distance from the LM to the top of the crater is ca. 1.5 km. Cone Crater itself is about 400 m in diameter. (NASA/GSFC/ASU photo)

(For landing site location, click **here**)

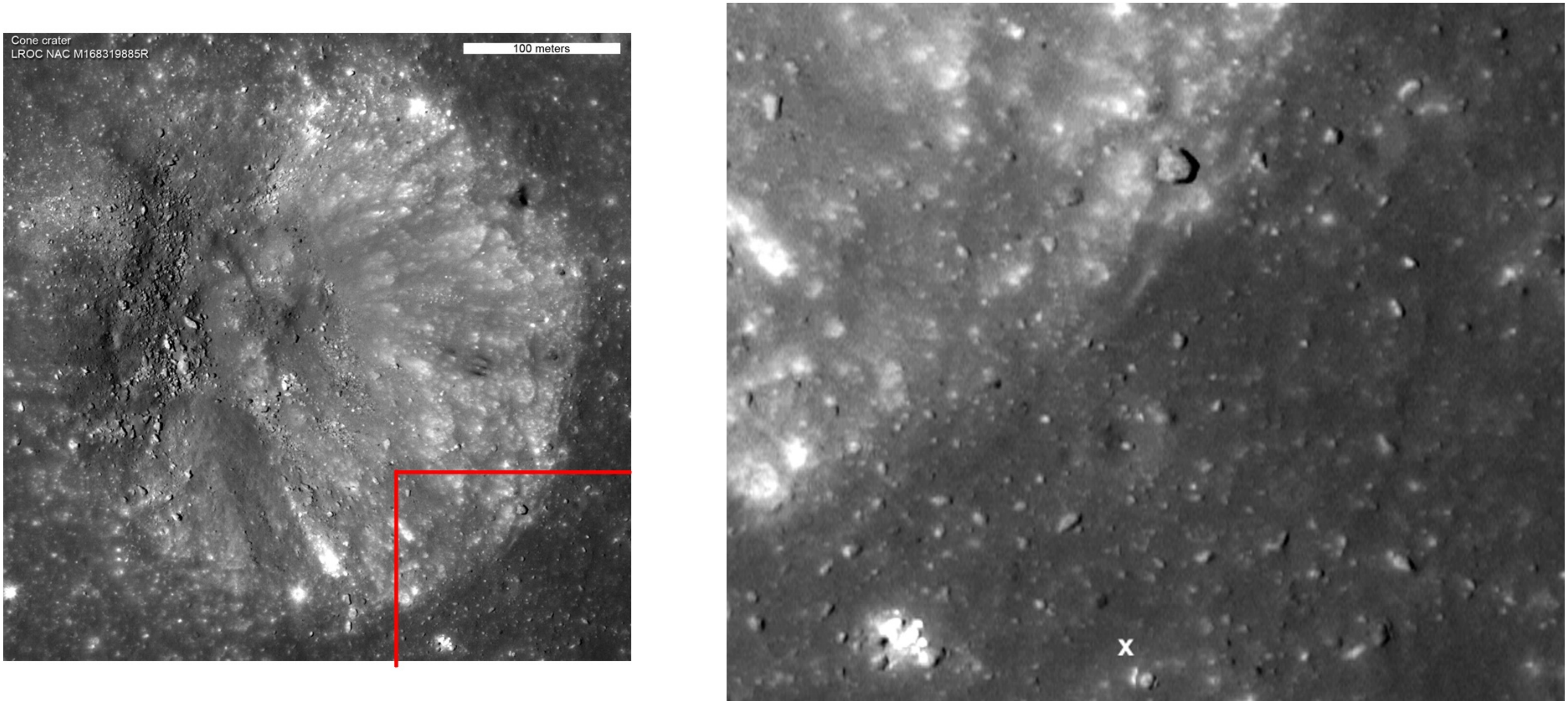


Fig. 2. An LRO view of Cone Crater taken in the early afternoon not long after the sun had passed the local meridian. The area delineated in red in the left view is shown enlarged at right. The white '**x**' near the bottom middle of the right view is Al Shepard's position when he made a panorama to the direction of Saddle Rock (white boulders directly left of the '**x**') towards the crater edge and most of the way around. 3D panels from this panorama are some of the most impressive perspective views of the rocky lunar surface as described in **Figs. 10-17**. This location differs from that of some other researchers designated as Station C-prime, which they base on an old Lunar Orbiter photo (see Fig. 10). (NASA/GSFC/ASU photo).

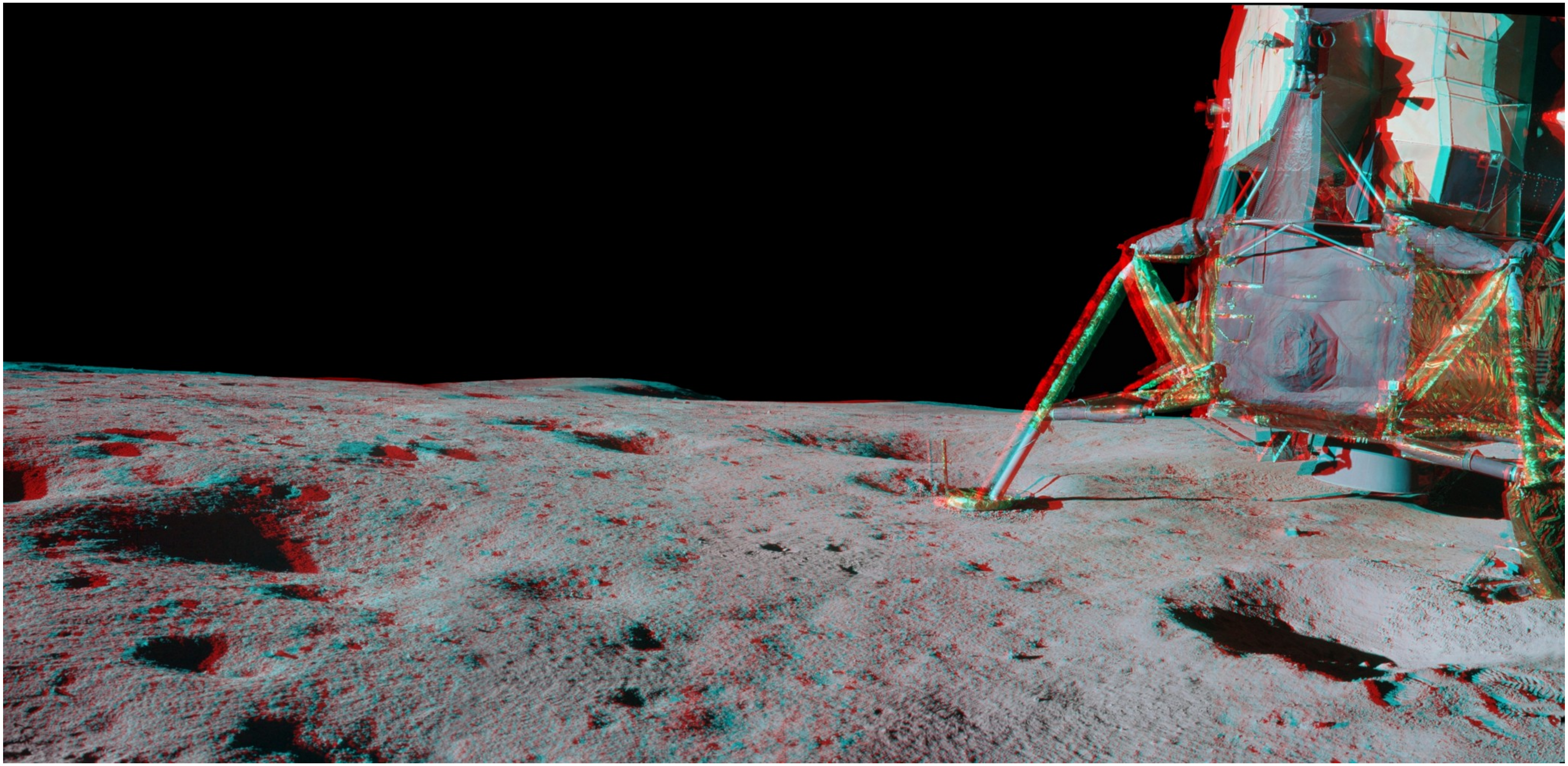


Fig. 3. The Apollo 14 **LM** *Antares* at its landing site showing the distribution of small, but fairly deep craters. Note the bent 6 ft. surface probe sticking out from the footpad. (From NASA photos AS14-66-9250, through -9255, inclusive).

(For photo location of the LM, click **here**)

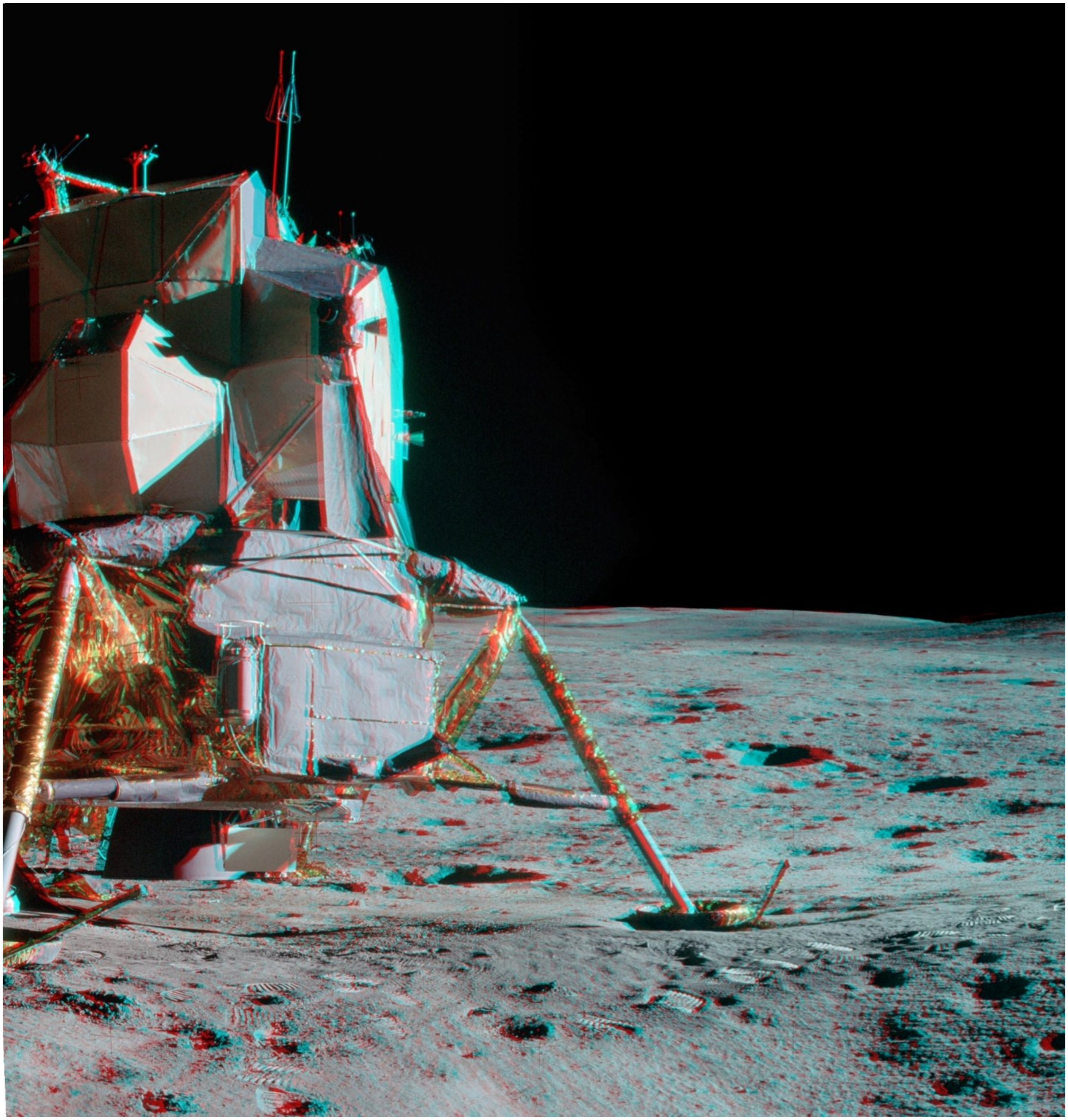


Fig. 4. Anaglyph of *Antares* from the other side of the footpad seen in **Fig. 3**. This view shows that the **LM** is sitting on the slope of a shallow saucer-shaped depression. Cone Crater, the ultimate destination of the astronauts, is about 1.5 km to the right.

(For photo location of the LM, click **here**)

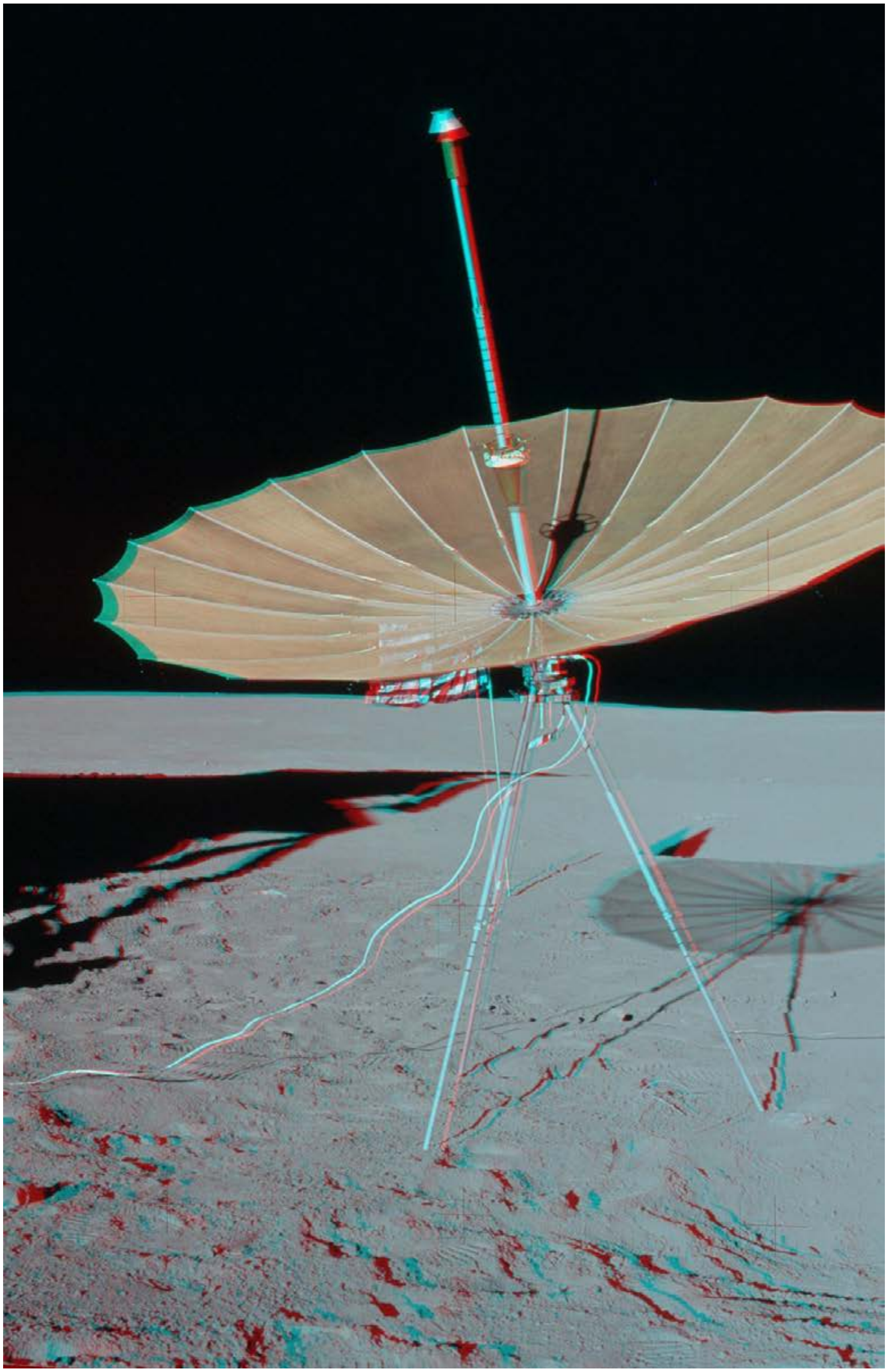


Fig. 5. The high gain antenna after deployment. The American Flag can be seen through and just under the dish-shaped mesh The shadows left to right are: the **LM**, the Flag, and the antenna. The location of the antenna is just to the right of **Fig. 3**. (From NASA photos AS14-66-9256, and -9257).

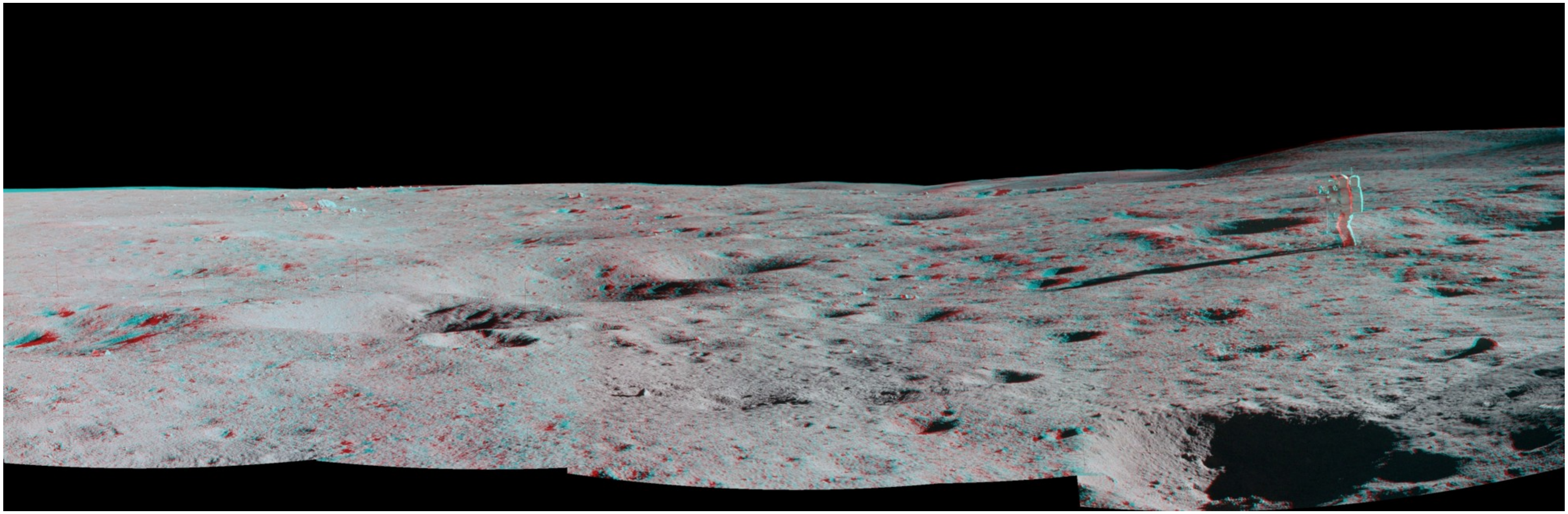


Fig. 6. Astronaut Ed Mitchell is at the TV camera turning it for viewers on Earth. The **LM** is just to the right of Al Shepard who is making the panorama from which this anaglyph was made. The ridge which the astronauts will climb to the top of Cone Crater is just beyond Mitchell leading to the right. (From NASA photos AS14-66-9297, through -9302 inclusive).

(For photo location, see the large inset of **Fig. 1**)

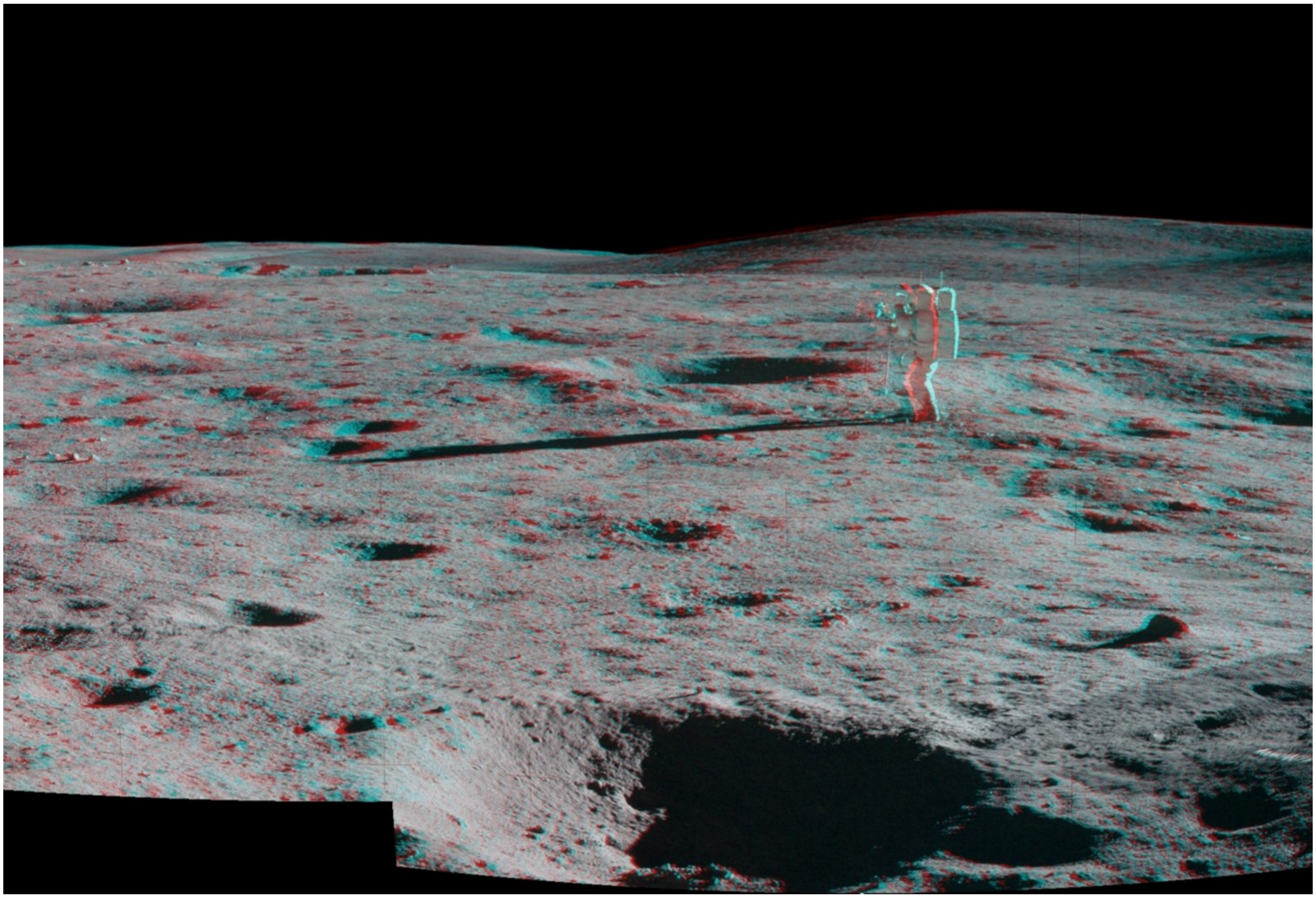


Fig. 7. The right half of the panorama of **Fig. 6** showing Mitchell in more detail. (From NASA photos AS14-66-9300, -9301, and -9302).

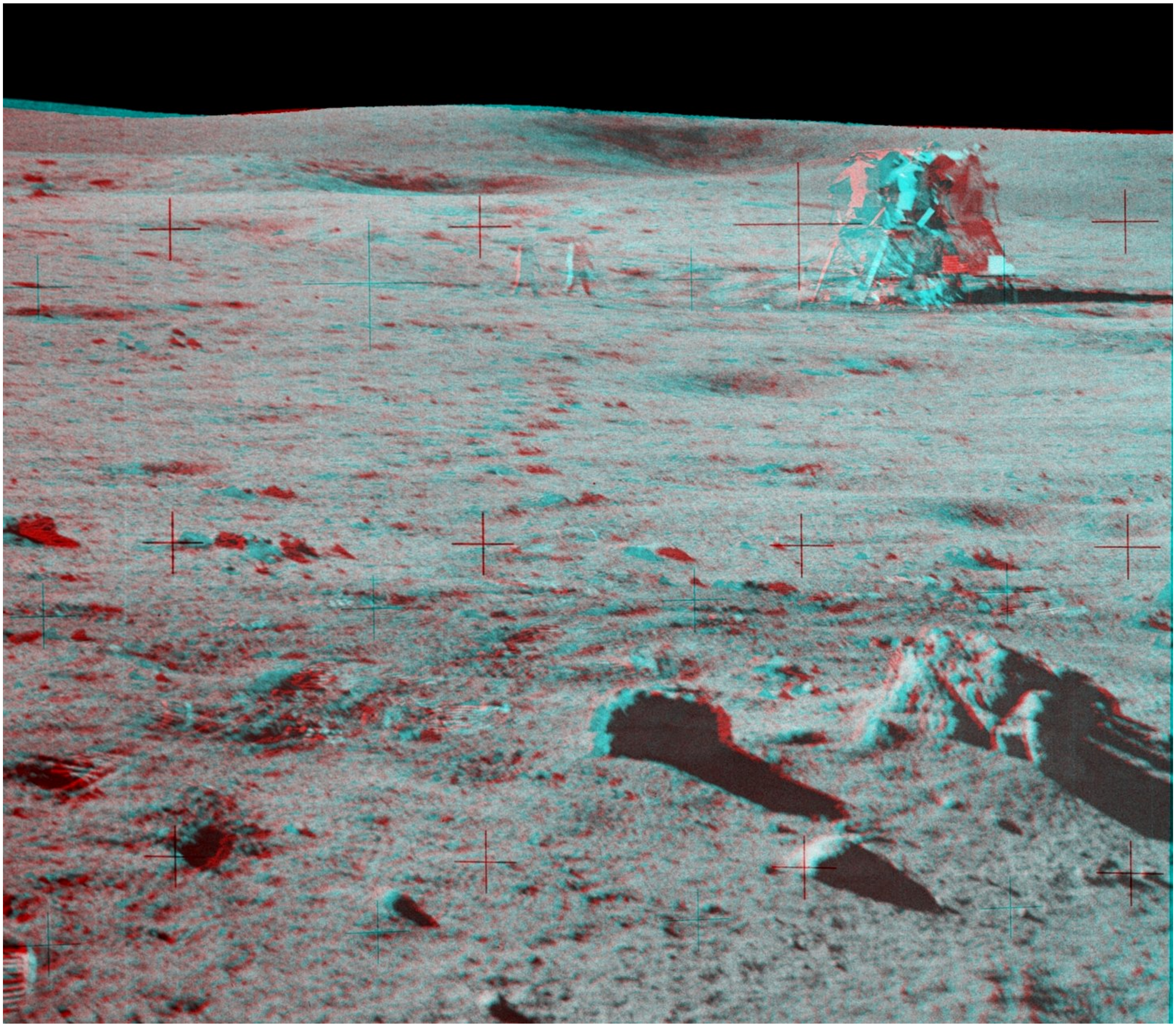


Fig. 8. Al Shepard at the TV camera pointing it towards the Modularized Equipment Storage Assembly (**MESA**) on the **LM**. Ed Mitchell is at station H taking the pictures. Turtle Rock is behind Mitchell as seen in the next photo (**Fig. 9**). The large depression on the hill in the distance is "Old Nameless" Crater. (From NASA photos AS14-68-9486, and -9487).

(For photo location of Turtle Rock in the large inset, click **here**)

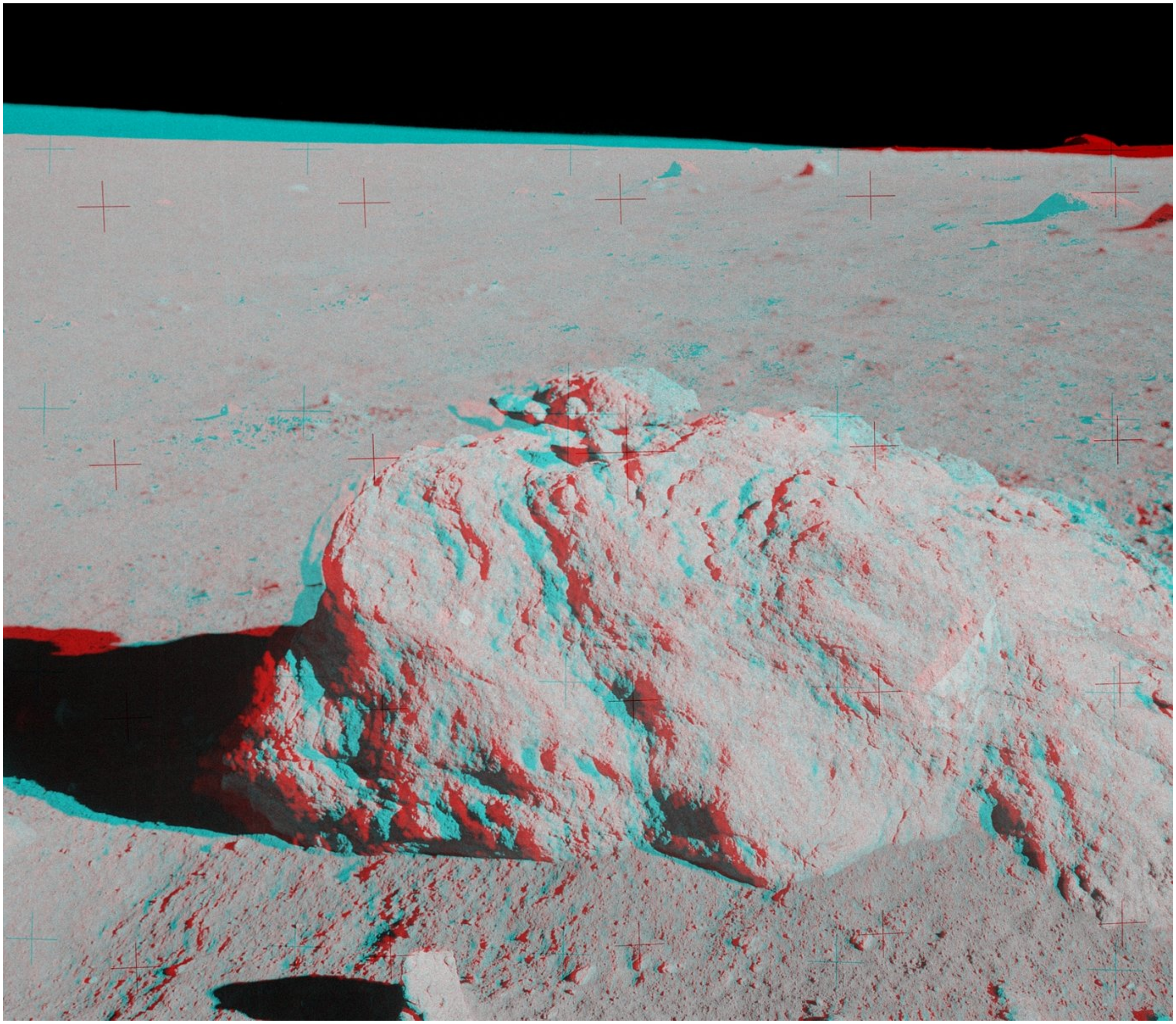


Fig. 9. Turtle Rock at Station H, so-called because of the accidental grouping of rocks on the top of the large boulder. (From NASA photos AS14-68-9472, and -9475).

(For photo location of Turtle Rock in the large inset, click **here**)

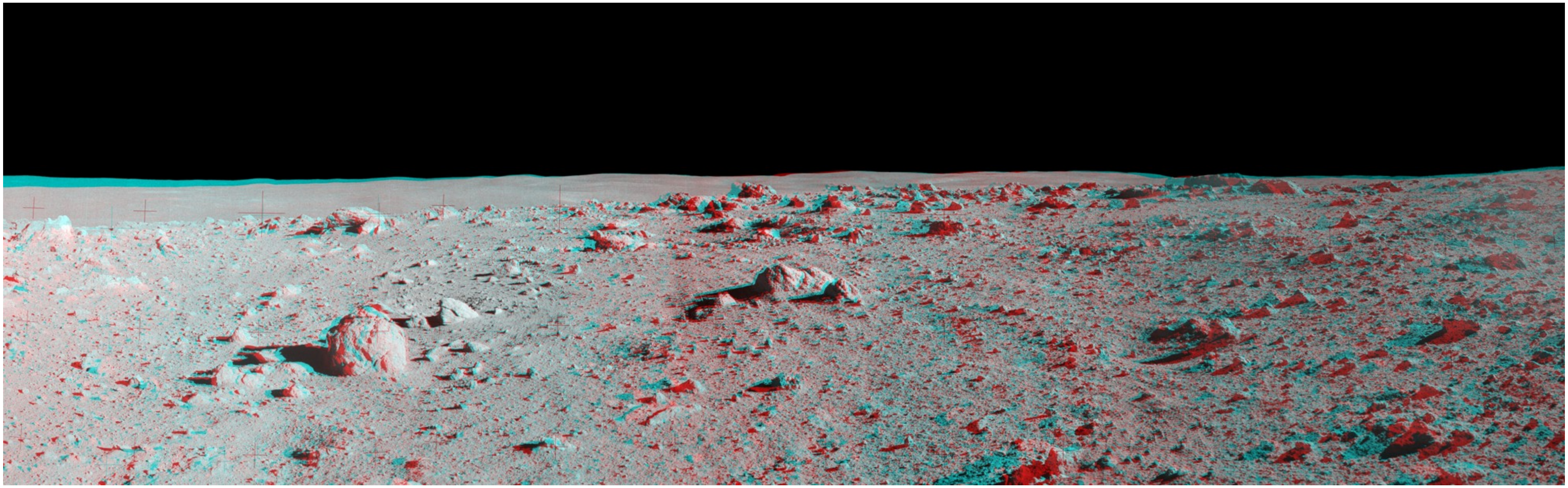
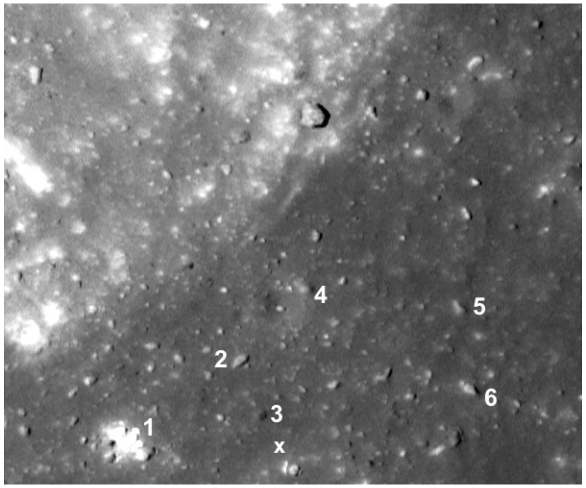


Fig. 10. Part of the panorama taken at Station C-prime by Al Shepard. The location where Shepard is standing is marked on the enlargement of the LRO photo given in Fig. 2 and in the inset below by the white '**x**' as determined from the boulders visible in the following panels. The bright, white 'Saddle Rock' at the far left, the elongated boulder, and the large round boulder at left are marked **1**, **2**, and **3** in the inset, respectively. The other numbers are explained in following photos. The direction of view in the center of the pan is approximately to the North. The direction of 'Saddle Rock' is looking approximately to the West. (From NASA photos AS14-64-9100 through -9108 inclusive)



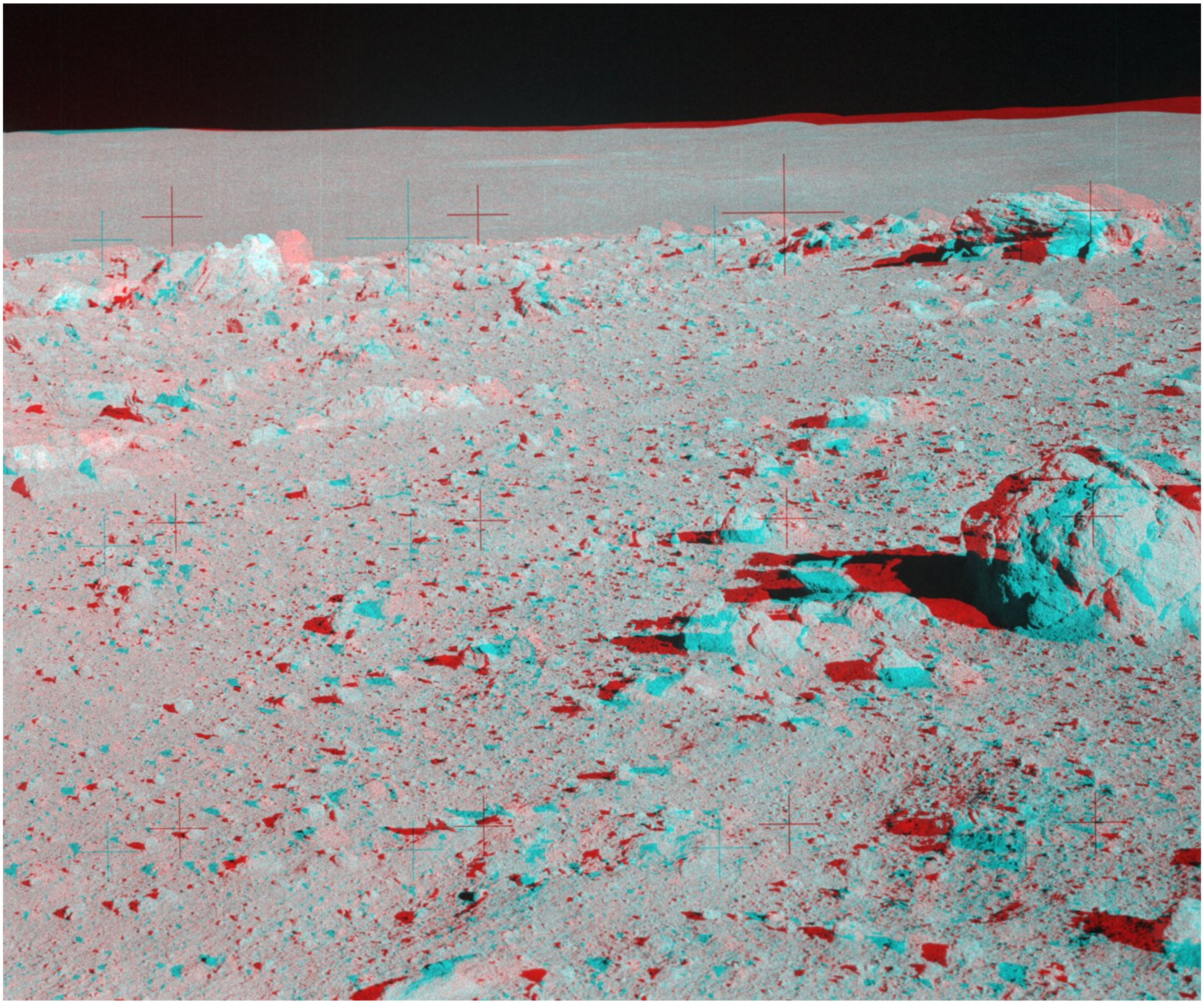


Fig. 11. The C-prime pan beginning at 'Saddle Rock'. The reason for that name is clearer in this enlarged view. 'Saddle Rock' and the two large boulders at right are marked **1**, **2**, **3** in the **inset** of **Fig. 10**. (From NASA photos AS14-64-9100, and -9101).

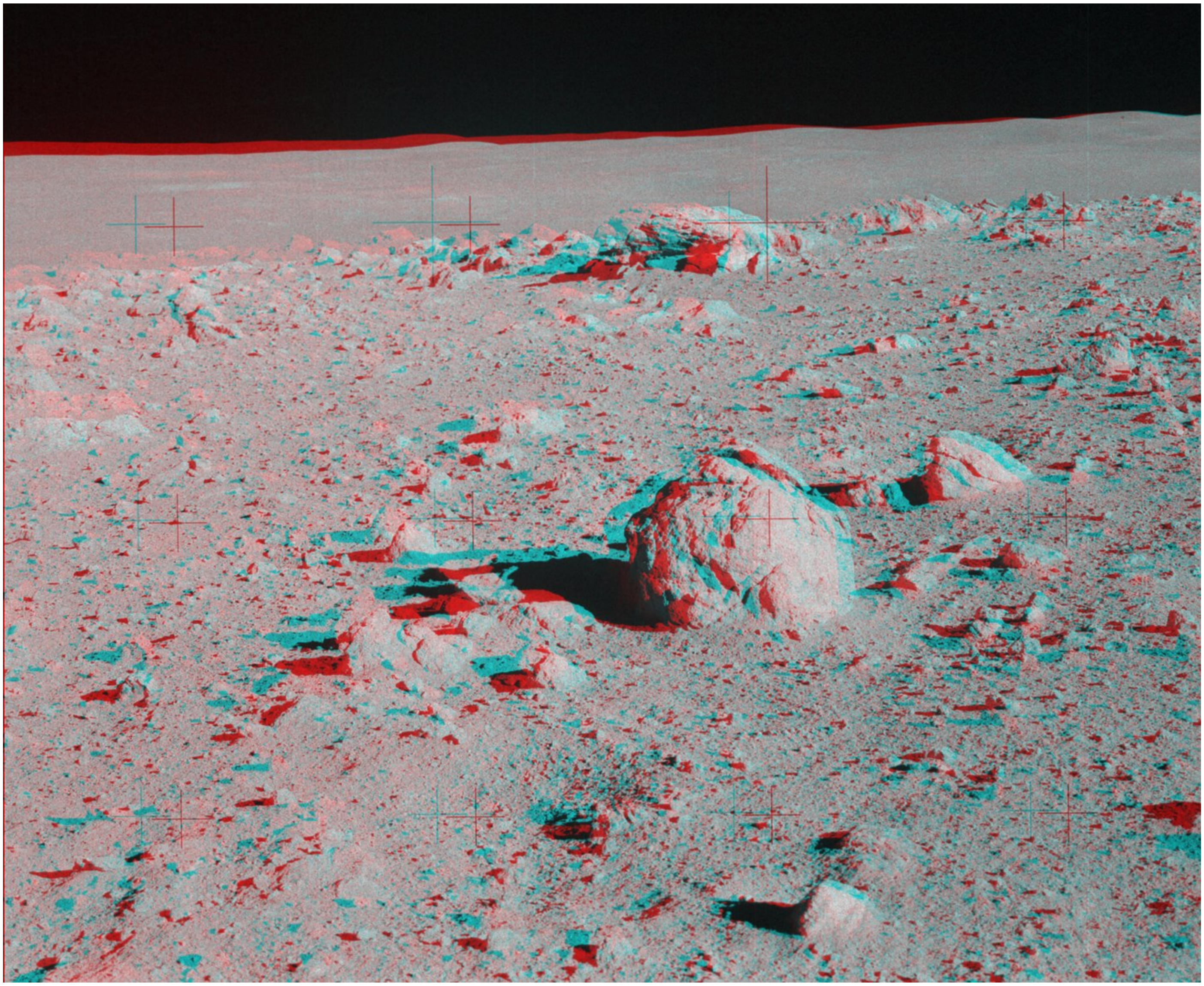


Fig. 12. Continuing to the right of **Fig. 11**. The enlongated and round boulders are right of center. Had the astronauts walked just beyond the elongated boulder to the boulders right of it, they would have been at the rim edge and could have seen down into the crater (see **inset**). However, they were unsure of their position and so decided to return to the **LM**, taking some closeup photos of 'Saddle Rock' on the way. The latter location would be their closest position to the crater edge. They did collect the rock samples that were a primary goal of the mission. (From NASA photos AS14-64-9101, and -9102).

(See **Fig. 10** for the whole pan)

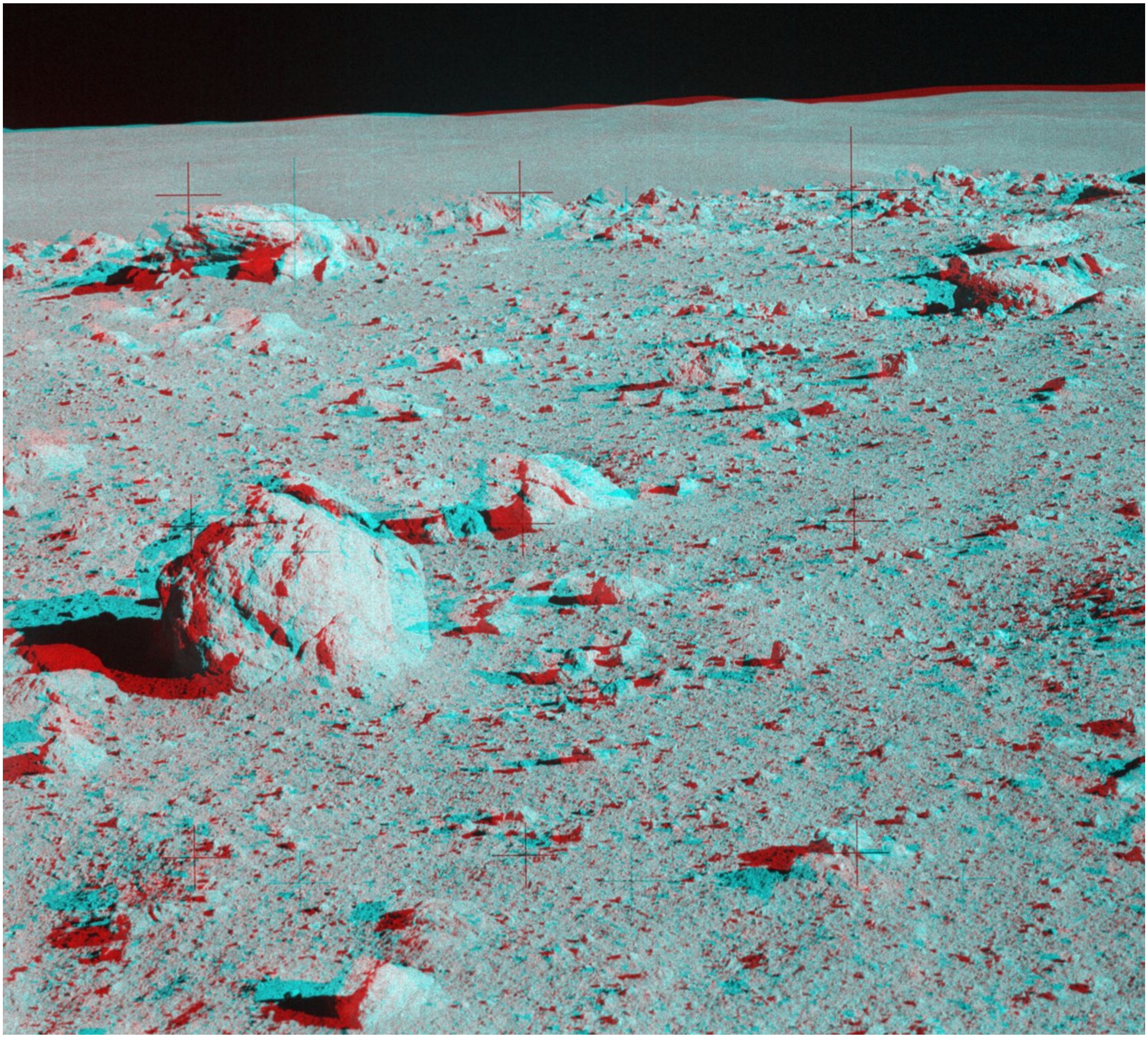


Fig. 13. Continuing to the right of **Fig. 12**. The boulder with rounded top above the fiducial cross at center top of the photo is very close to the crater rim edge. See **Fig. 10** for the whole pan. (From NASA photos AS14-64-9102, and -9103).

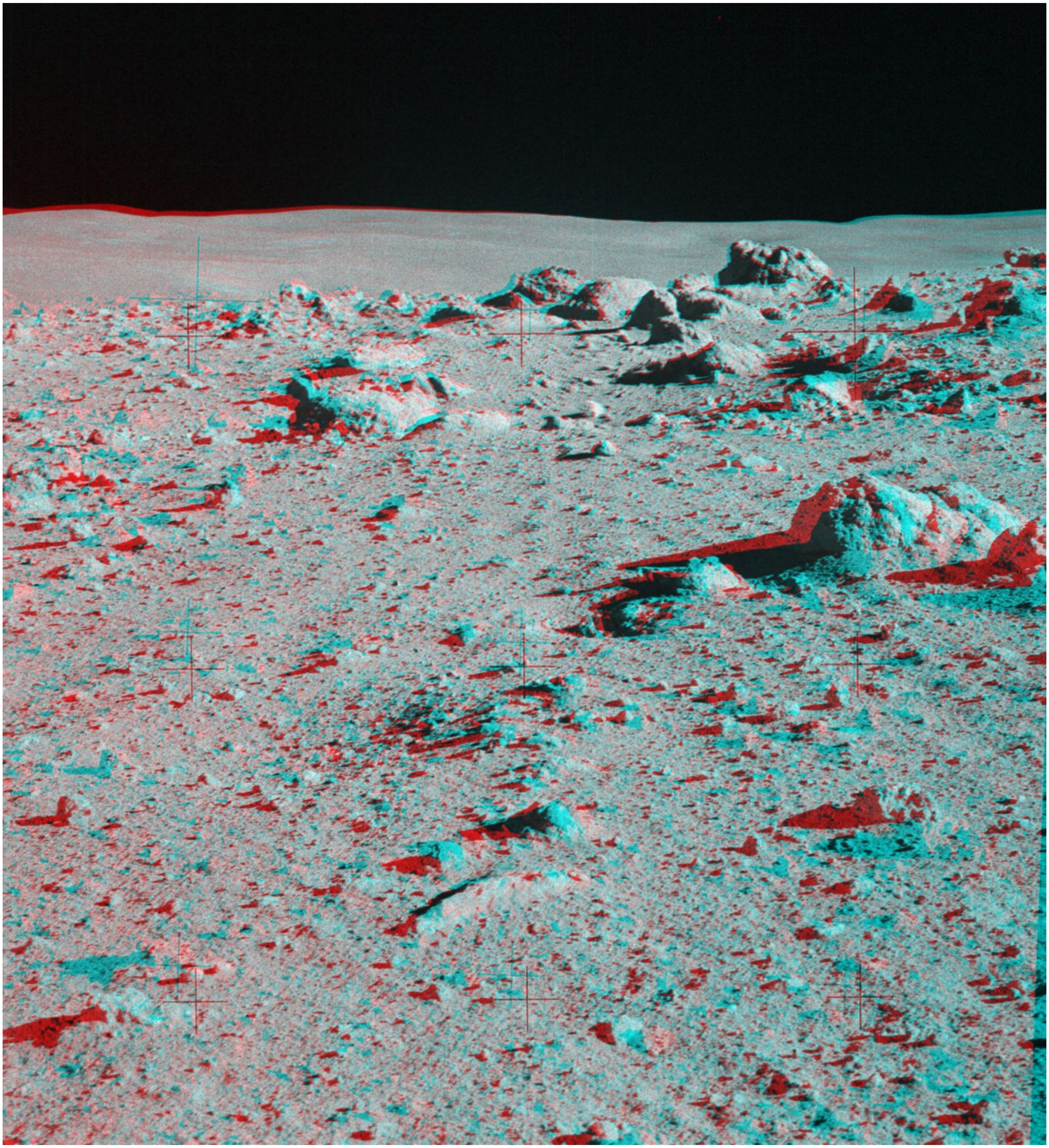


Fig. 14. Continuing to the right of **Fig. 13**. The large boulder at right with the dome shape pointing up to the left is marked '**4**' in the **inset**. It is sitting on the edge of a small crater not visible above. The boulders to the right of the upper central fiducial cross above are the ones on the opposite side of that crater seen in the **inset**. (From NASA photos AS14-64-9103, and -9104),

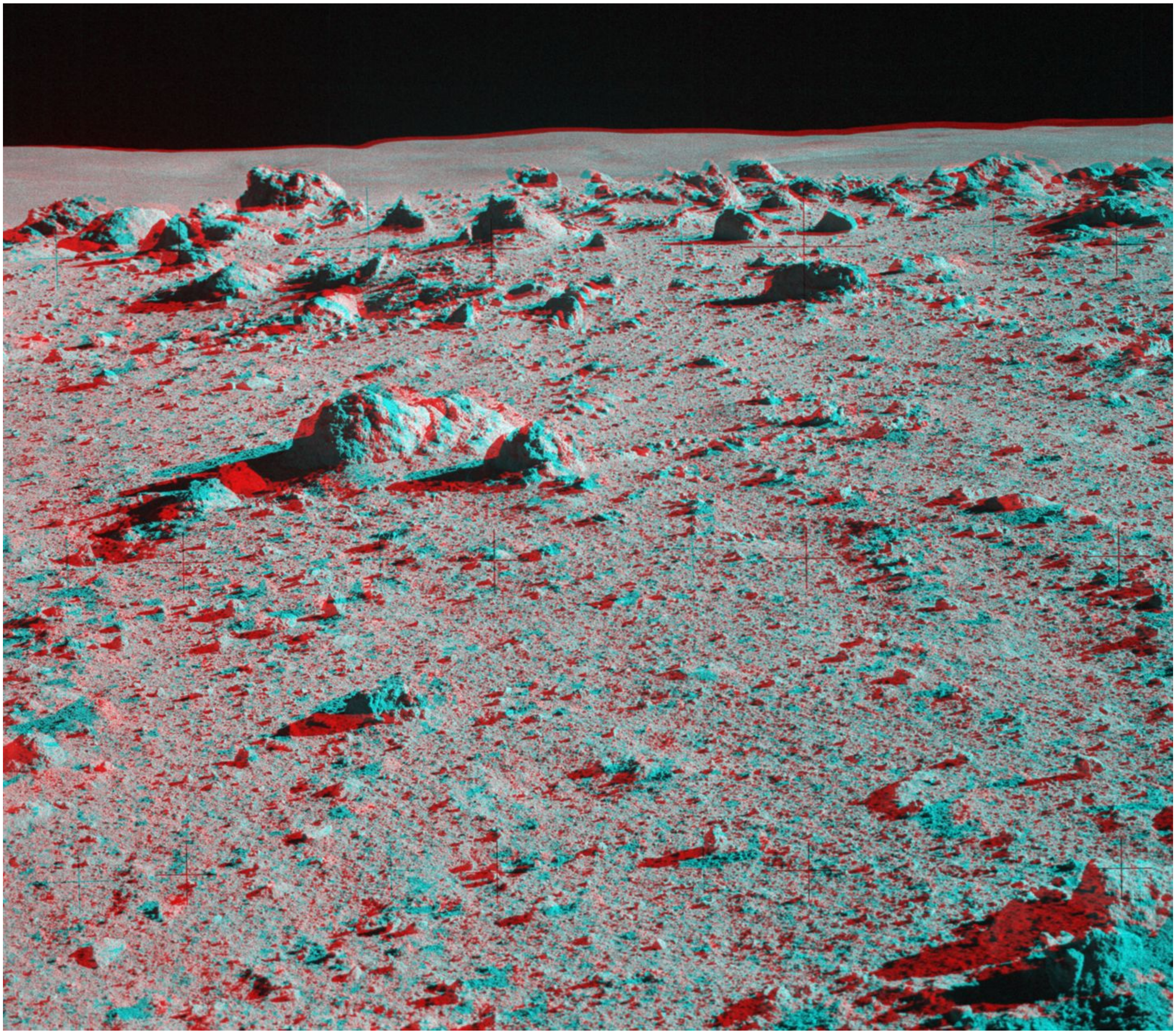


Fig. 15. Continuing to the right of **Fig. 14**. NNE is approximately left of the center line. (From NASA photos AS14-64-9104, and -9105).

(See **Fig. 10** for the whole pan)

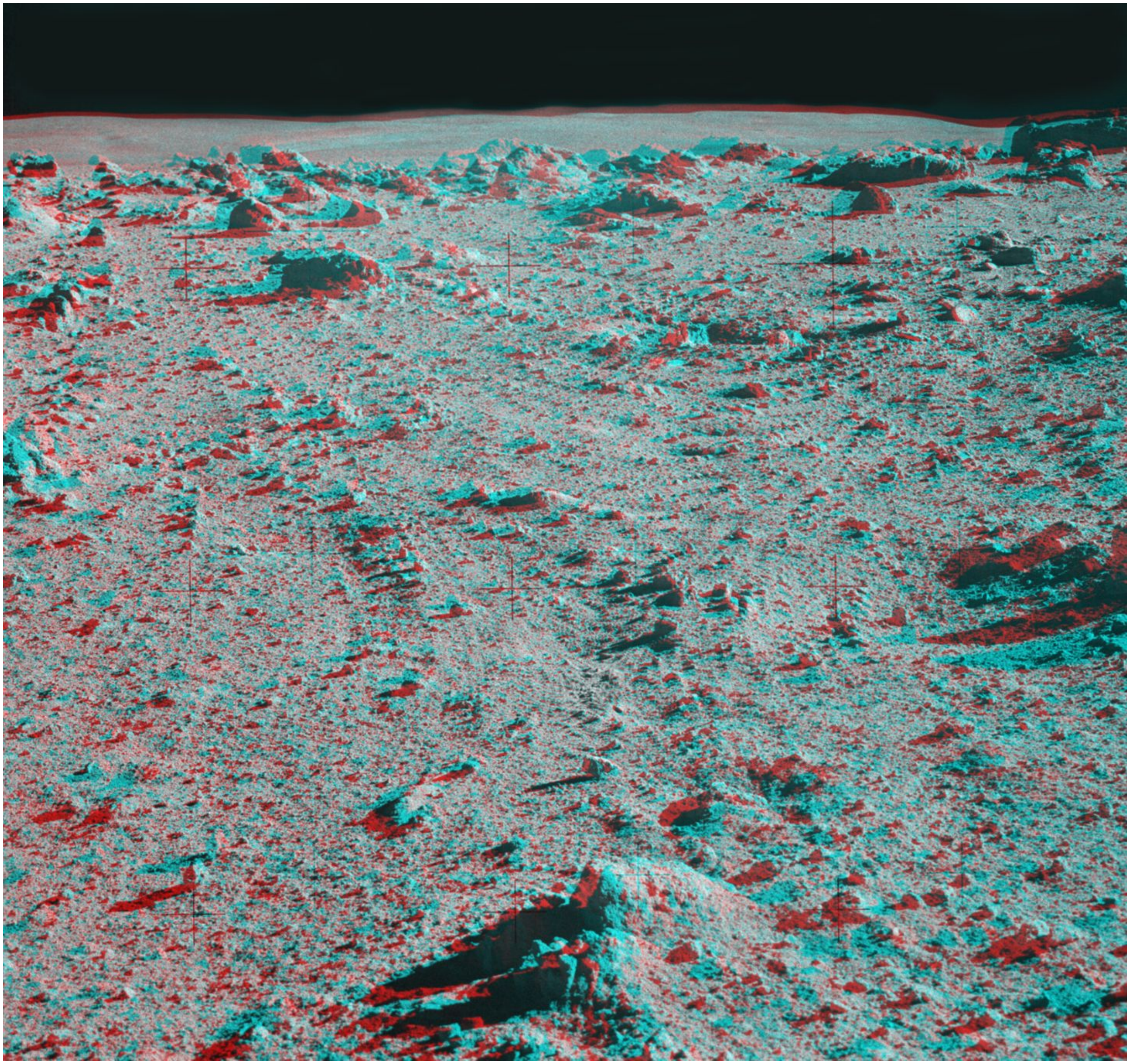


Fig. 16. Continuing to the right of **Fig. 15**. (From NASA photos AS14-64-9105, and -9106).

(See **Fig. 10** for the whole pan)

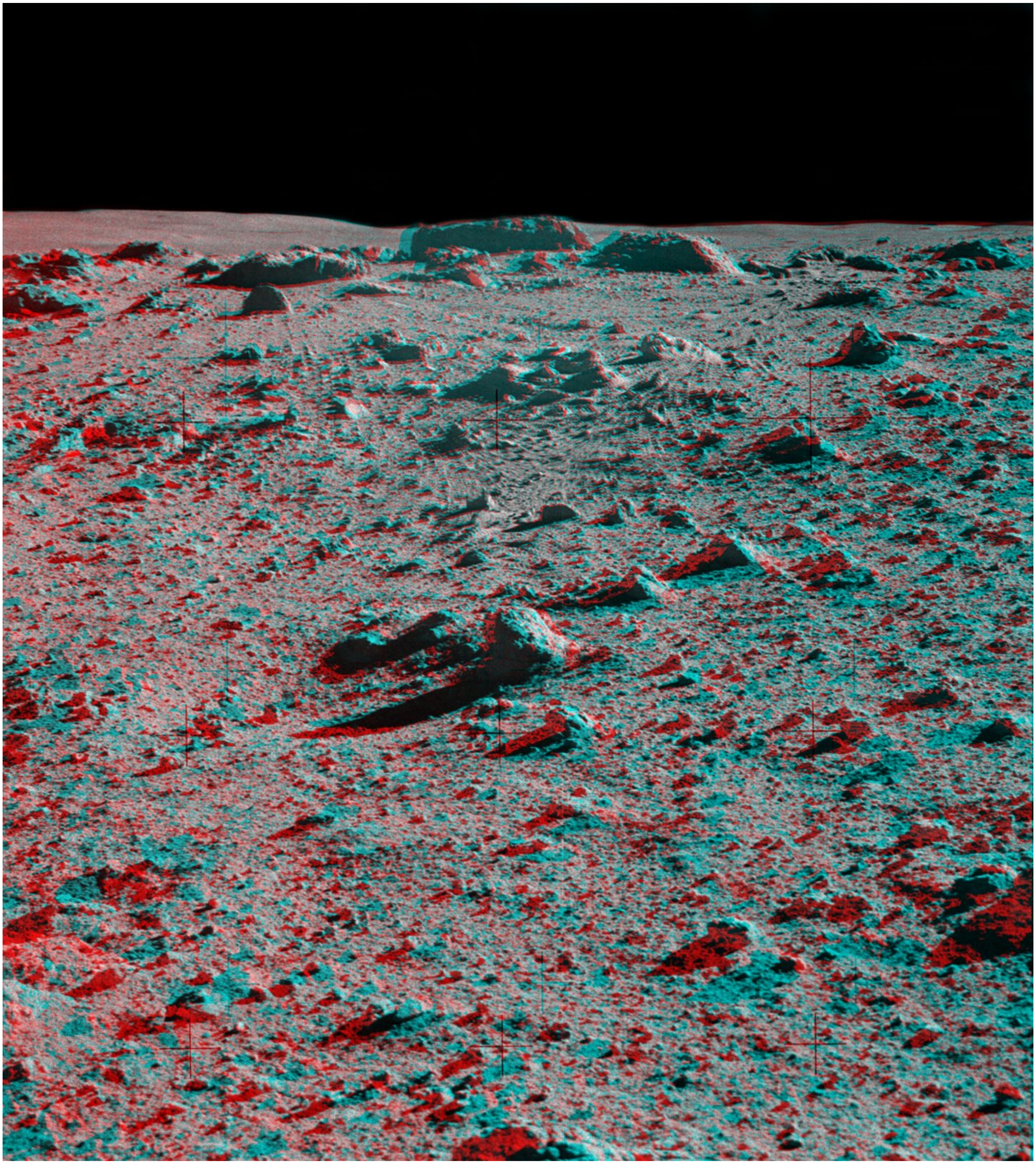


Fig. 17. Continuing to the right of **Fig. 16**. The large, rectangular block at top center is marked '**5**' in the **inset**. The trapezoidal-shaped block to its right is marked '**6**'. The direction between them is approximately to the Northeast. (From NASA photos AS14-64-9106, and-9107).

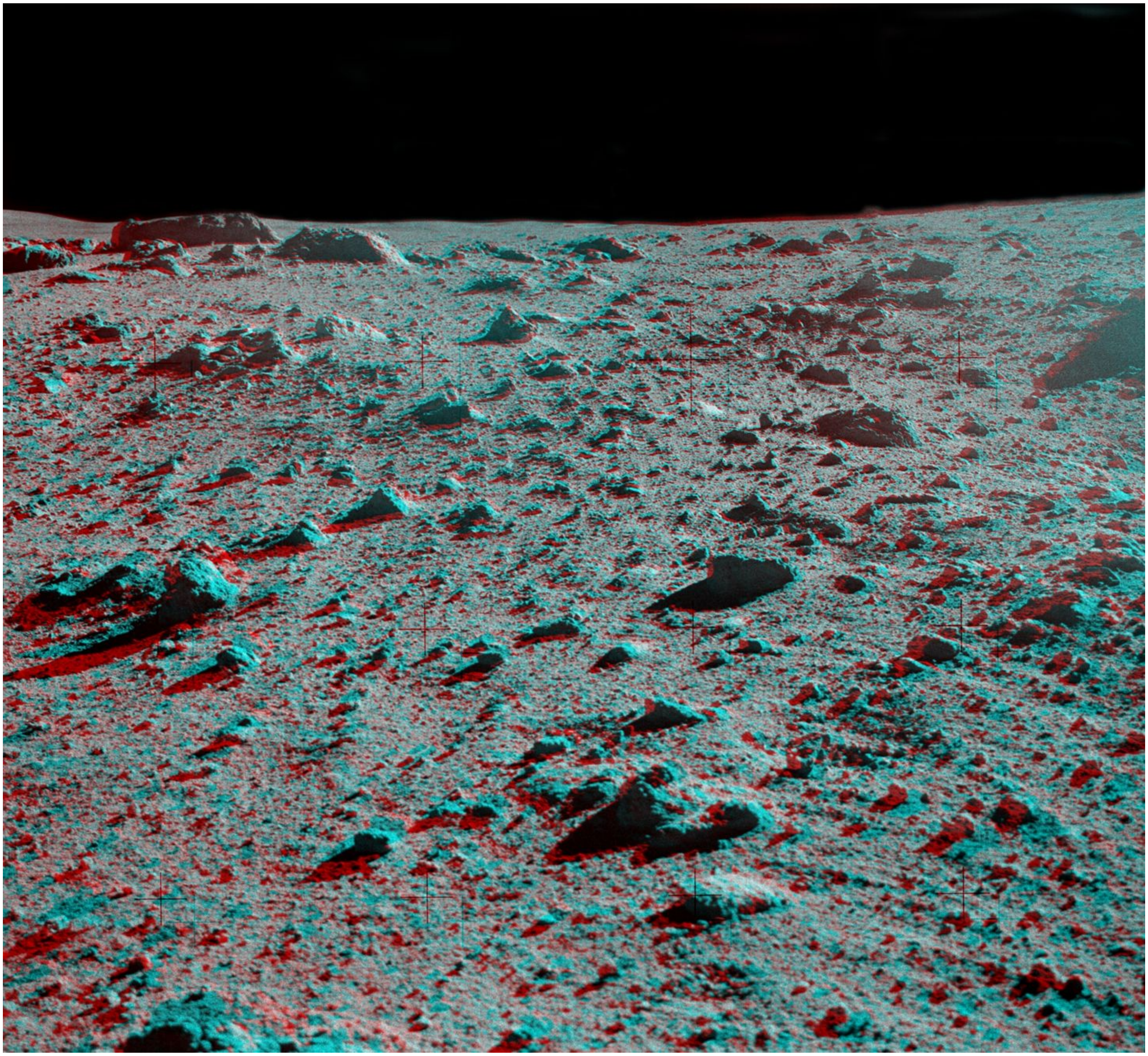


Fig. 18. Continuing to the right of **Fig. 17**. This anaglyph is the last in the series of **Fig. 10**. The next frames immediately to the right contained little detail due to the camera pointing in the direction of the sun. A continuation of the pan from the ESE towards the SW follows in the next several photos. (From NASA photos AS14-64-9107, and -9108).

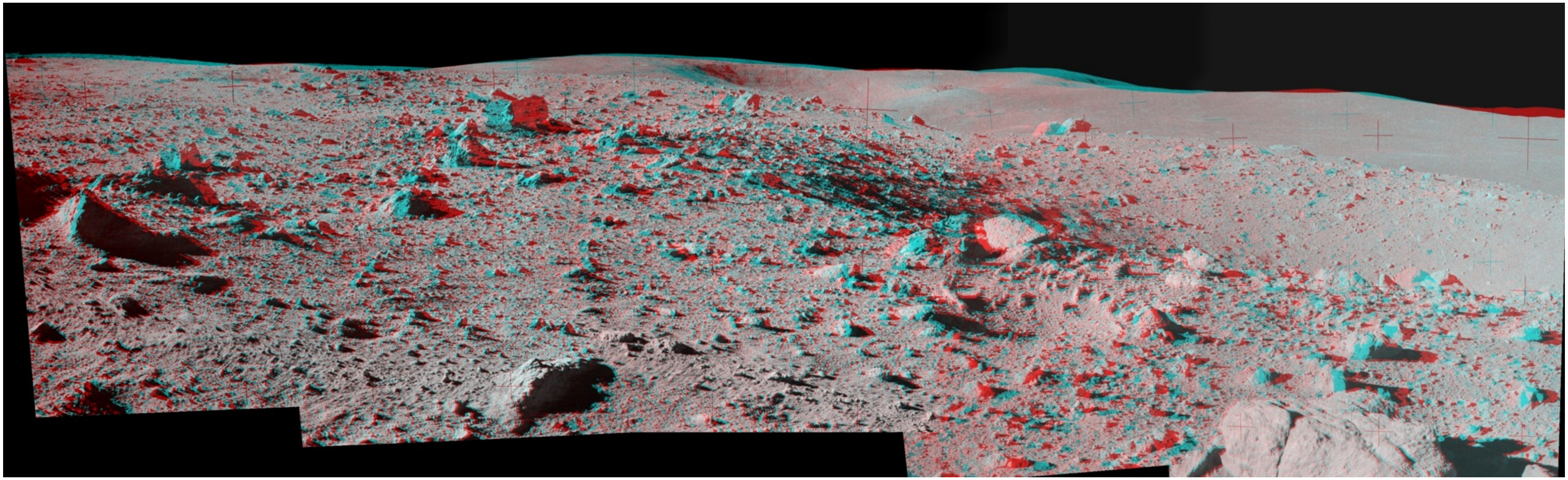
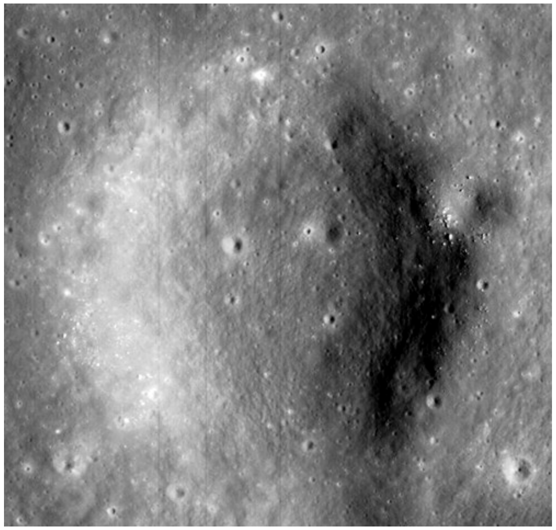


Fig. 19. Continuation of Al Shepard's pan at Station C-prime from the ESE (left) to the SW (right). The depression on the hill in the distance is 'Old Nameless' Crater ca. due south of Al. The small photo of 'Old Nameless' below is an overhead from LRO with South at the top (to match the direction in the above photo). The small crater on the right rim of 'Old Nameless', just visible here, is seen more easily in [Fig. 22] and [Fig. 23]. (From NASA photos AS14-64-9114 through -9119 inclusive; and NASA/GSFC/ASU LRO small, plain, non-3D cropped photo).



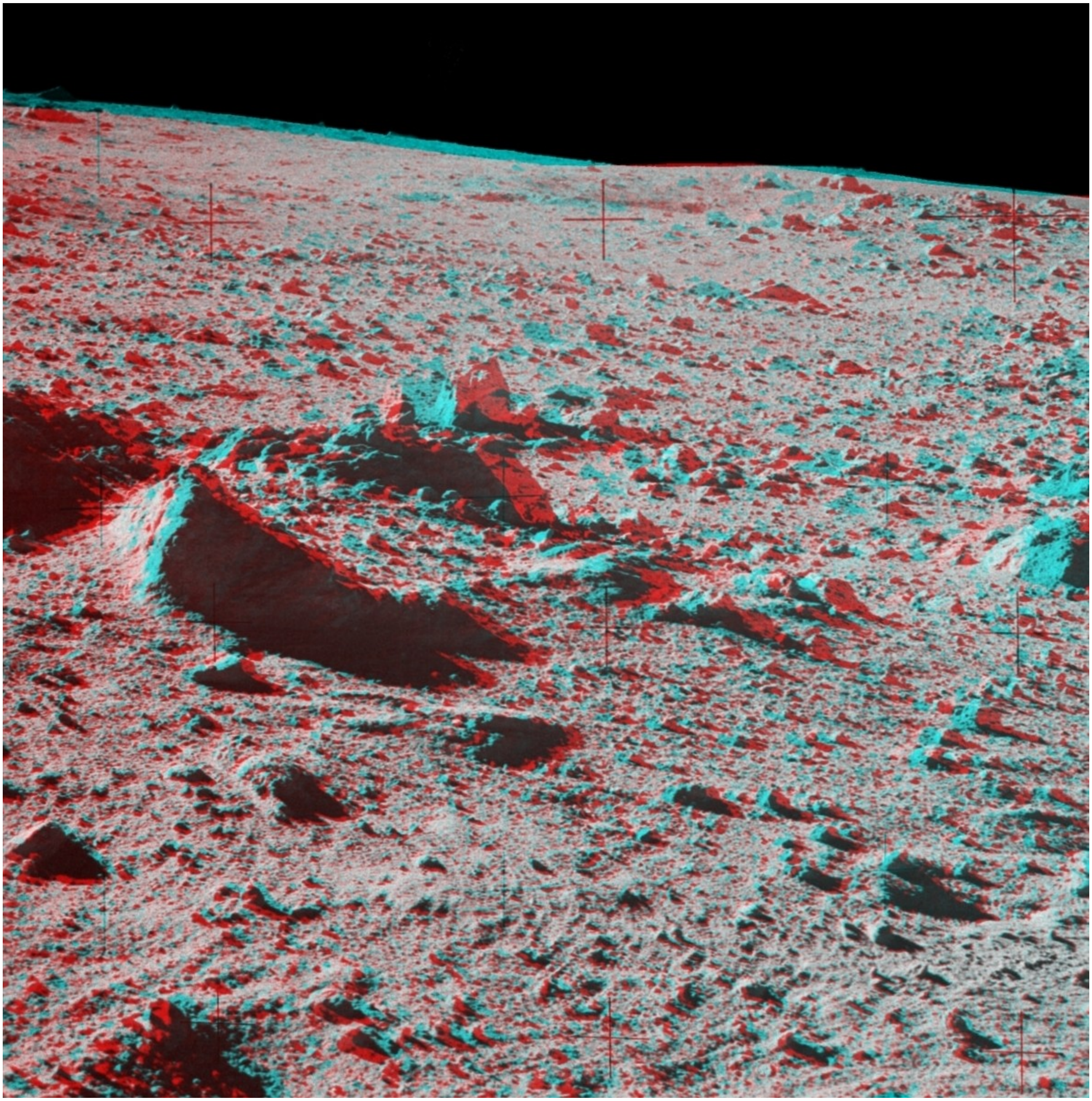


Fig. 20. First in the series of the southern side of Al Shephard's pan at "Station C-prime". See left panel of **Fig. 19** for its position in the panorama. (From NASA photos AS14-64-9114, and -9115).

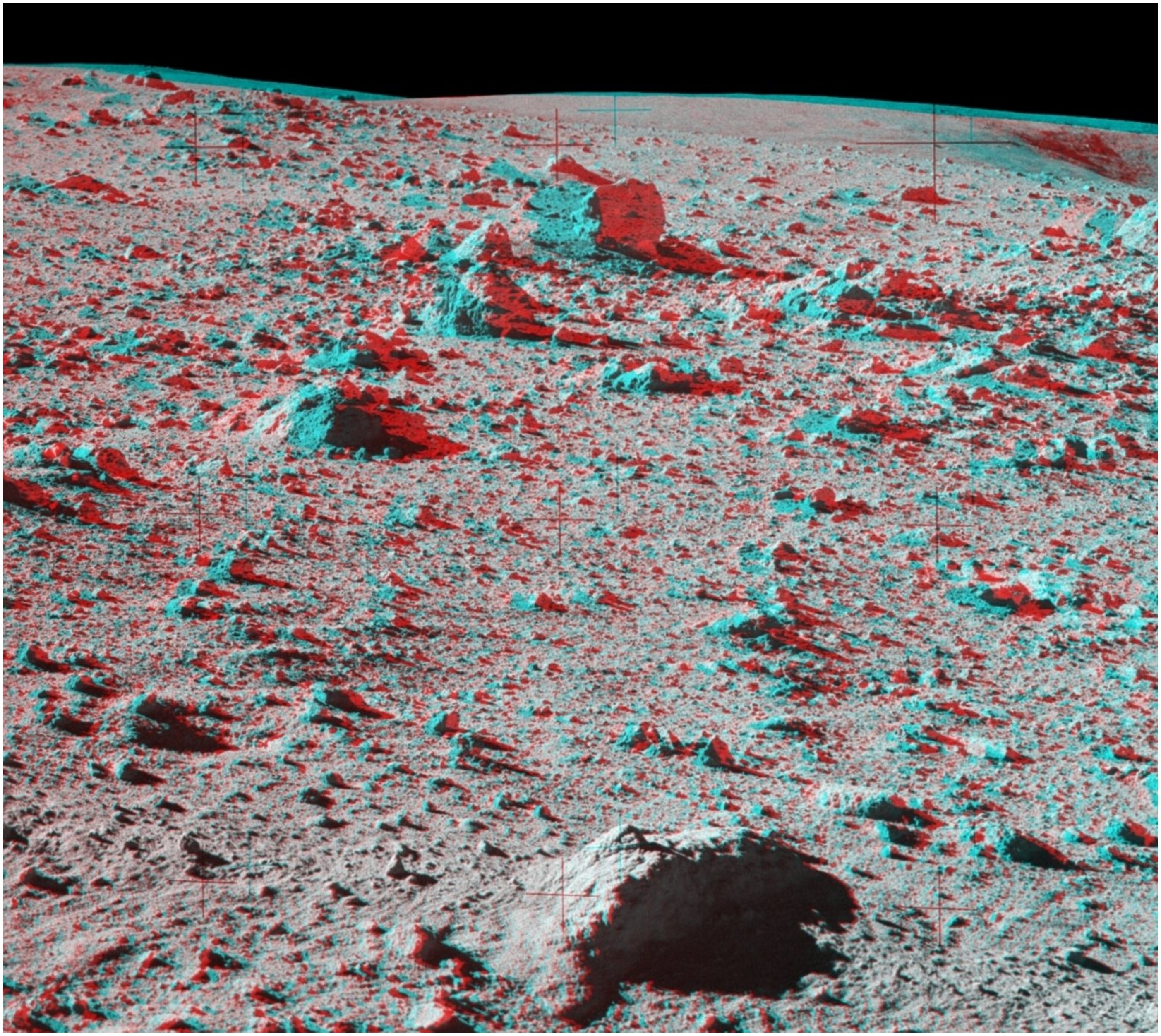


Fig. 21. Continuation to the right of **Fig. 20**. The downward slope to the right of the near field is because the astronauts walked up a ridge to the top of Cone Crater. ‘Old Nameless’ crater, partially in view at the far right, lies on a hill about 3 km away. (From NASA photos AS14-64-9115, and -9116).

(See **Fig. 19** for the whole panorama).

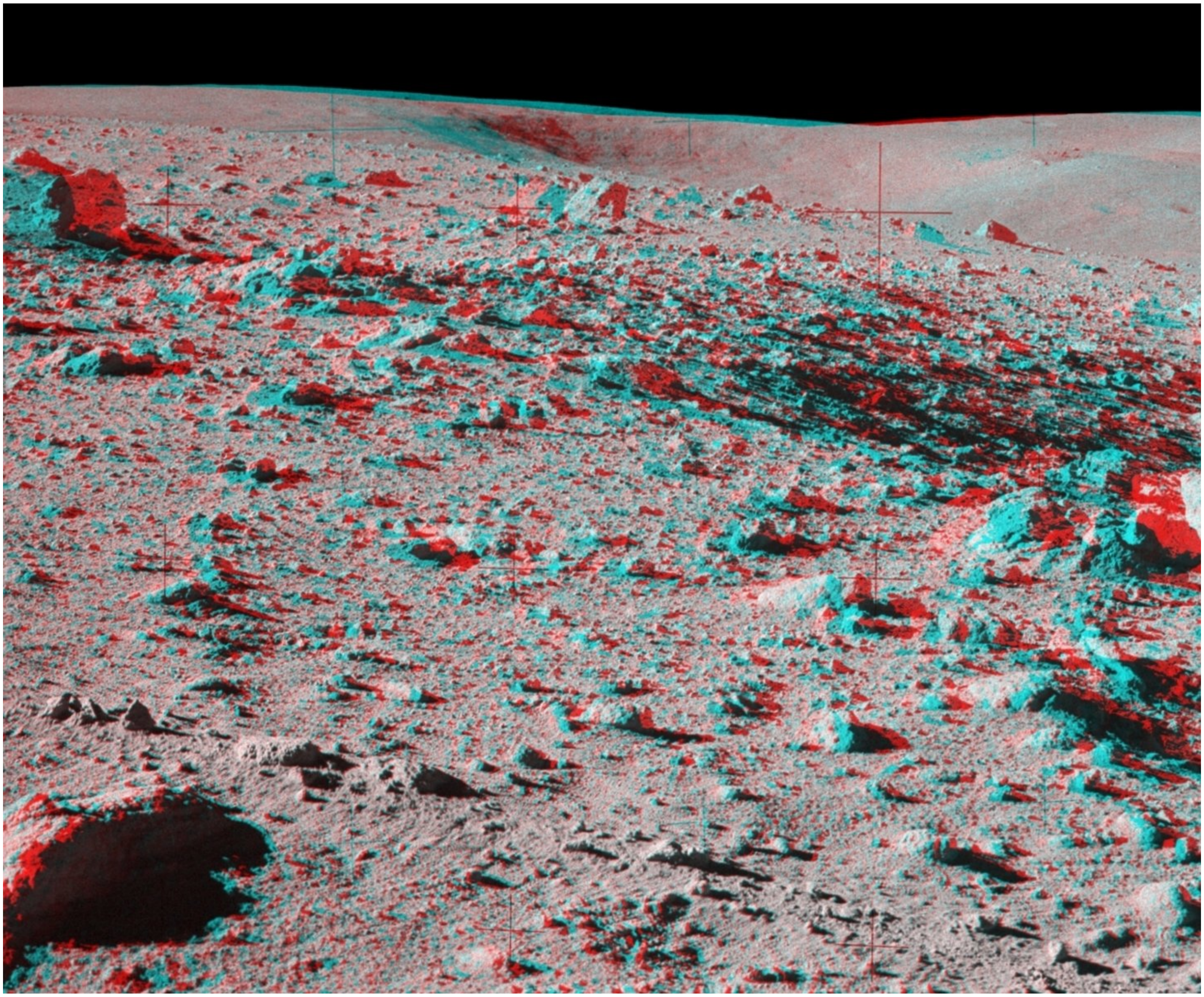


Fig. 22. Continuation to the right of **Fig. 21**. The small rim crater on the right of 'Old Nameless' can be seen with a number of boulders scattered on its outer and inner slopes. (From NASA photos AS14-64-9116, and -9117).

(See **Fig. 19** for the whole panorama).

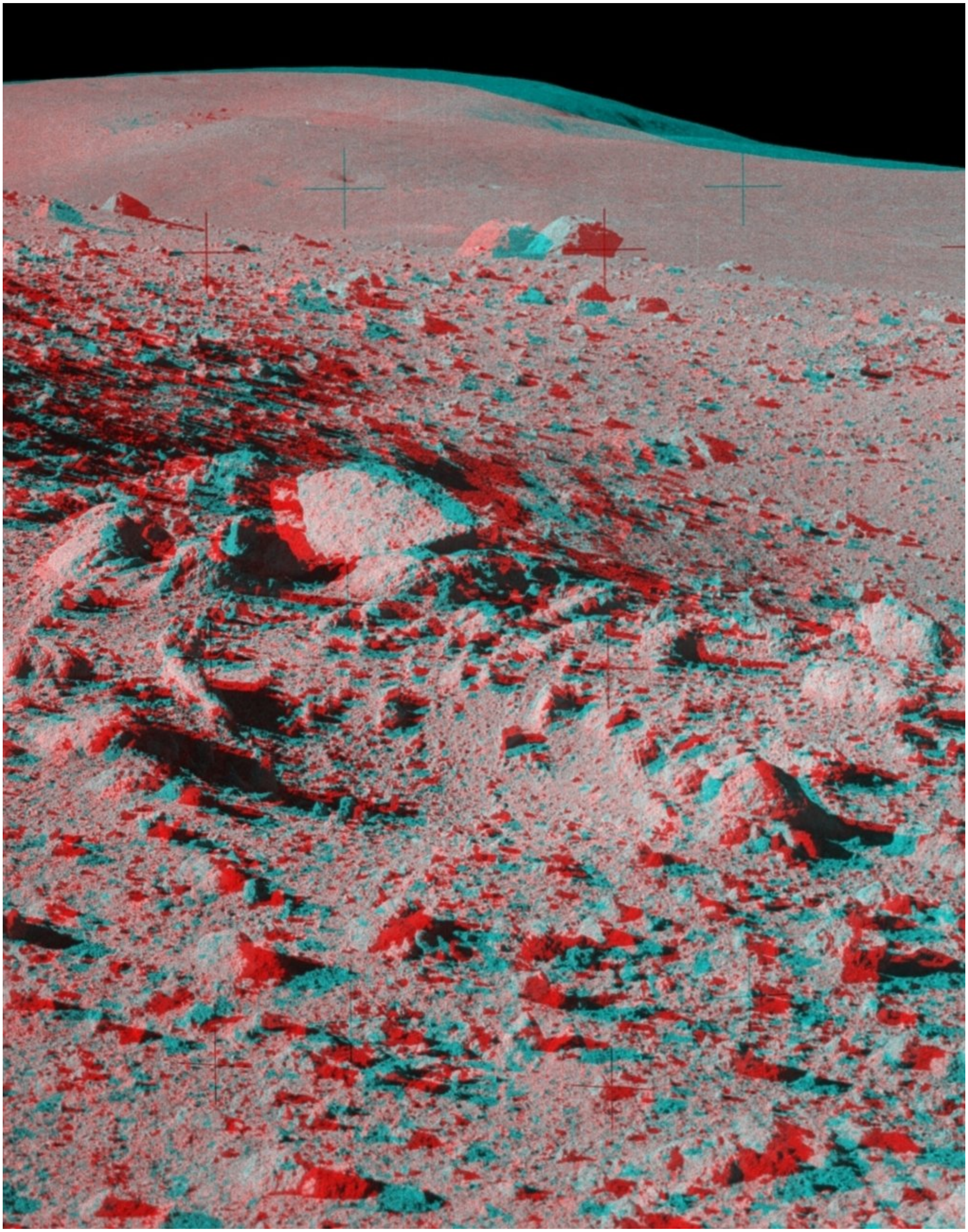


Fig. 23. Continuation to the right of **Fig. 22**. The rim crater with boulders on 'Old Nameless' is at upper left in the distance. The beginning of a double crater dominates the foreground of this scene. (From NASA photos AS14-64-9117, and -9118).

(See **Fig. 19** for the whole panorama).

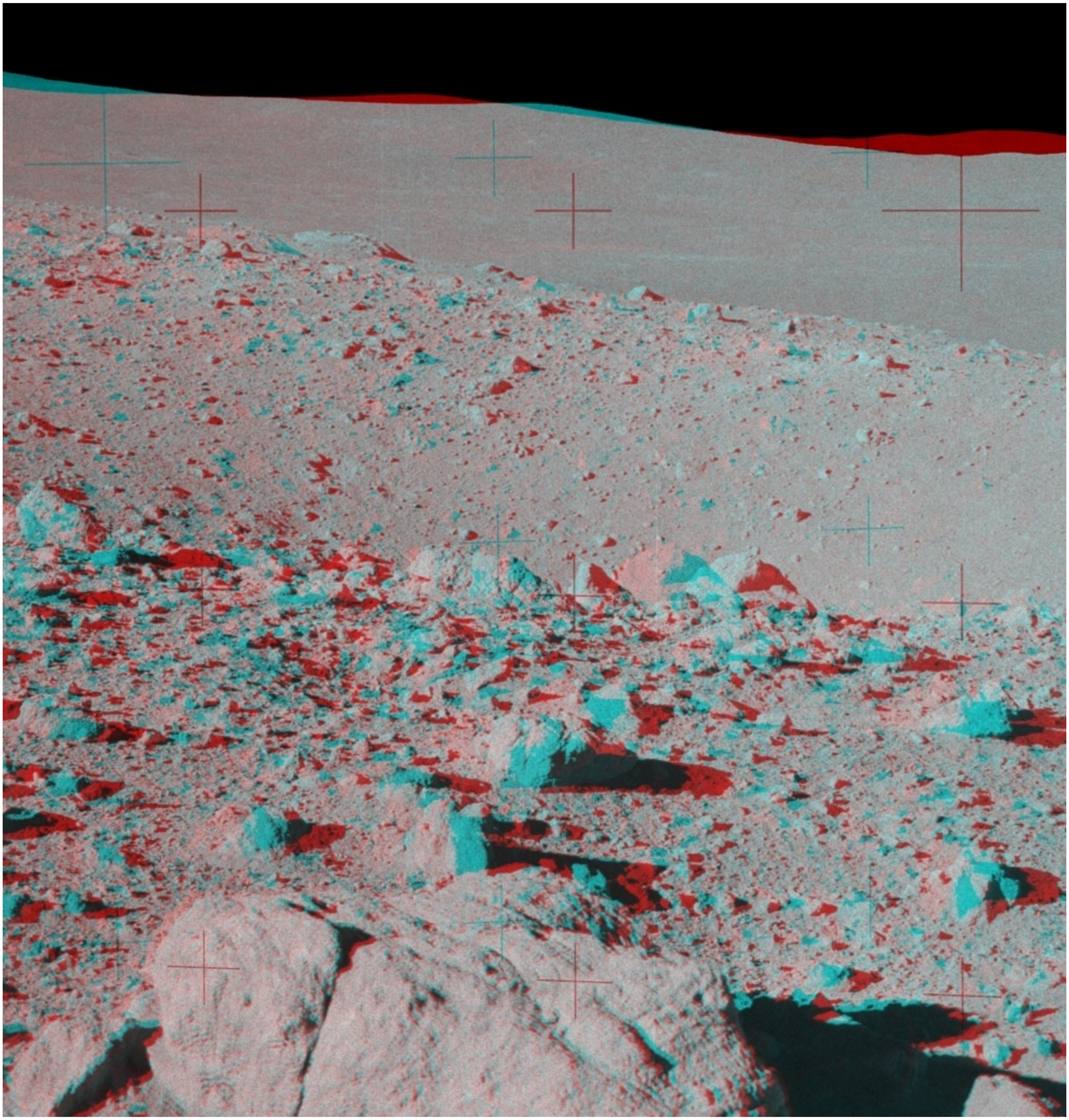


Fig. 24. The last panel of Al Shepard's panorama (**Fig. 19**) as an anaglyph. He continued to make a few more frames showing Ed Mitchell and the MET (Modular Equipment Transporter), a large cart, commonly referred to as the rickshaw, which the astronauts used to carry their geological tools, samples, a 16 mm film camera, etc. These cannot be added to the anaglyph panorama; but a portion of the **MET** can be shown in 3D and is given in **Fig. 25**. (From NASA photos AS14-64-9118, and -9119).

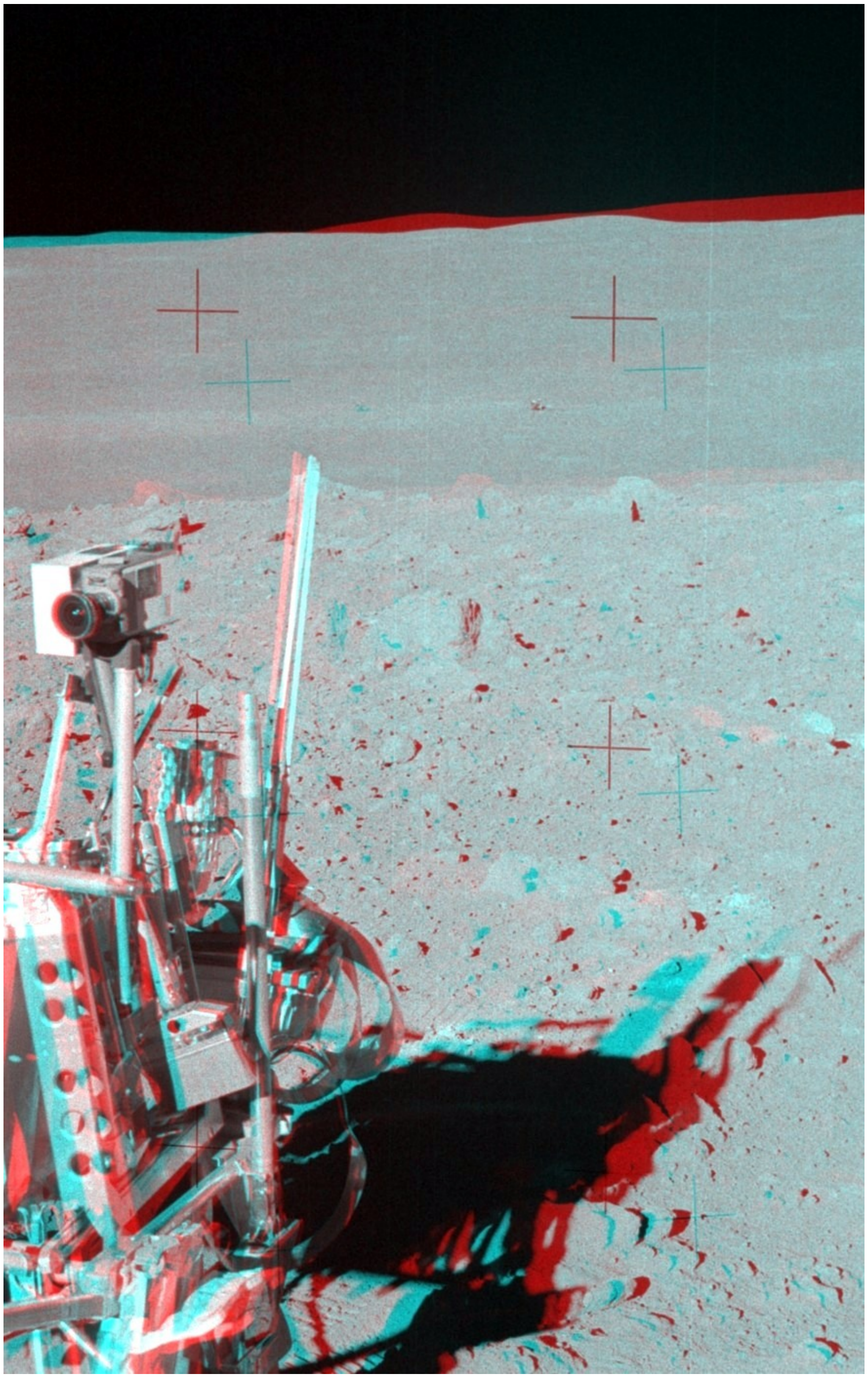
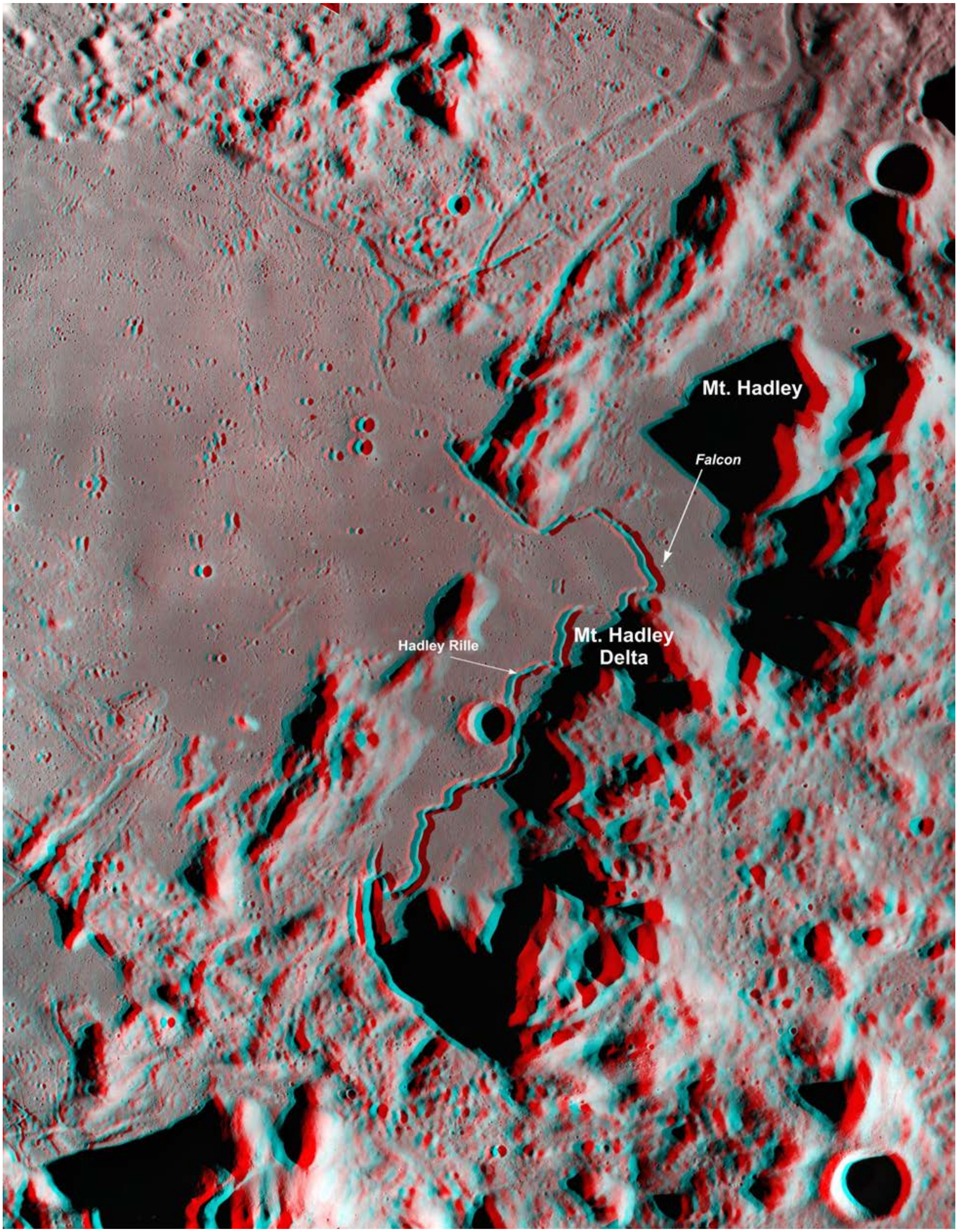


Fig. 25. The Modular Equipment Transporter (**MET**), only flown on Apollo 14 the last walking mission, located at the lower end of the crater in **Fig. 24** at right. It proved to be very cumbersome to pull behind the astronauts. There is a handle and tow bar at the left. The astronauts often had to carry it between them because traction of the rubber wheels in the soft lunar soil was difficult to maintain. Lunar vehicle wheels were redesigned in the form of a wire frame mesh for the rovers of the last three missions. The **LM** ***Antares*** can be seen sitting on the plain in the distance to the right of the core tubes. (From NASA photos AS14-64-9121, and -9122).



APOLLO 15

Falcon*, a Bird of Prey on the Plain at *Hadley Rille

July 30, 1971

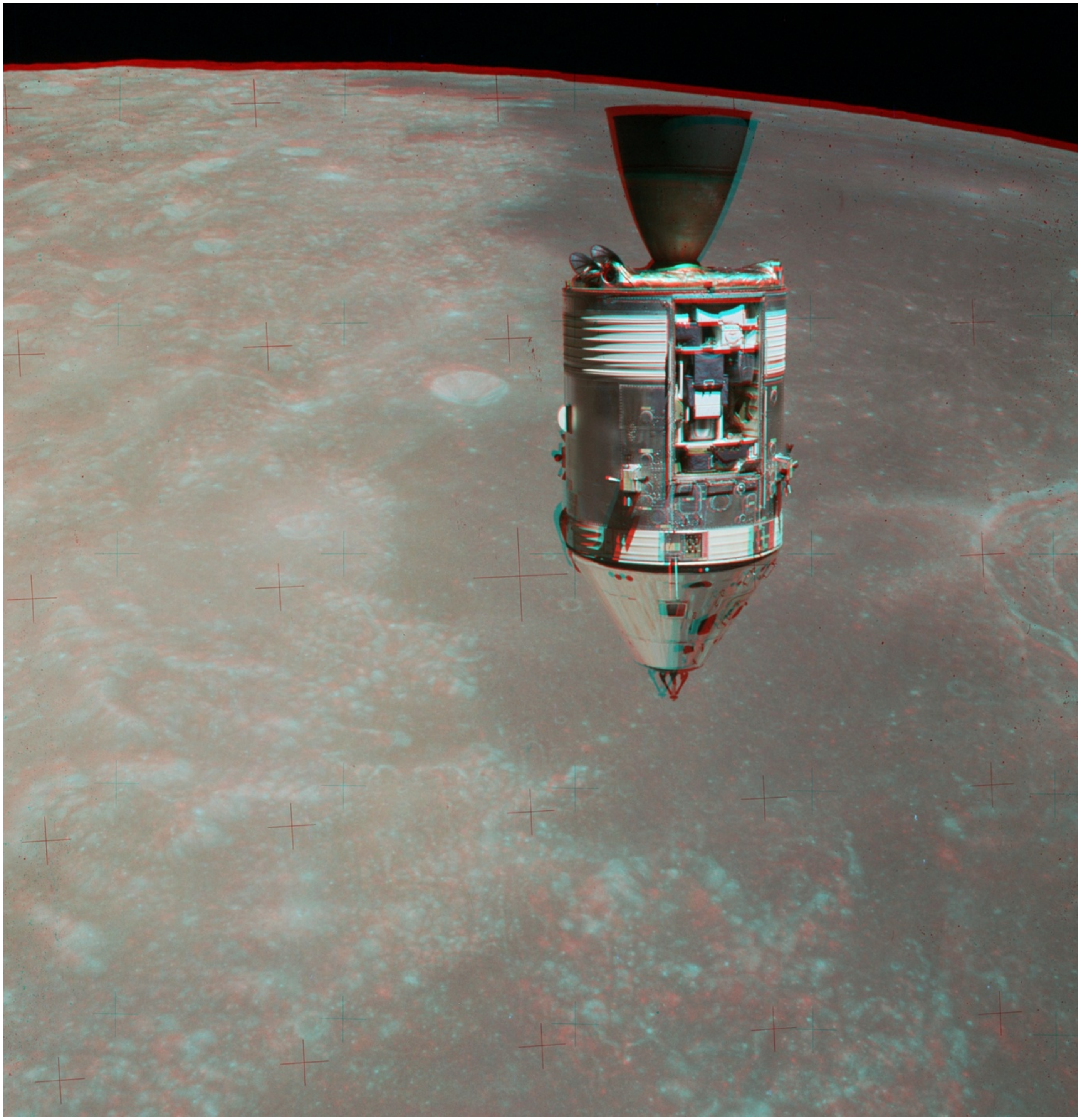


Fig. 1. The Apollo 15 Command and Service Module (**CSM**) ***Endeavour*** photographed from the **LM *Falcon*** after separation in preparation for landing. In this view, the Scientific Instrument Module (**SIM**) bay can be clearly seen showing the panoramic and metric cameras as well as a few other instruments. The bay cover was permanently jettisoned just before insertion of the **CSM** into lunar orbit. On the return journey to the Earth, astronaut Alfred M. Worden, the Command Module Pilot (**CMP**), exited the **CSM** on a tether and worked his way over to the **SIM** bay in order to retrieve the canisters containing the camera films. The spacecraft is above *Sinus Concordiae* at the eastern edge of *Mare Tranquillitatis*. The bright ringed crater with rays to its right is *Taruntius*. (From NASA photos AS15-88-11972, and -11973).

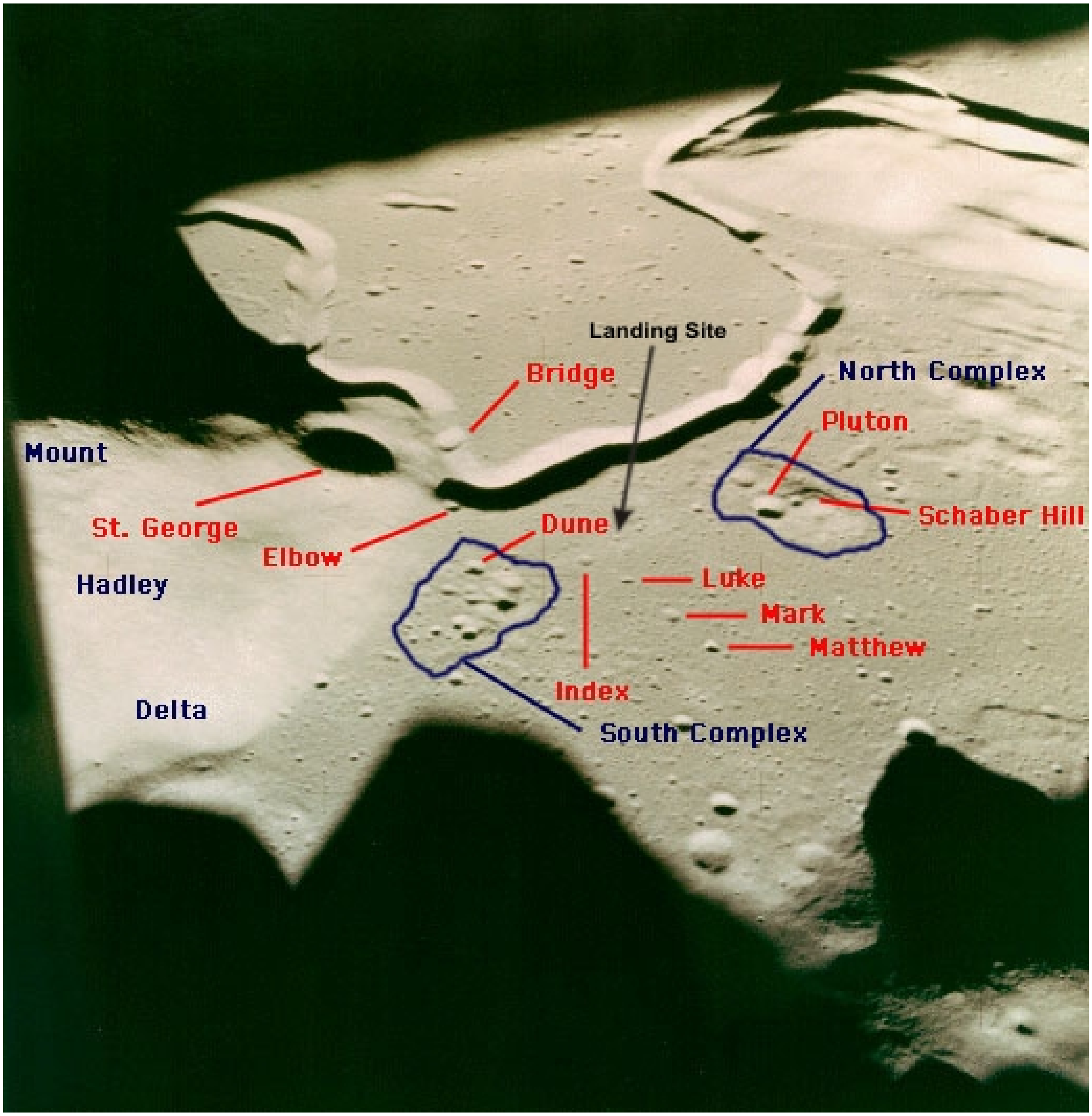


Fig. 2. A plain, non-3D photo by Lunar Module Pilot (**LMP**) Jim Irwin from the **LM** window before they landed. They are at an altitude of about 12 km on orbital revolution 13, the last pass over the landing site before descent to the surface. The Landing Site is marked by the arrowhead just to the right of the tail of the letter "e" near a crater called "Last" (the last crater before touchdown). The dark area at the top of the photo and at left is part of the window frame. (From NASA photo AS15-87-11717).

(For landing site location, click **here**)

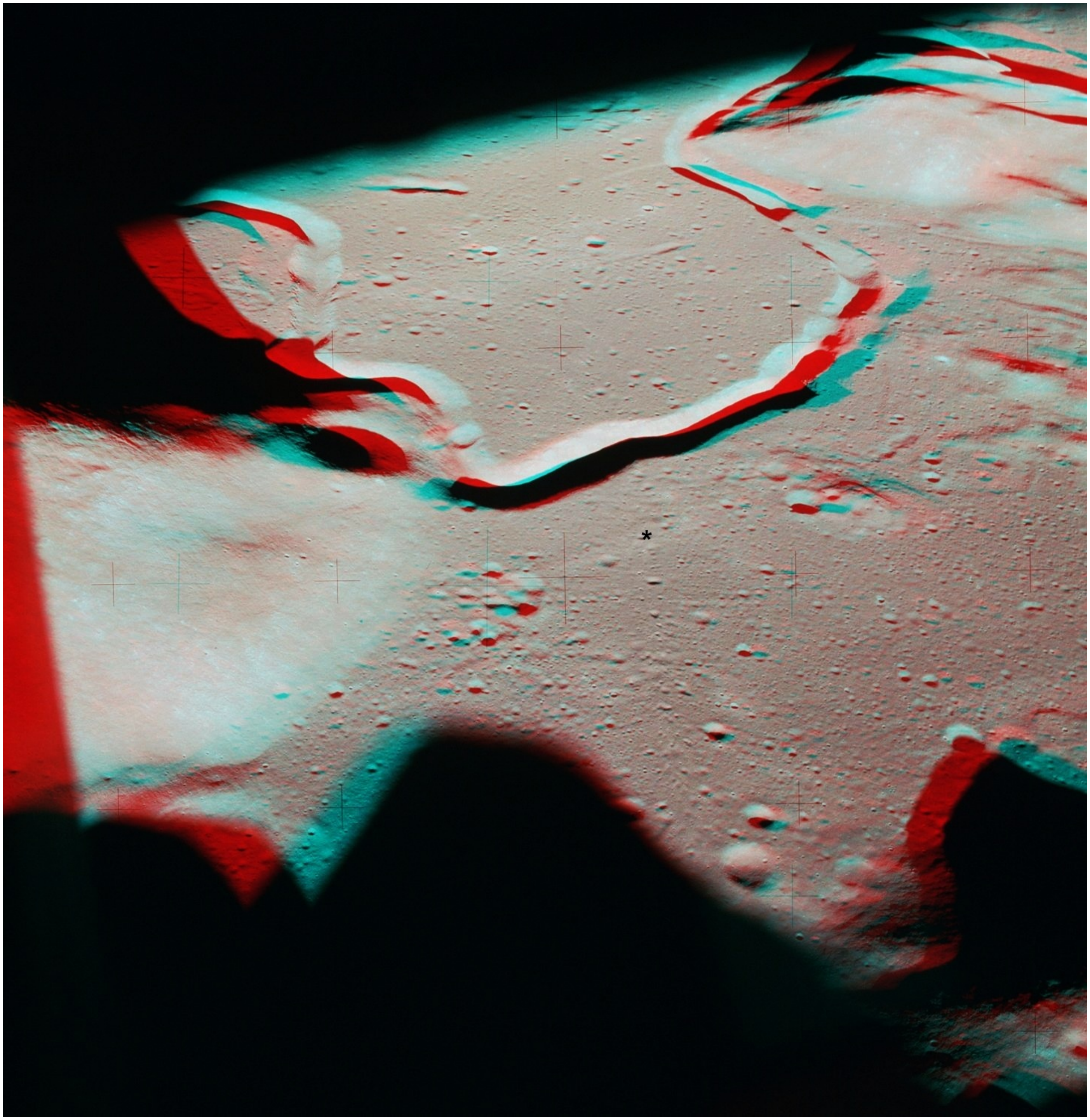


Fig. 3. Jim Irwin took several sequential photos as the astronauts made this last pass over the landing area before the final descent. The two used here made an excellent 3D view. The landing site is to the right of center marked by the star. (From NASA photos AS15-87-11716, and -11717).

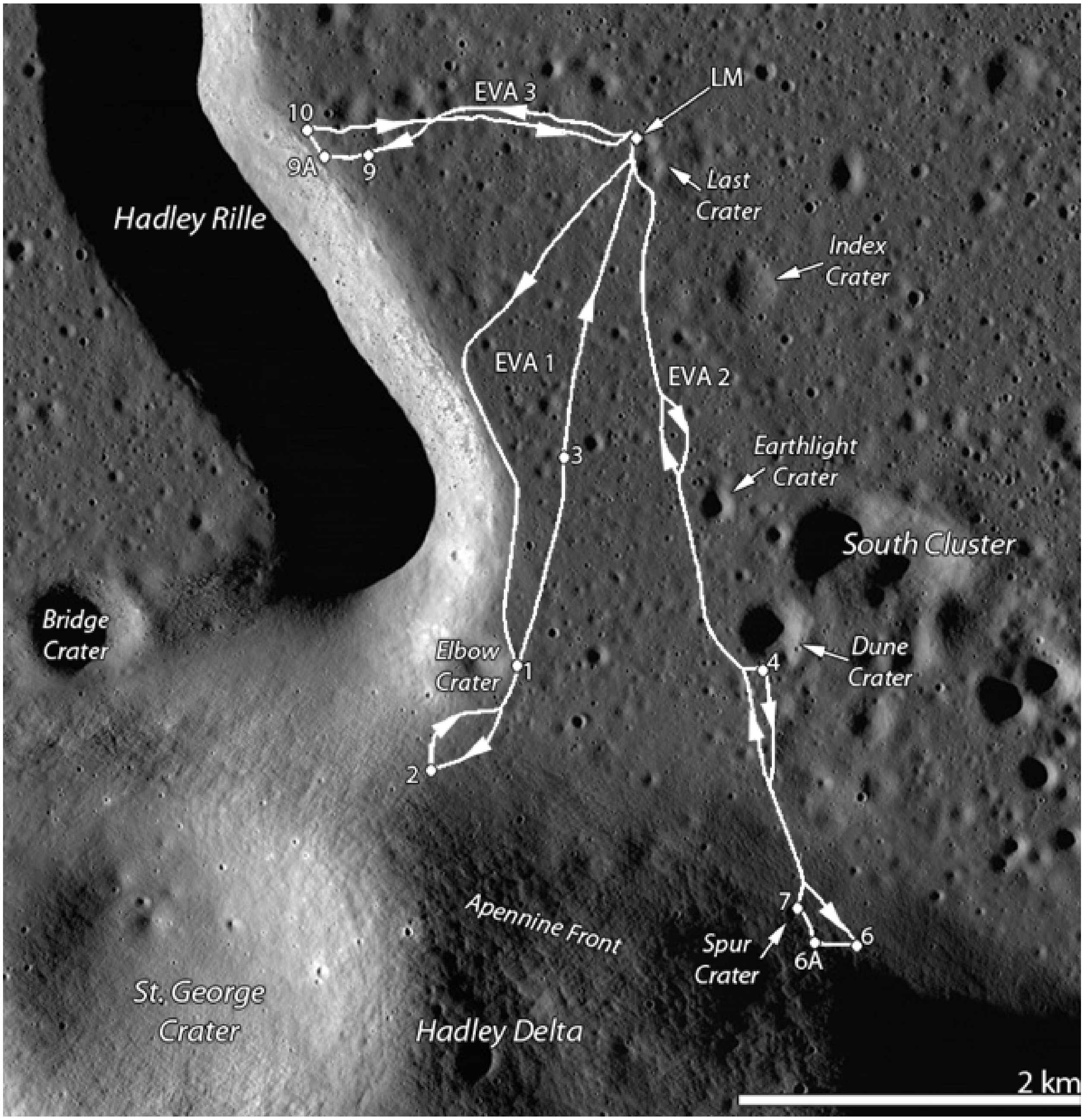


Fig. 4. The routes of the 3 **EVAs** taken by Commander (**CDR**) Scott and **LMP** Irwin while driving the Lunar Roving Vehicle (**LRV**) during the Apollo 15 mission. EVA 1 was a trip along the edge of Hadley Rille up to and around Elbow Crater to the slopes below St. George Crater. One of the more spectacular views was made at Station 2 along the rille. EVA 2 was spent driving to and up the slopes of Mt. Hadley Delta to Stations 6, 6a, 7 and stopping at Station 4 on the way back to the **LM** (the arrows in this photomap incorrectly indicate that the stop at Station 4 occurred before Station 6 rather than on the return trip). EVA 3 was spent on a direct drive to the edge of Hadley Rille and photographing the stratigraphic layers of bedrock in the walls. (NASA/ASU/GSFC photo).

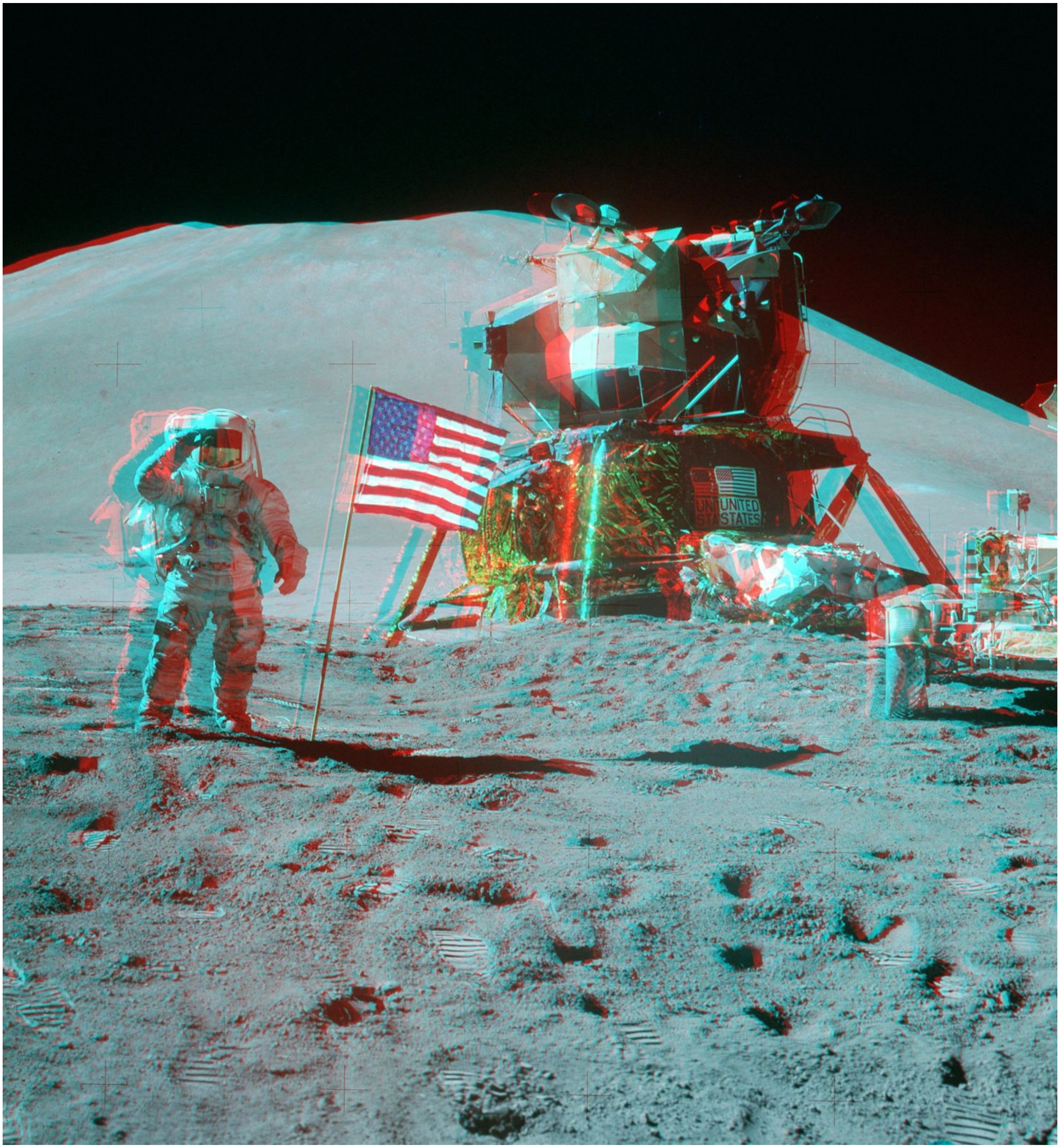


Fig. 5. Jim Irwin saluting the flag. A part of the **LRV** can be seen to the right of the **LM** ***Falcon***. In the distance is the 3500 m (11,000 ft) high Mt. Hadley Delta. The LM appears to be leaning at an appreciable angle, and the following photos emphasize that point. (From NASA photos AS15-88-11865, and -11866).

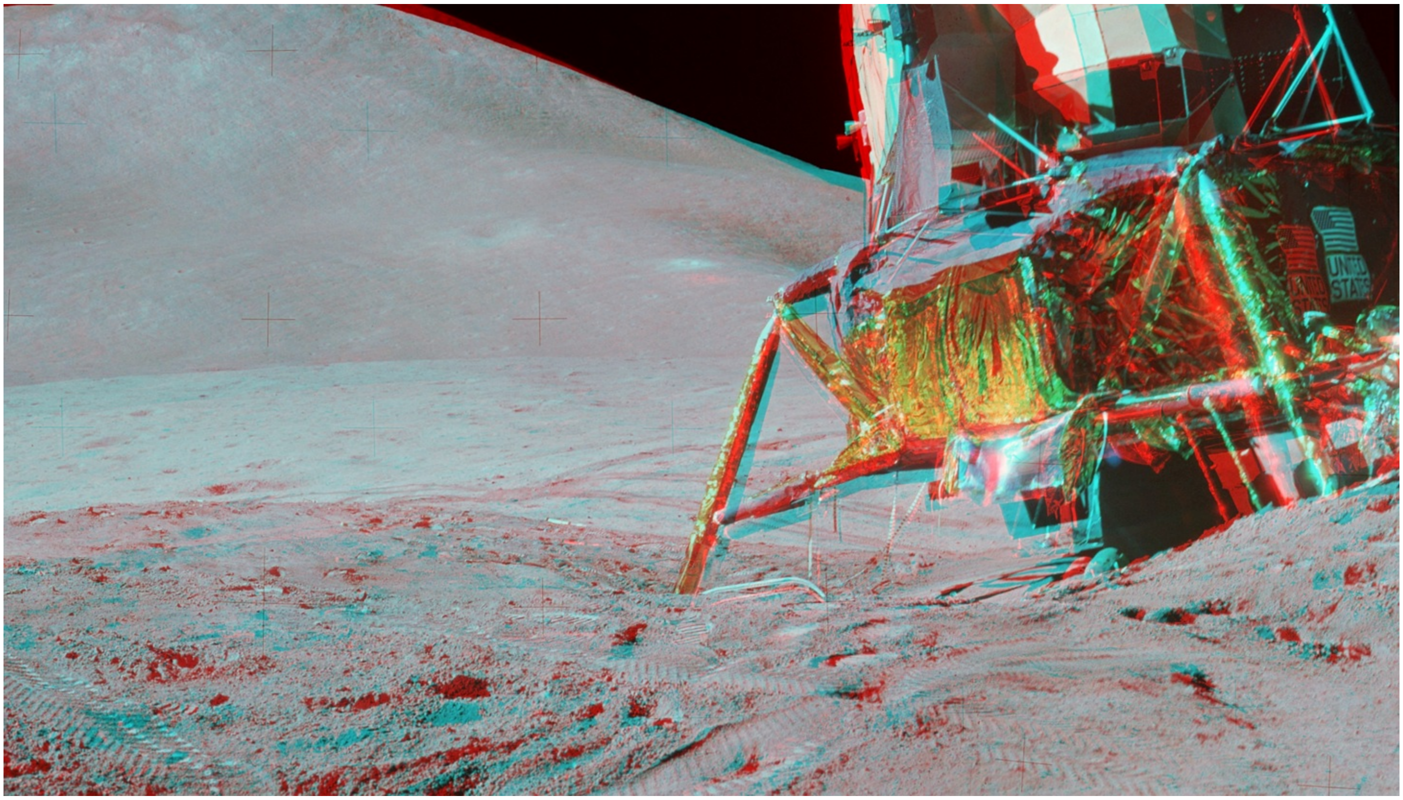


Fig. 6. Here the dramatic tilt of the spacecraft is quite evident. It is sitting on a slope of about 10°! The maximum slope that the **LM** could have sustained on any mission and still launch successfully back into orbit was about 15°. Part of Mt. Hadley Delta is in the background. (From NASA photos AS15-87-11817, and -11819).

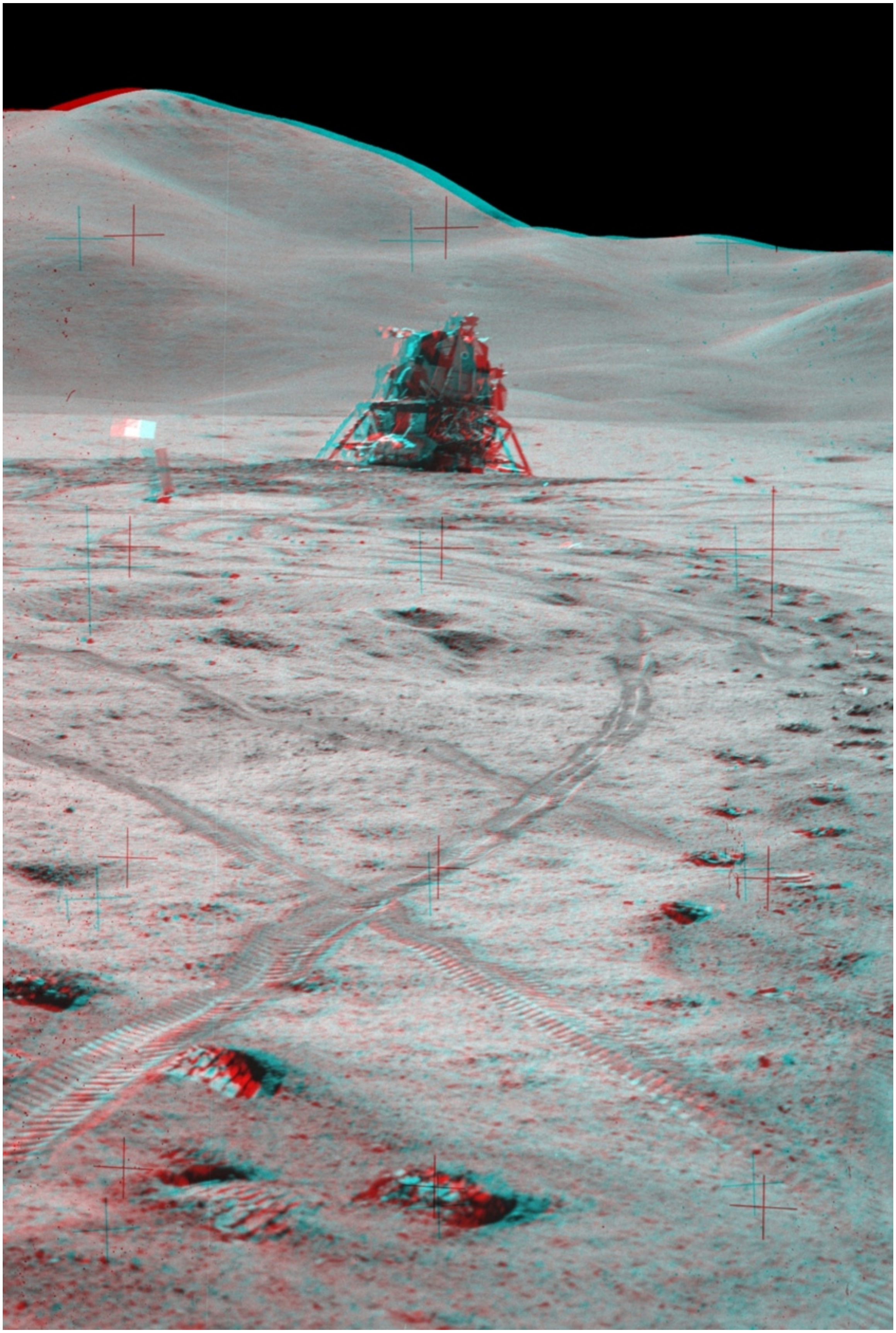


Fig. 7. A view looking towards the east, again showing the tilt of the spacecraft. At left is the Solar Wind Collector (**SWC**) and the American Flag. (From NASA photos AS15-82-11056, and -11057).

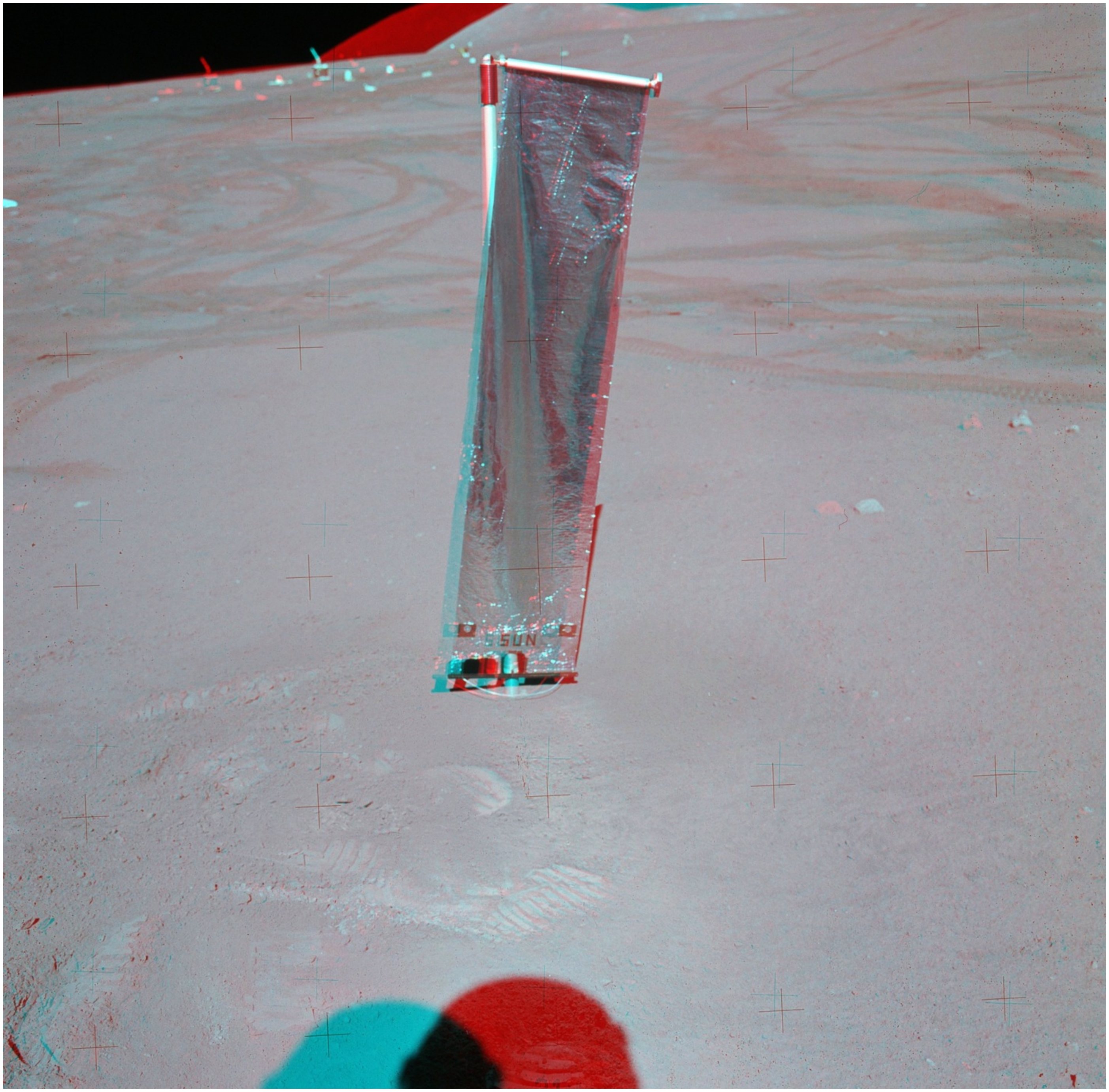


Fig. 8. An anaglyph of the Solar Wind Collector (**SWC**) just before it was rolled up for transport back to the Earth. In the distance is the Apollo Lunar Surface Experiments Package (**ALSEP**). The globe shaped shadow at the bottom is from Dave Scott's helmet. (From NASA photos AS15-88-11888, and -11889).

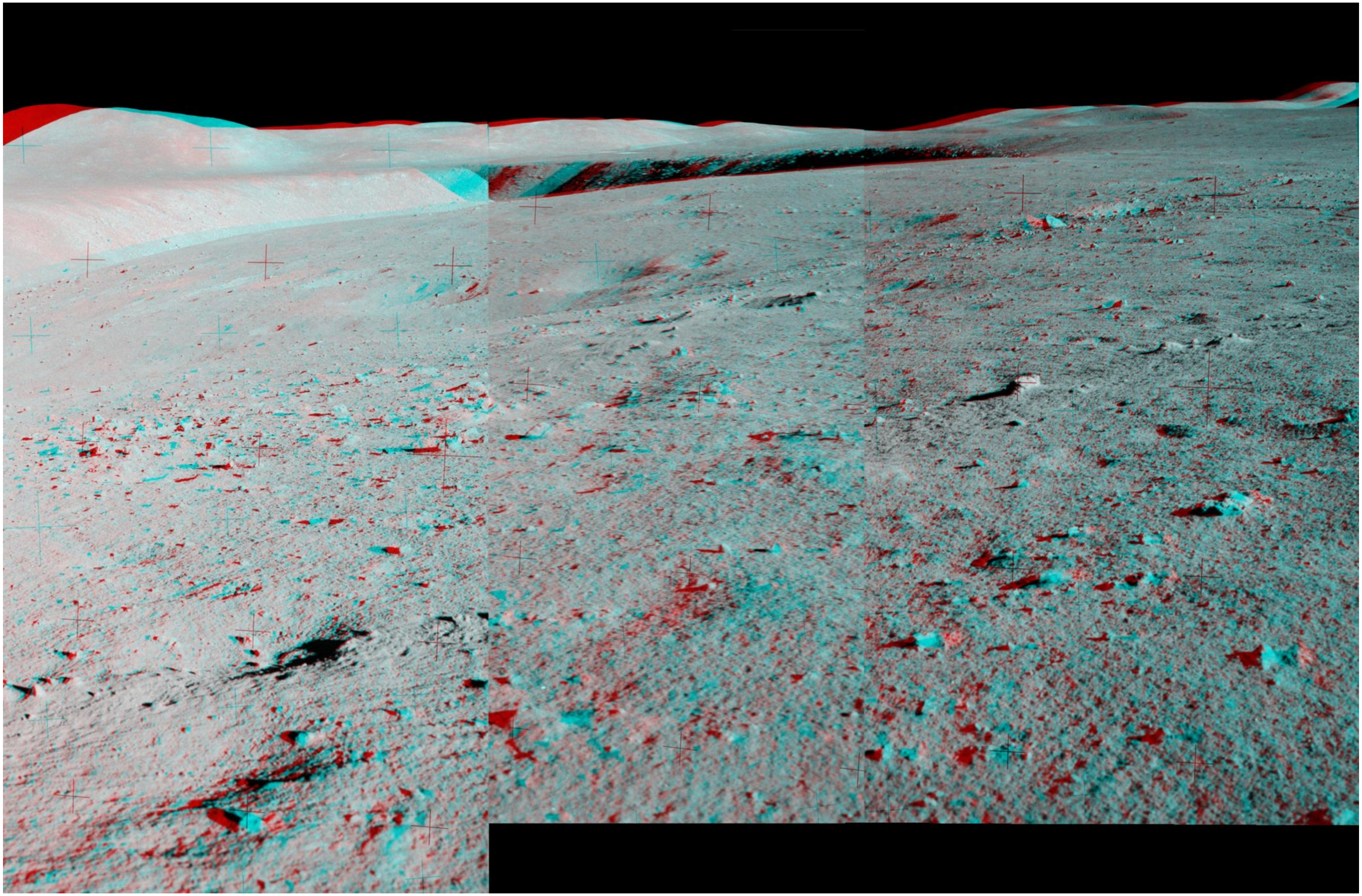


Fig. 9. A combination of anaglyph panels from Jim Irwin's panorama taken at **Station 1** near Elbow Crater, which is out of view to the left. There were a number of other anaglyph sections possible from this pan, but this scene is the most interesting. (From NASA photos AS15-85-11399, -11400, 11401, and 11402).

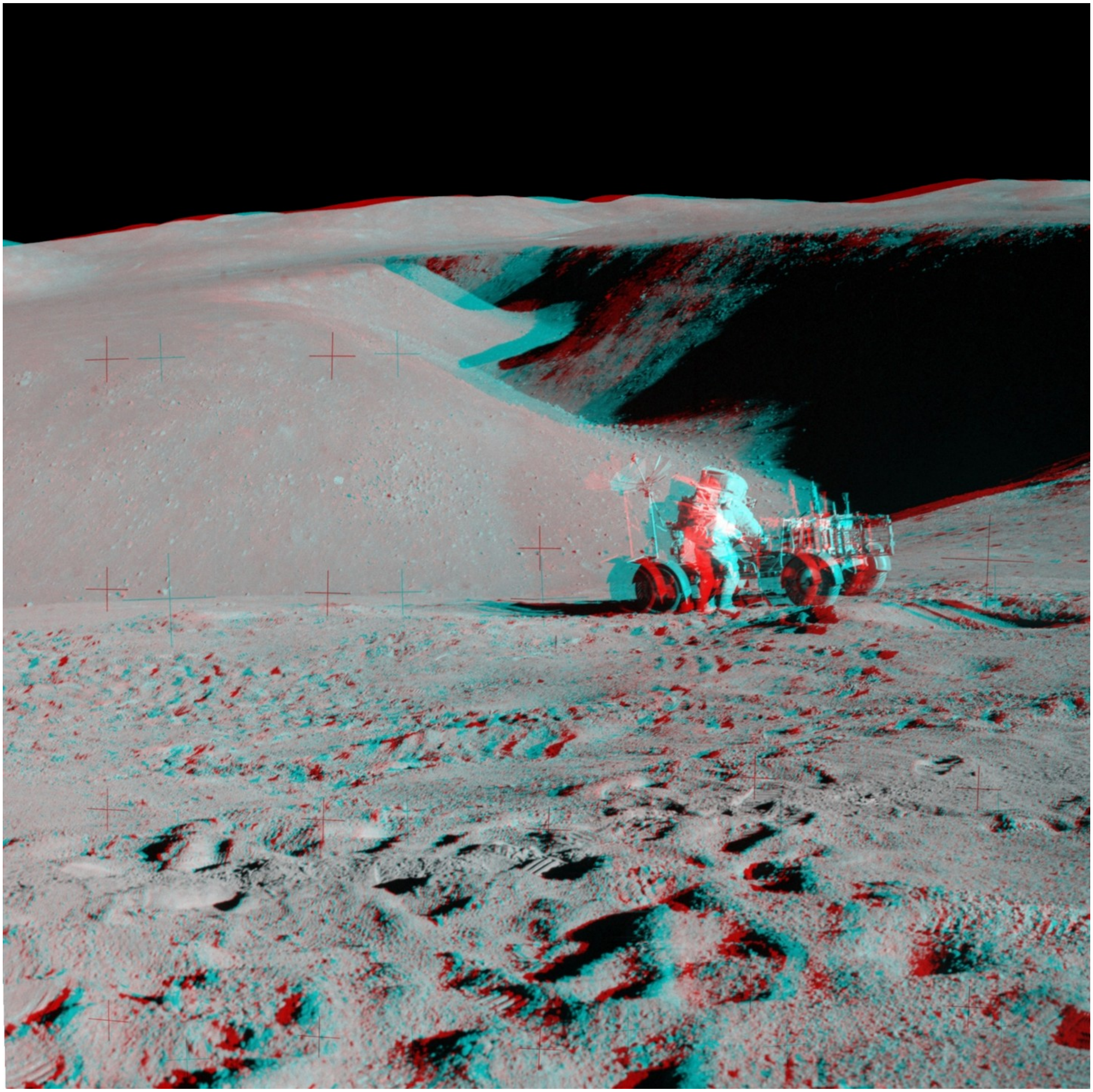


Fig. 10. By far the most dramatic scene from the mission is this anaglyph composite from three photos made by Jim Irwin taken at **Station 2** of Dave Scott at the **LRV**. The astronauts are on the slope below the hillside crater St. George but above Elbow Crater which is to the right and out of sight over the ridge line. (From NASA photos AS15-85-11449, -11450, and-11451).

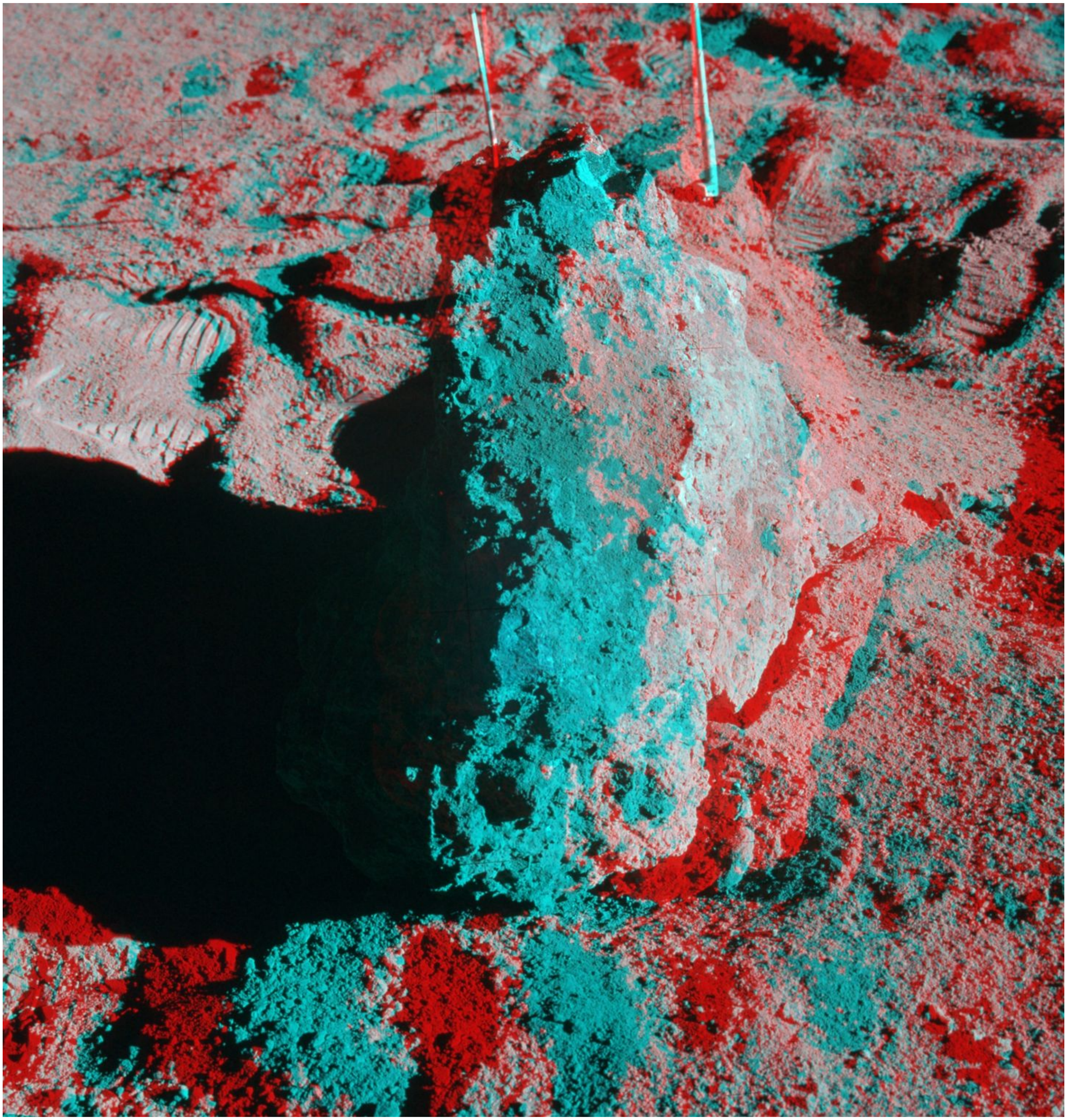


Fig. 11. This view of a boulder at **Station 2** is a good example of depth, soil texture, and astronaut activity (boot prints). Note that the chink where Dave Scott took a rock sample from this boulder can be seen at its upper right corner. Sample tongs are stuck into the ground behind the boulder. (From NASA photos AS15-86-11558, and -11559).

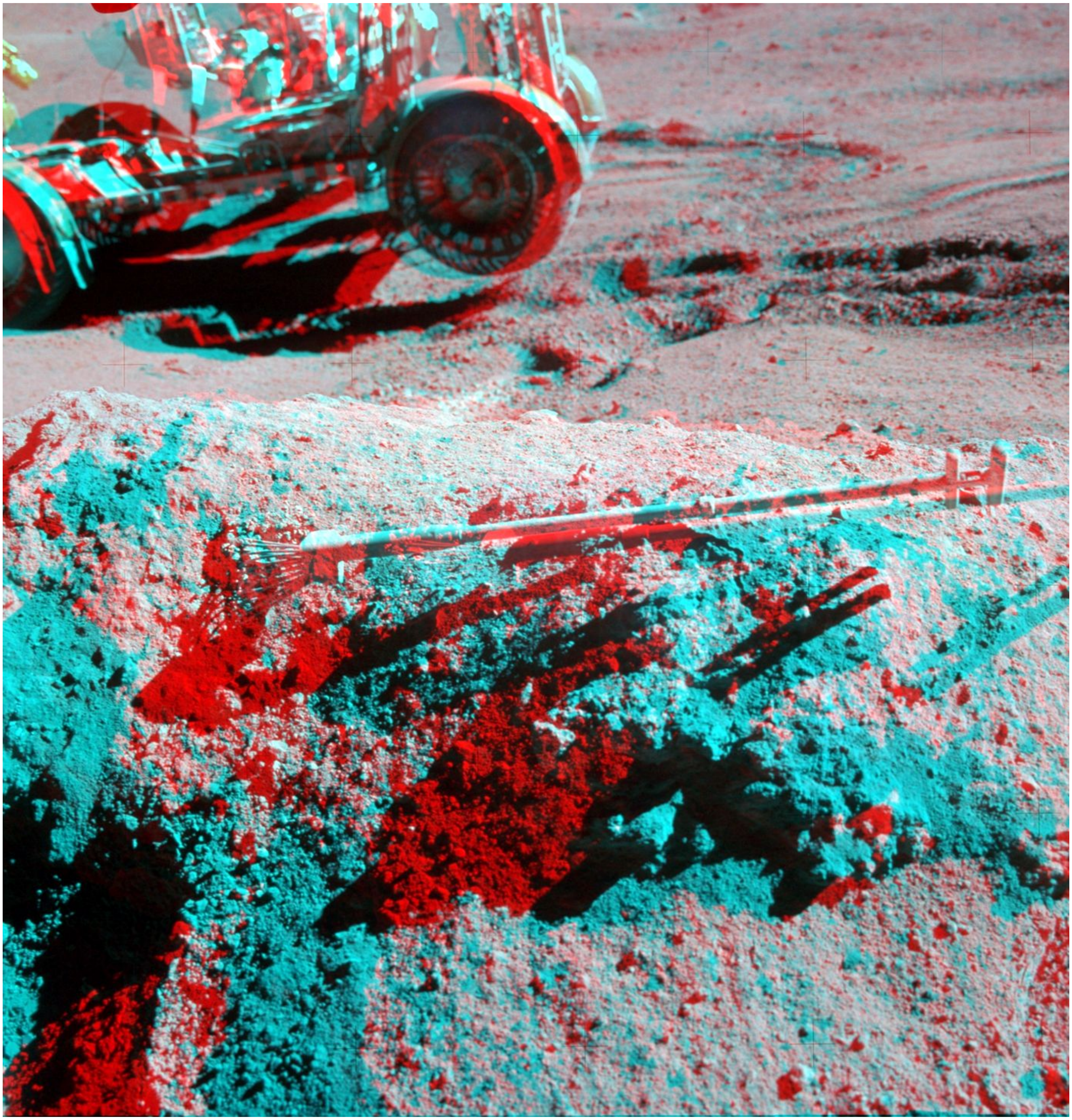


Fig. 12. Dave Scott has taken this stereo view of the rover parked at the boulder which he has been sampling at **Station 6**, the first stop on the drive up Mt. Hadley Delta. They were scheduled to stop at Station 4, Dune Crater, as part of this **EVA**, but made that stop on the way back to the **LM** instead. His geological sample tool is lying across the boulder. Note that the rover left rear wheel is not touching the ground. Jim Irwin is standing on the other side of the rover. (From NASA photos AS15-87-11781, and -82).

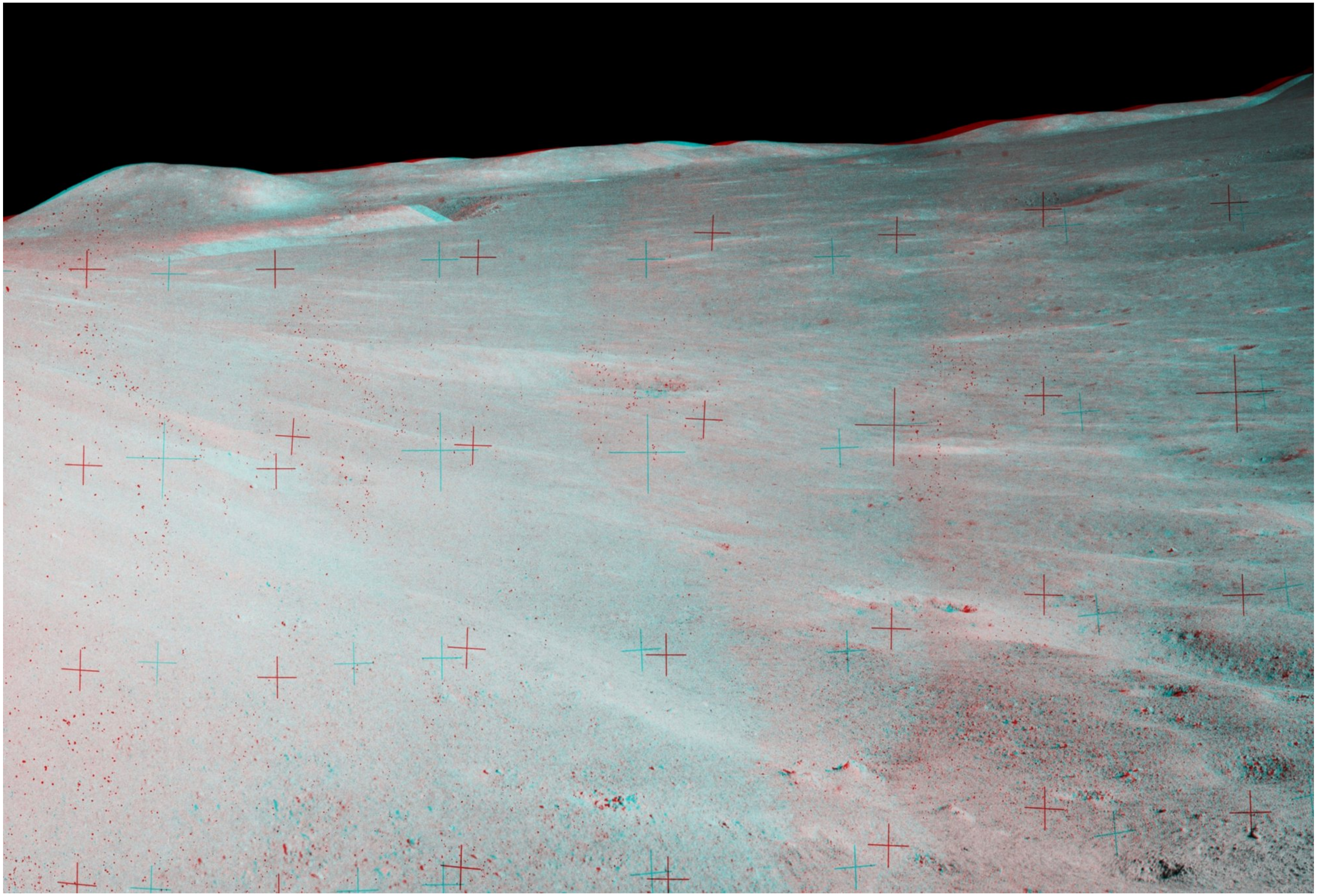


Fig. 13. An anaglyph composite of overlaps from the beginning of Jim Irwin's **Station 6a** pan (see ordinary pan combination in **Fig. 14**). The small hillside crater above the central fiducial cross is Spur Crater at **Station 7**, a notable stop before the astronauts return to the **LM**. (From NASA photos AS15-90-12180, -81, -82, -83, and -84).

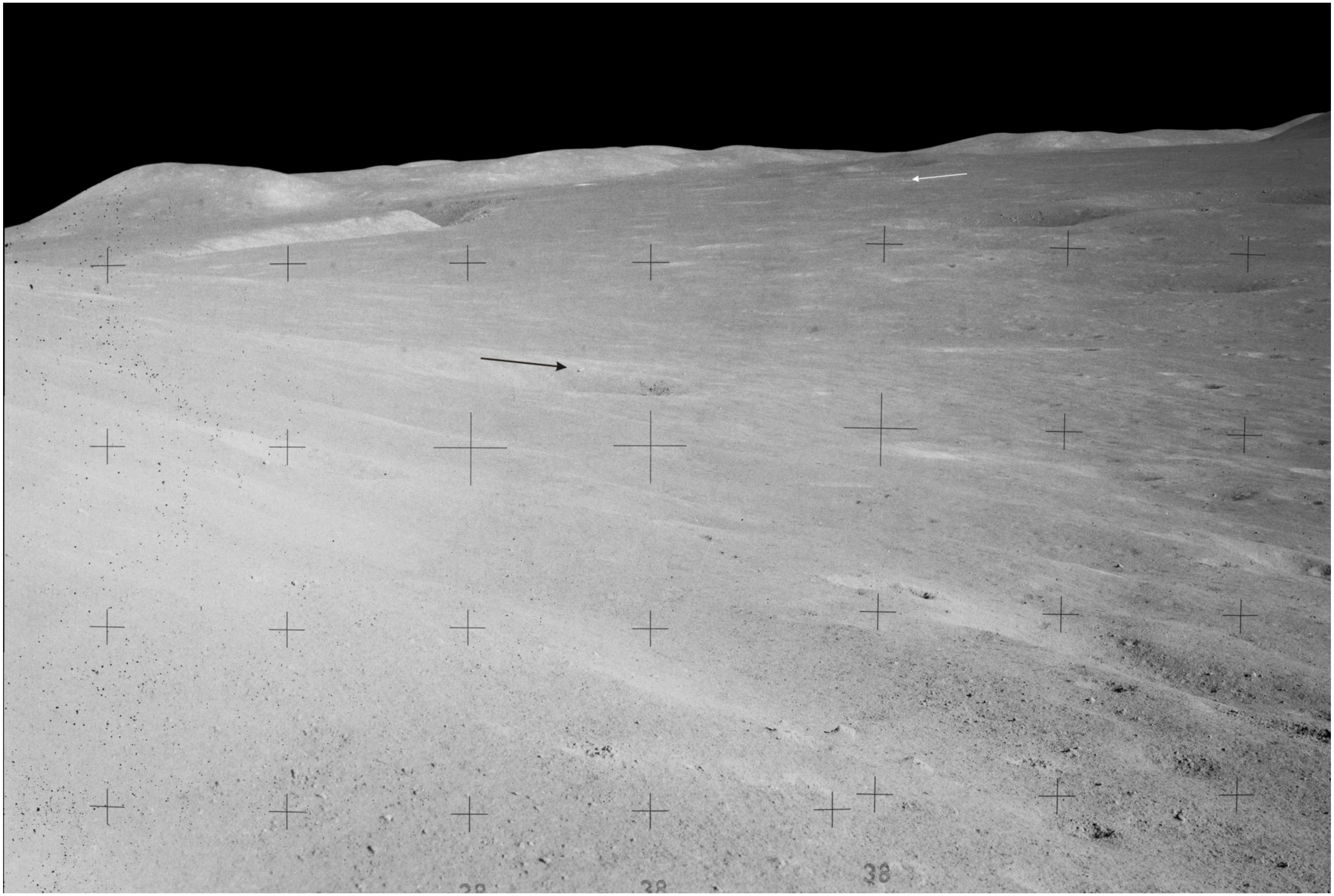


Fig. 14. A non-3D view from the beginning part of Jim Irwin's **Station 6a** pan (cf. **Fig. 13**). The black arrow denotes the large clast boulder sampled at **Station 7**, Spur Crater, on whose rim it lies. The white arrow in the distance points to the **LM**. It may be necessary to enlarge this page in the viewer in order to see both objects. Dune Crater is the elongated crater with rocks in its far dark wall below and to the right of the white arrow. (From NASA photos AS15-90-12181, -182, and -183).

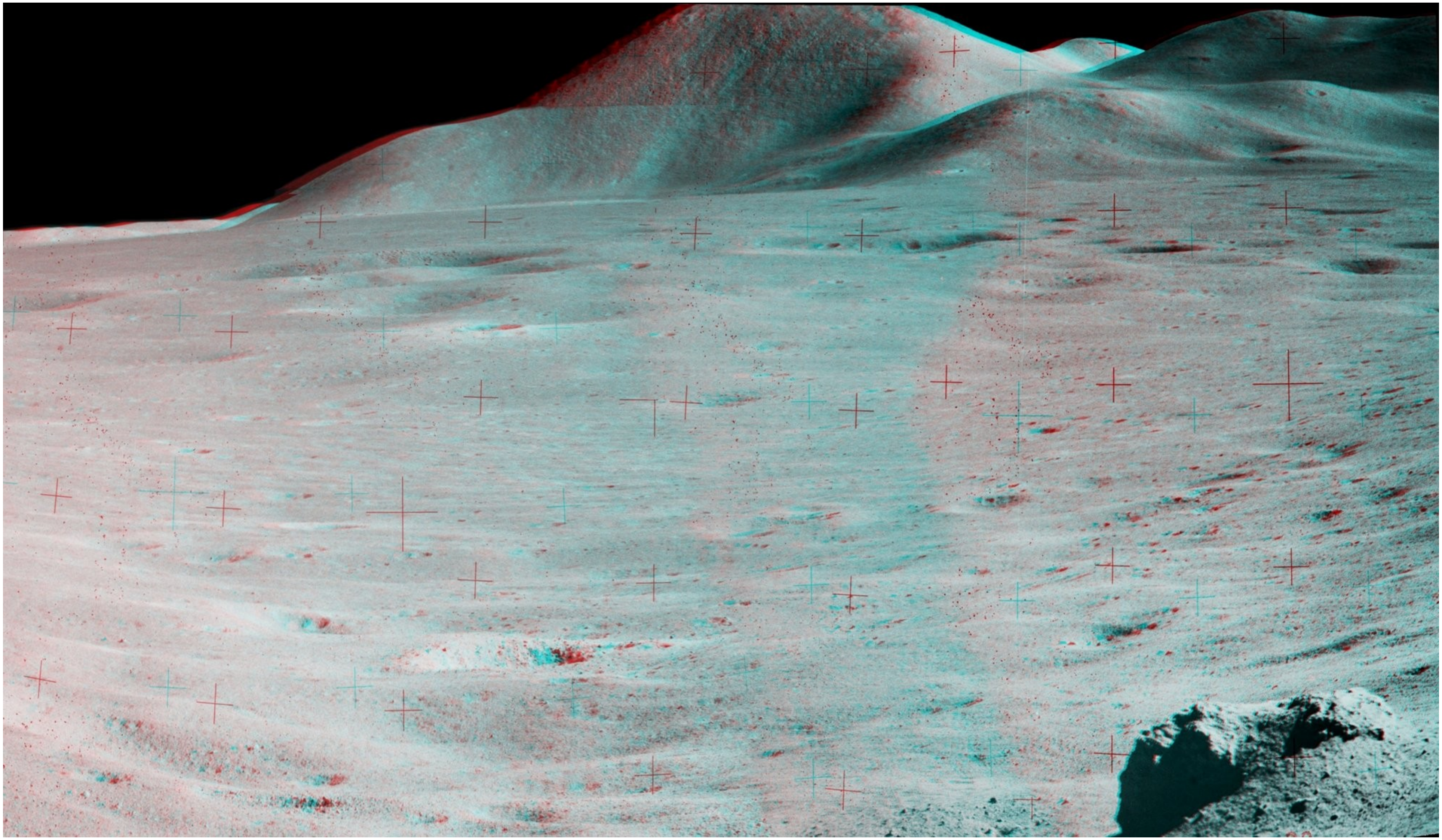


Fig. 15. Continuation of Irwin's **Station 6a** pan. (The jagged variation in brightness across the valley floor is an artifact of the panorama stitching process). A non-3D version is given in **Fig. 16**. The boulder at right was called the "Green Boulder". (From NASA photos AS15-90-12184, -85, -86, -87, and -88).

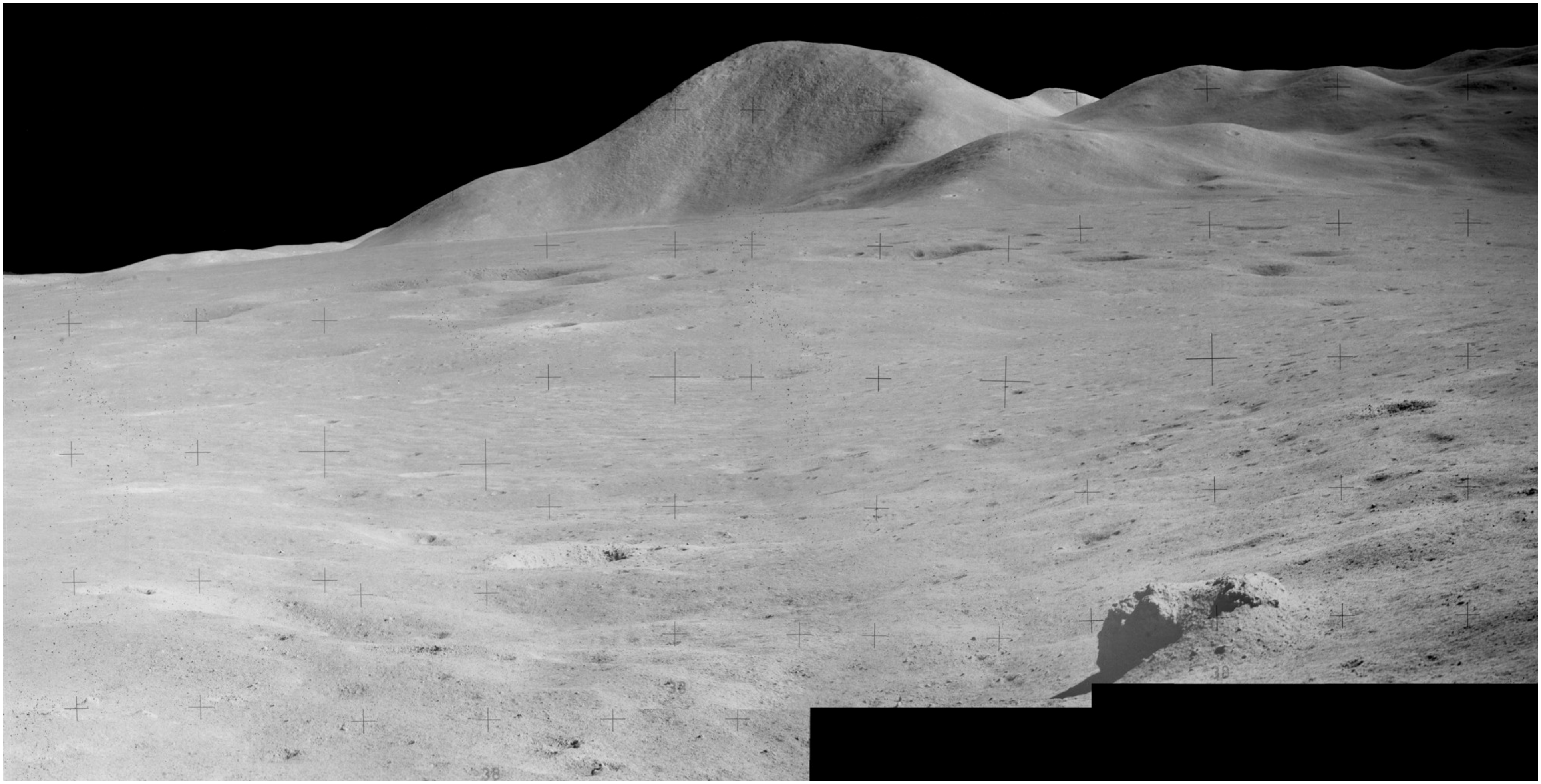


Fig. 16. Non-3D Continuation of Jim Irwin's pan at **Station 6a.** As noted in **Fig. 15**, the boulder here was called the "green' boulder because of its greenish cast. Green soil was found in significant amounts at **Station 7** nearby, similar to Jack Schmitt's "orange" soil which he discovered at Station 4 during the Apollo 17 mission. Note the striations in the face of Mt. Hadley in the distance. (From NASA photos AS15- 90-12184, through -88).

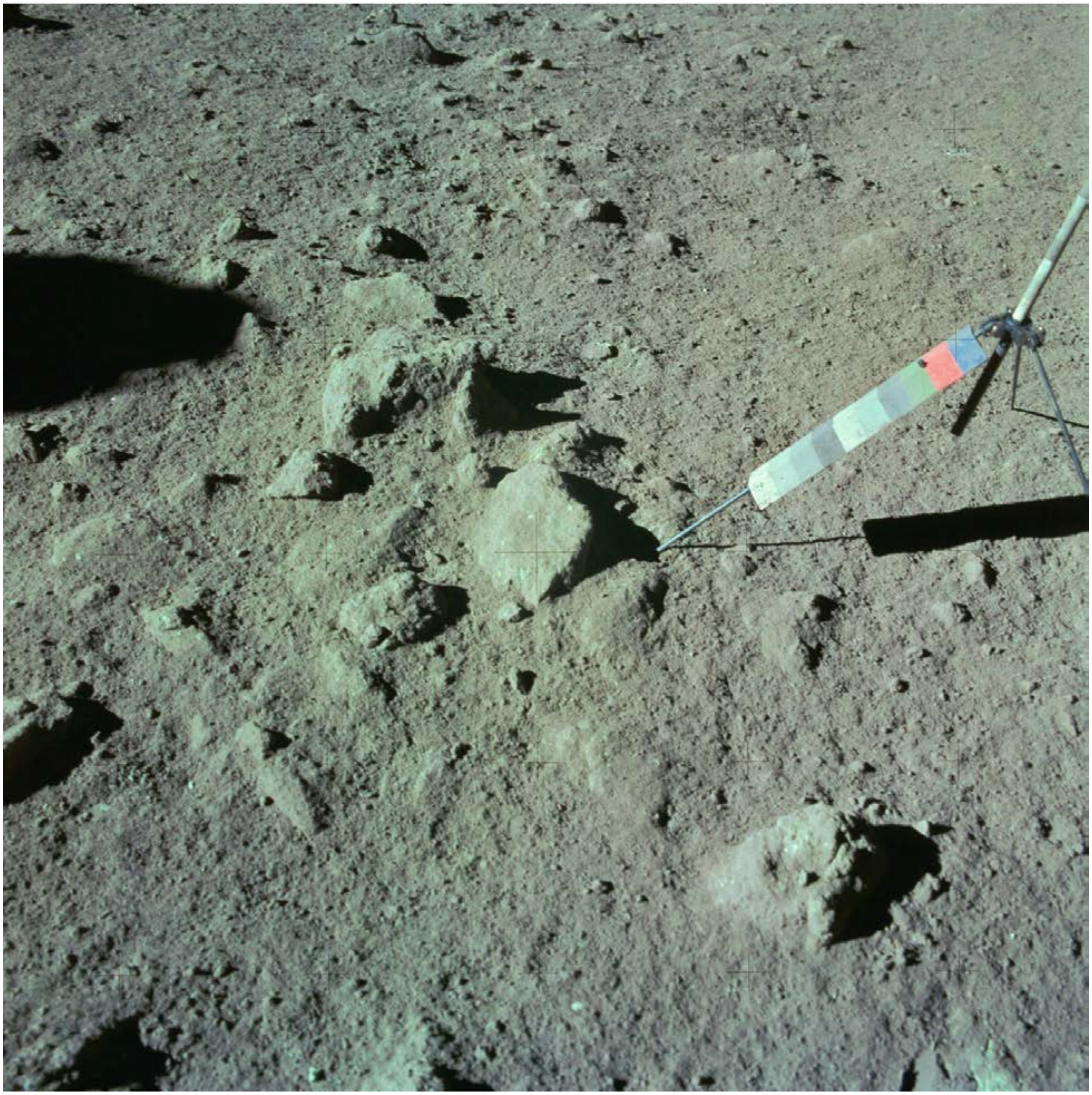


Fig. 17. Example of the green soil in a non-3D photo taken at **Station 7** by Dave Scott. (The eyes should be rested a few minutes without the red-cyan glasses before viewing) The colors have been enhanced equally across all photographic wavelengths so that the green coloration and its variation stand out more clearly. The color is a result of the cooling rate of the glass content in the volcanic soil. Compare the soil color with the green chips in the color chart on the gnomon. The several photos taken here could be made into stereo views, but anaglyph versions do not render the green color very well. Cf. the orange soil of **Fig. 24** in the Apollo 17 photos. (From NASA photo AS15-86-11666).

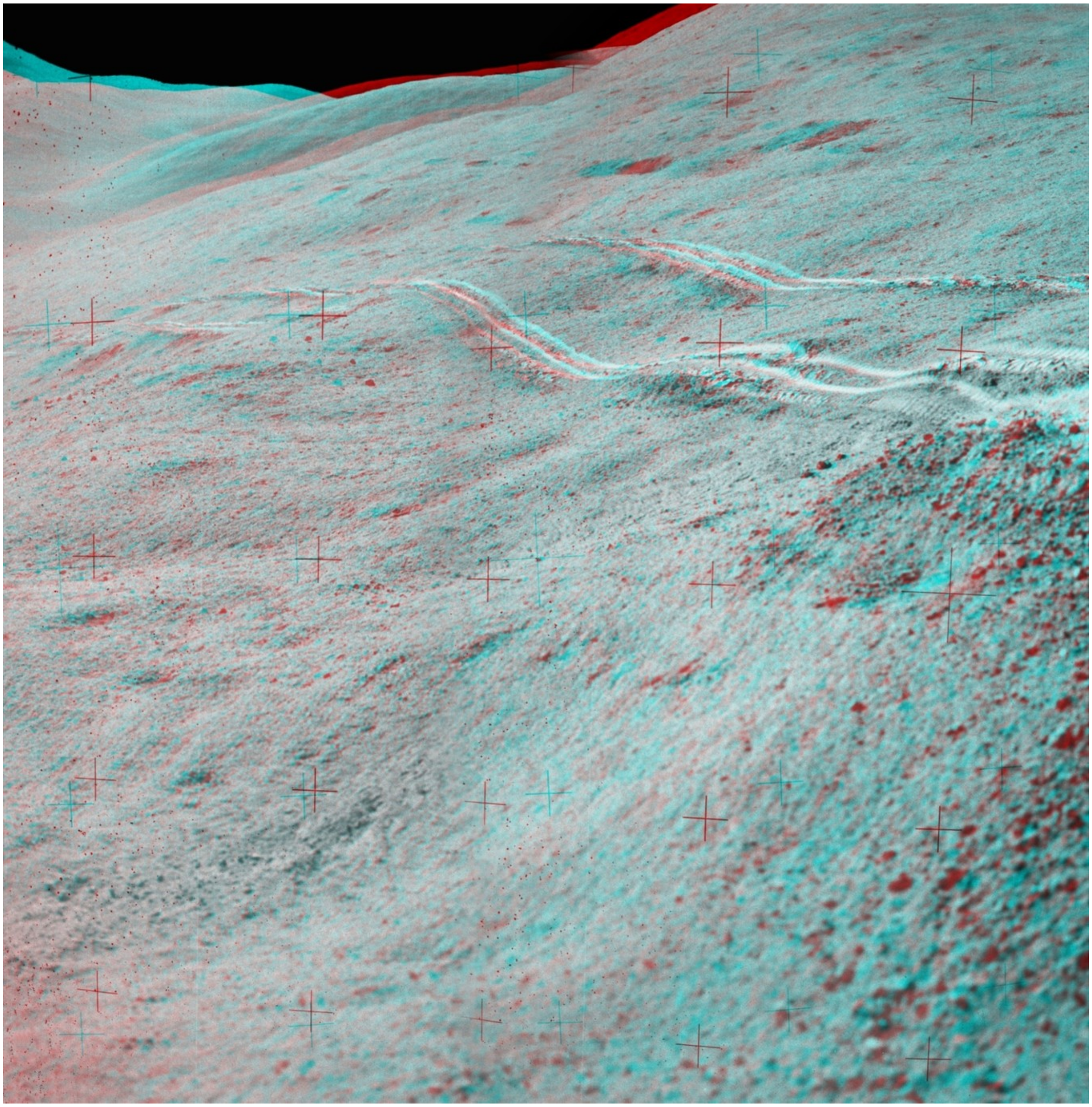


Fig. 18. This view from the last part of Irwin's **Station 6a** pan shows the rover tracks in the soft soil. At right the variegated slumps of soil represent debris sliding down the hill as the rover drove along. Such slumps can be seen all along the tracks coming from **Station 6**. Four tracks can be seen because the rear wheels are not directly behind the front wheels. (From NASA photos AS15-90-12191, -92, and-93).

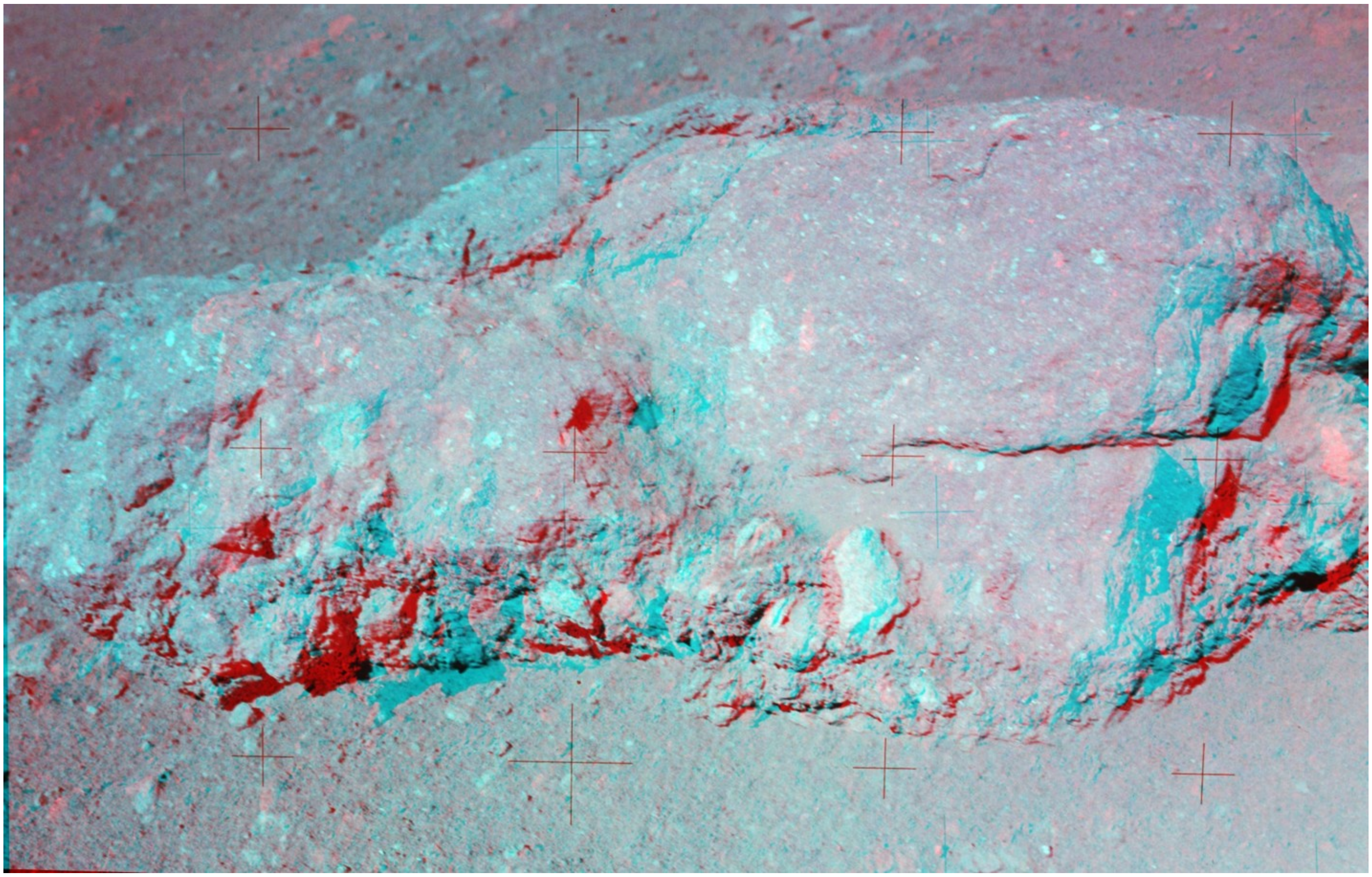


Fig. 19. The boulder lying on the inner rim of Spur Crater (marked by the black arrow in **Fig. 14**). It is notable in that there are a number of white clasts scattered through the boulder. The boulder also has a greenish cast to it. See also **Fig. 20**, a view from the right end looking across the top of the boulder. (From NASA photos 86-11684, and -85).

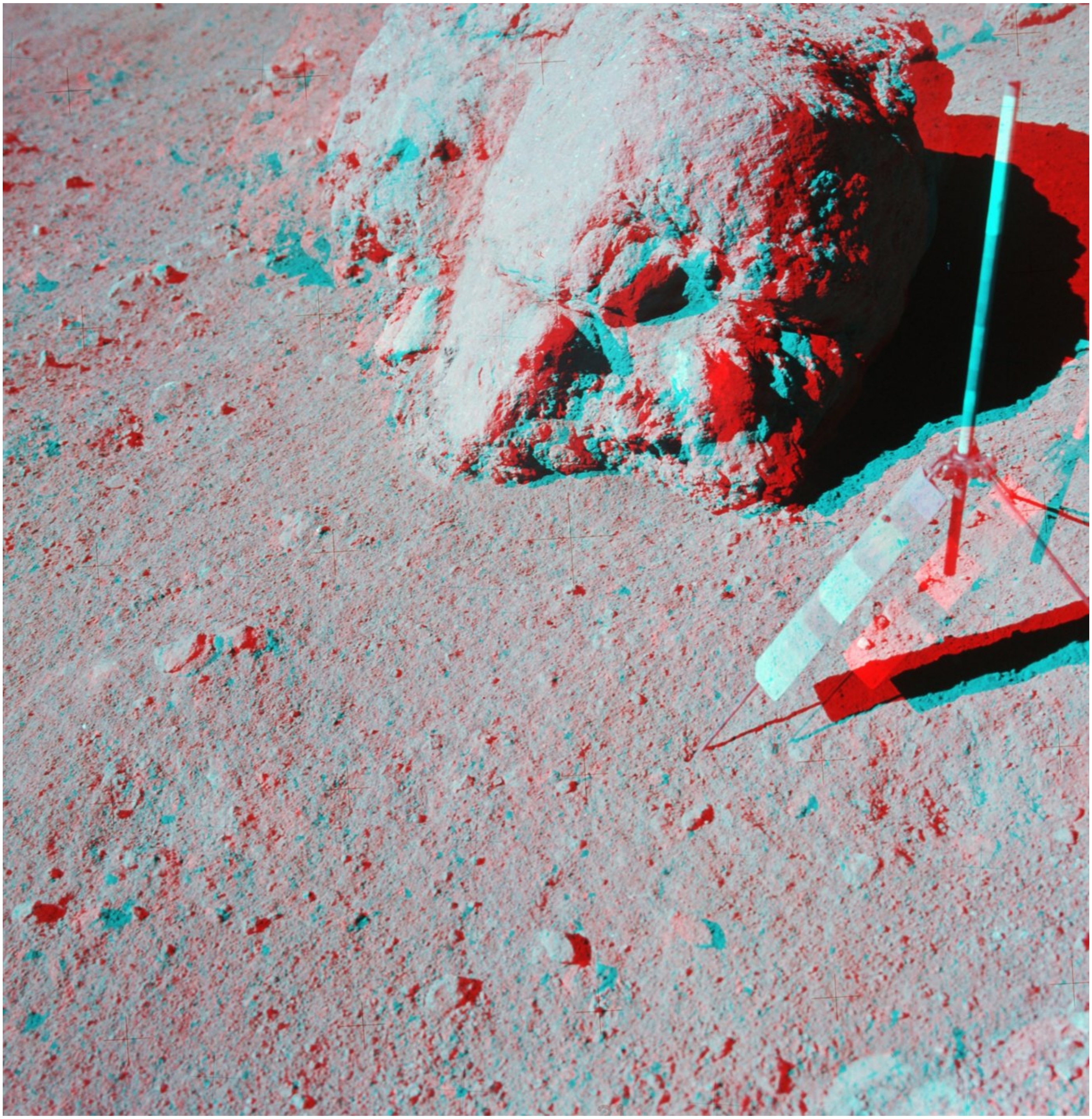


Fig. 20. The **Station 7** boulder at Spur Crater from the north end looking uphill. (From NASA photos AS15-86-11682, and -83).

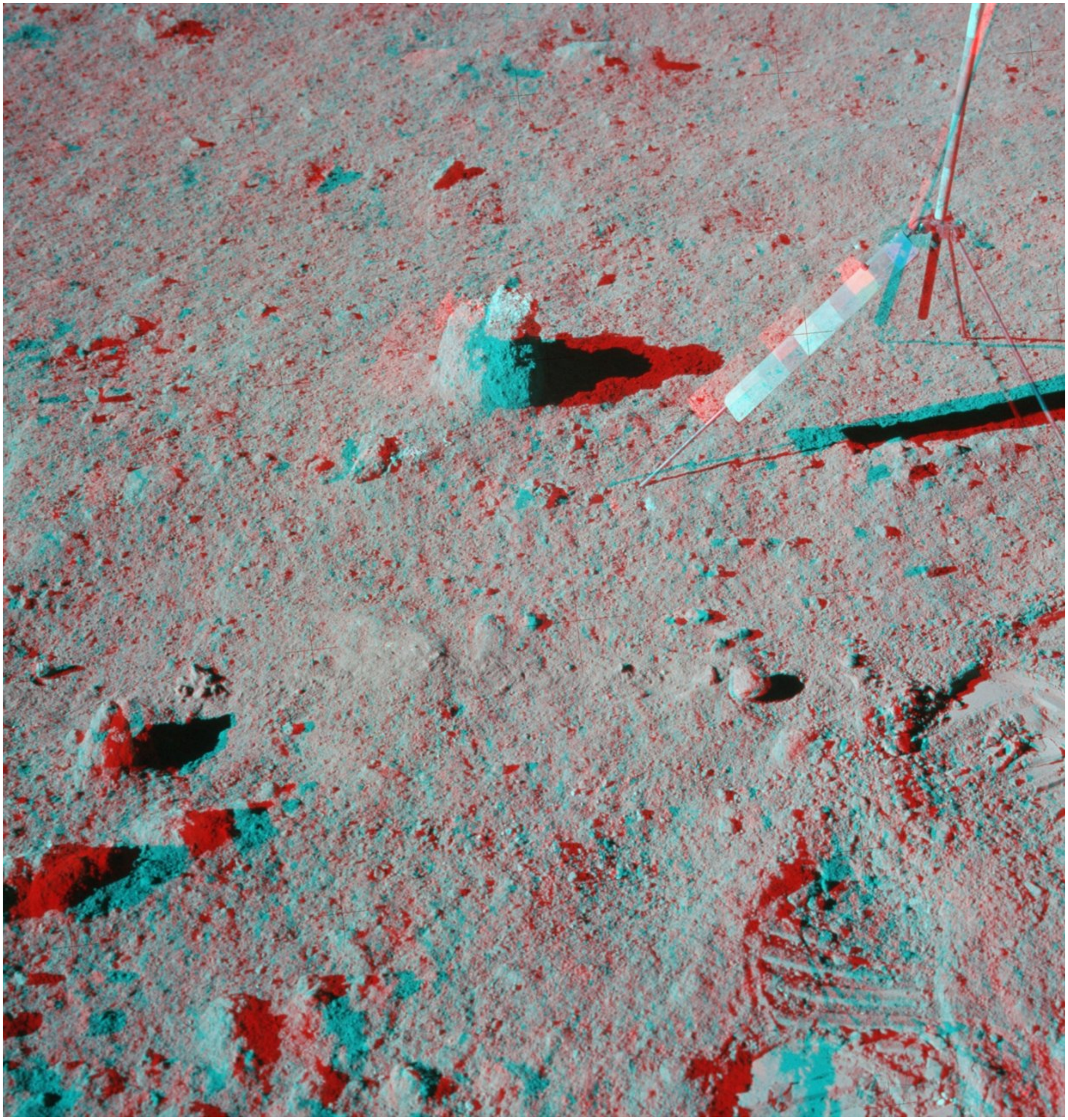


Fig. 21. The most famous rock (to most reporters who named it) returned from the Moon, the so-called Genesis Rock, the small cube-shaped white rock perched on the top of a matrix clod at **Station 7**. It is pure anorthosite, containing a crystalline plagioclase thought to be from deep within the lunar crust, one of the oldest samples returned (although older rocks were later found by the Apollo 17 crew)— hence, the name given to it by reporters. (From NASA photos AS15-86-11670, and -71).

Fig. 22. Dave Scott shortly after arriving at **Station 7** sighting through the telescope to align the high gain antenna with the Earth. The astronauts had to perform this step each time they stopped. (From NASA photos AS15-90-12219, and -20).

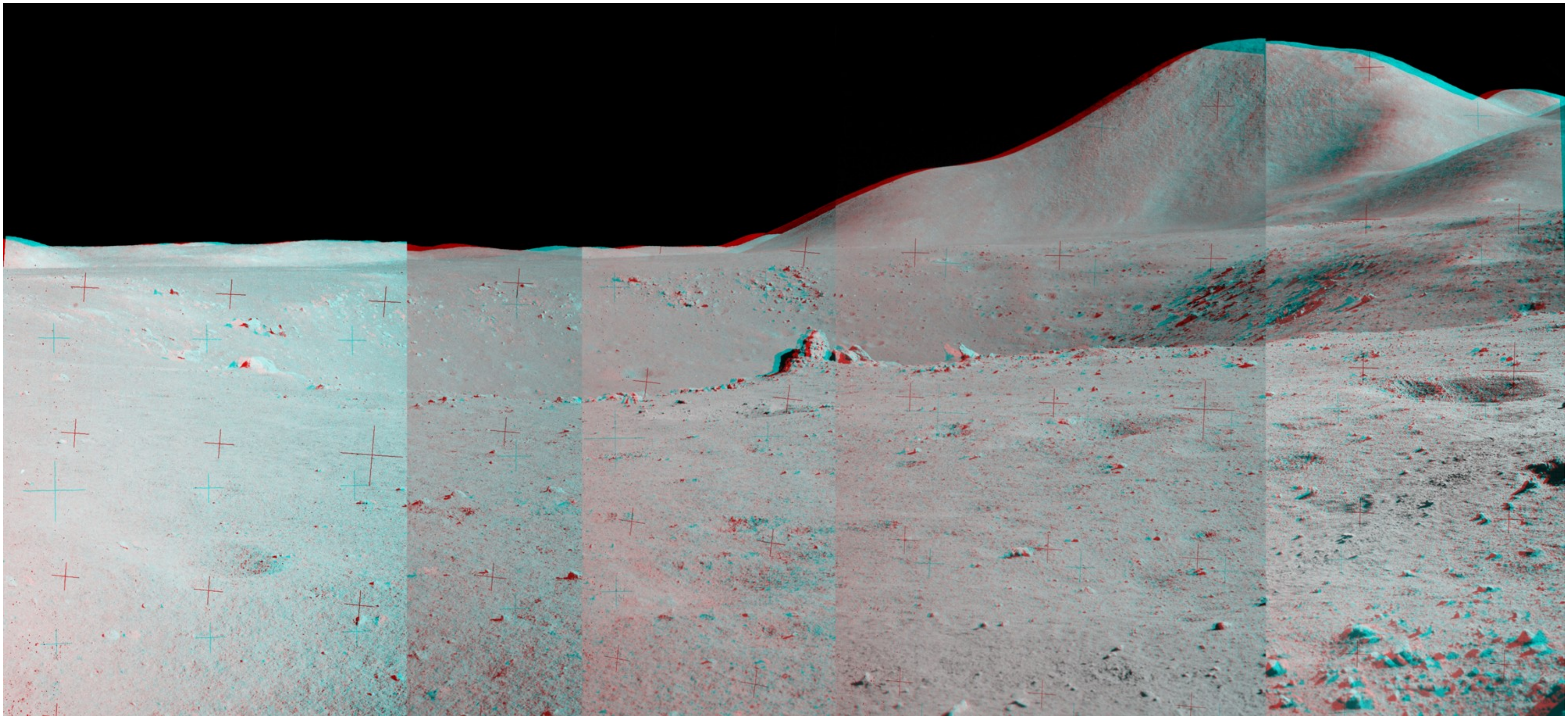


Fig. 23. On the way back to the **LM** from **Station 7**, the astronauts stopped at **Station 4** at a 400 m diameter crater called Dune Crater. Jim Irwin made a panorama on the rim of the crater. Elements of the panorama are shown as the combined anaglyph above. The non-3D view is given in the following **Fig. 24**. A notable feature is the group of boulders in the center of the view exhibiting a number of large diameter vesicles, or cavities formed by gas bubbles in volcanic rock. (From NASA photos AS15-90-12240, -241, -242, -243, -244, -245, and -246).

Fig. 24. A portion of Jim Irwin's **Station 4** panorama. The overlap portions of this pan were used to produce the combined anaglyph view given in **Fig. 23**. In the distance is the 14,000 foot high Mt. Hadley. Dune crater can be seen from the slopes of Mt. Hadley Delta in Irwin's Station 6a pan. In **Fig. 14**, it is the elongated shape with boulders in its far wall below the white arrow and slightly to its right, extending between 2 fiducial crosses and beyond the rightmost cross. (From NASA photos AS15-90-12240, -241, -242, -243, -244, and -245).

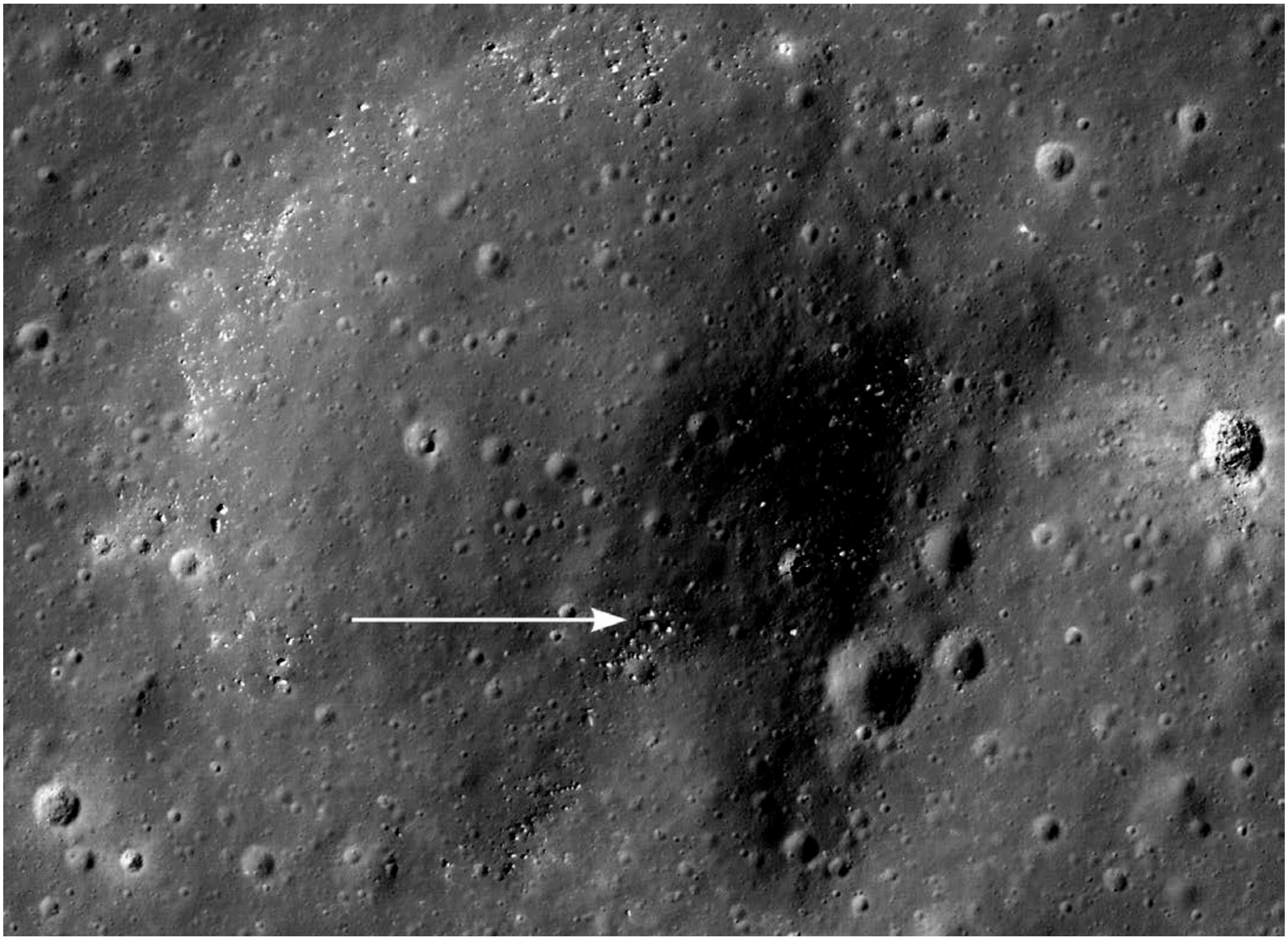


Fig. 25. A portion of a low-pass (36 km altitude) **LRO** high resolution (0.26 m/pixel) photo of Dune Crater. The white arrow points to the group of boulders seen in the central views of **Figs. 23** and **24**. The group of smaller boulders surrounding the small crater to the southwest of the larger group can also be seen as the line of small rocks leading left away from the larger group. The small crater itself cannot be seen because it lies on ground sloping away from Irwin. (From NASA/ASU/GSFC photo M175252641).

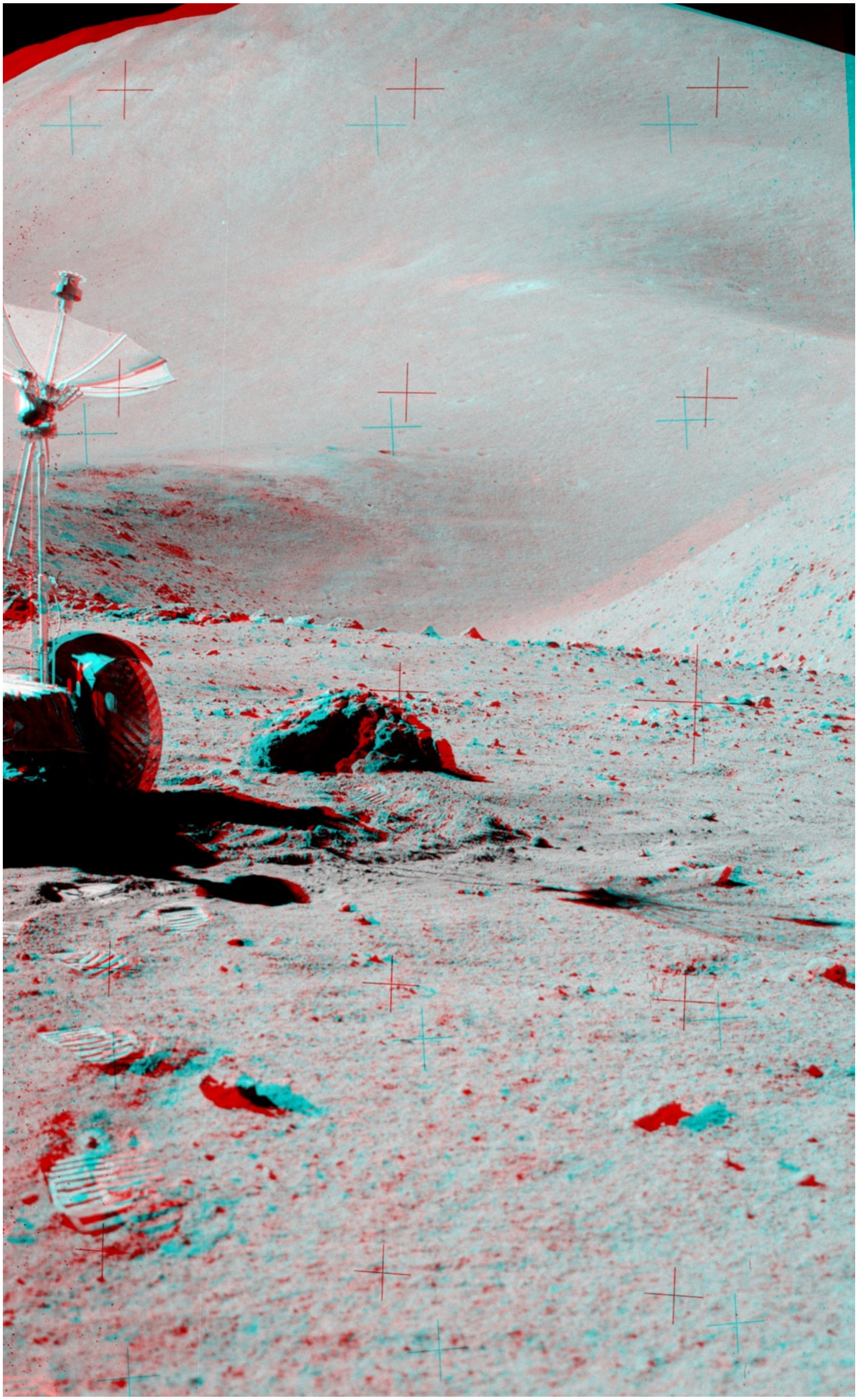


Fig. 26. View looking south along Hadley Rille from Jim Irwin's pan at **Station 9A**. (From NASA photos AS15-82-11121, and -22).

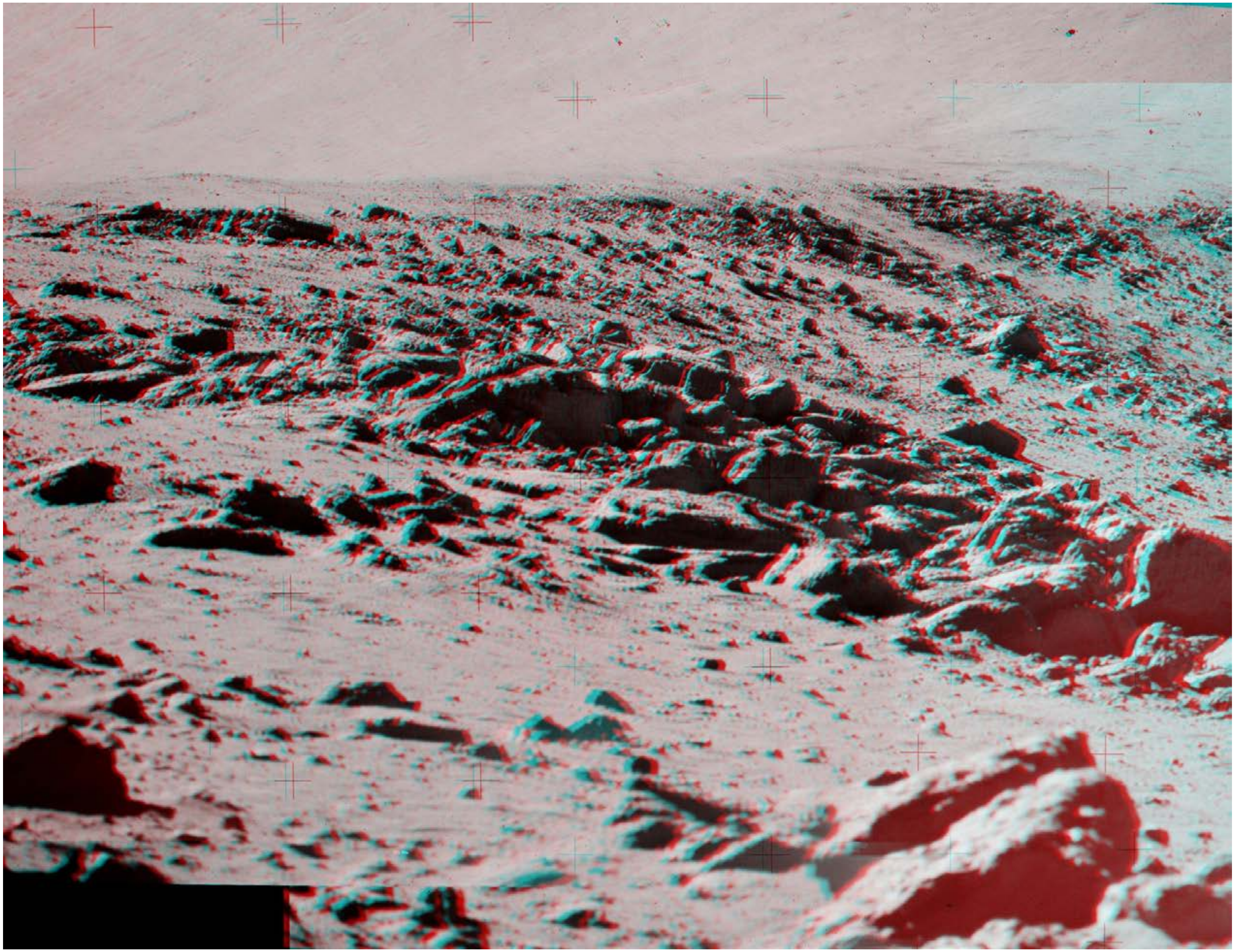


Fig. 27. Anaglyph from Dave Scott's pan at Station 9A showing boulder detail in the East wall of Hadley Rille. Many of them may be part of the bedrock. (From NASA photos AS15-89-12088, -89, -90, and -91 inclusive).

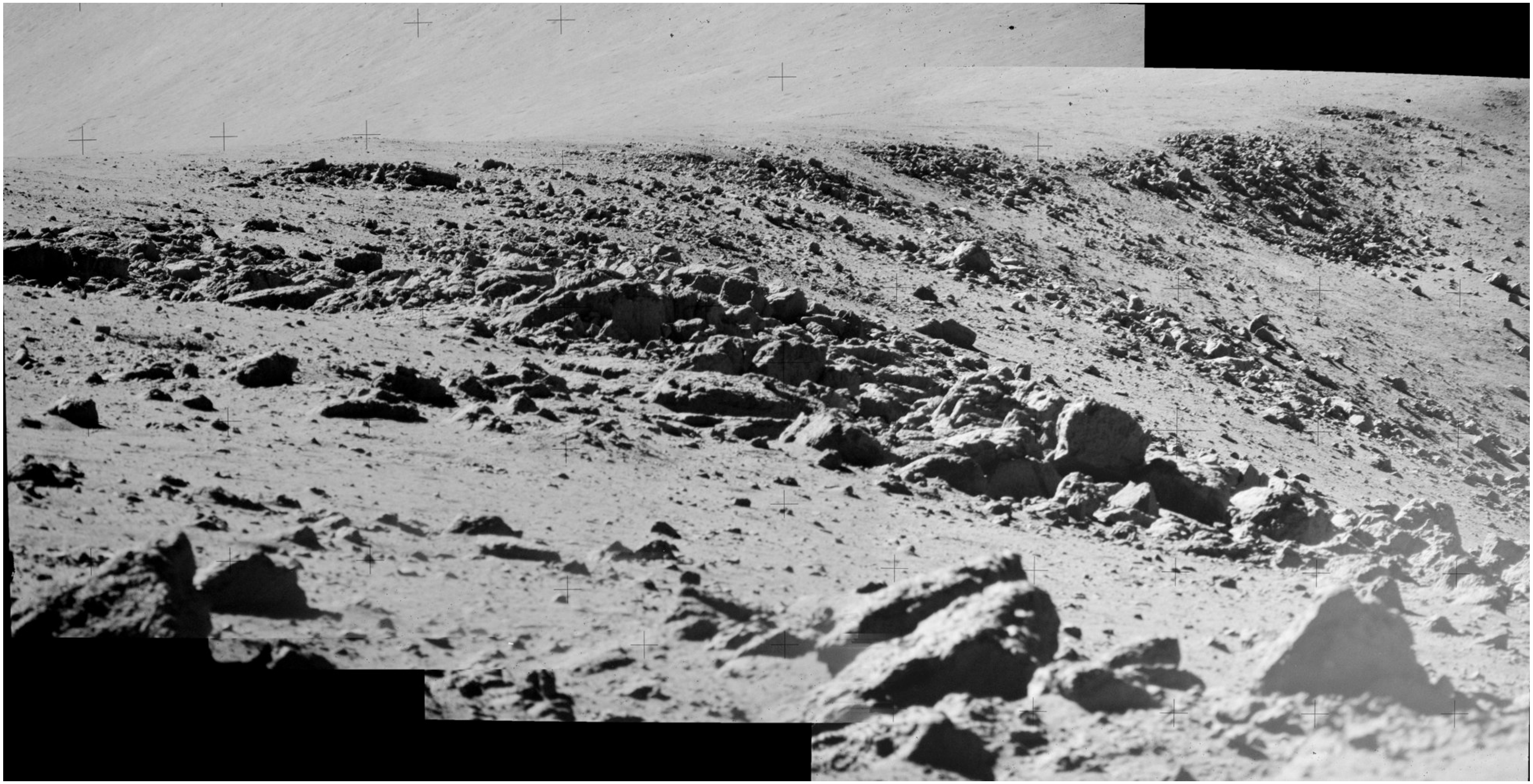


Fig. 28. The non-3D components of Dave Scott's **Station 9A** pan from which the anaglyph version was constructed. The East wall of Hadley Rille, of course, drops down much more steeply off the photo at right. (From NASA photos AS15-89-12088, -89, -90, and -91 inclusive).

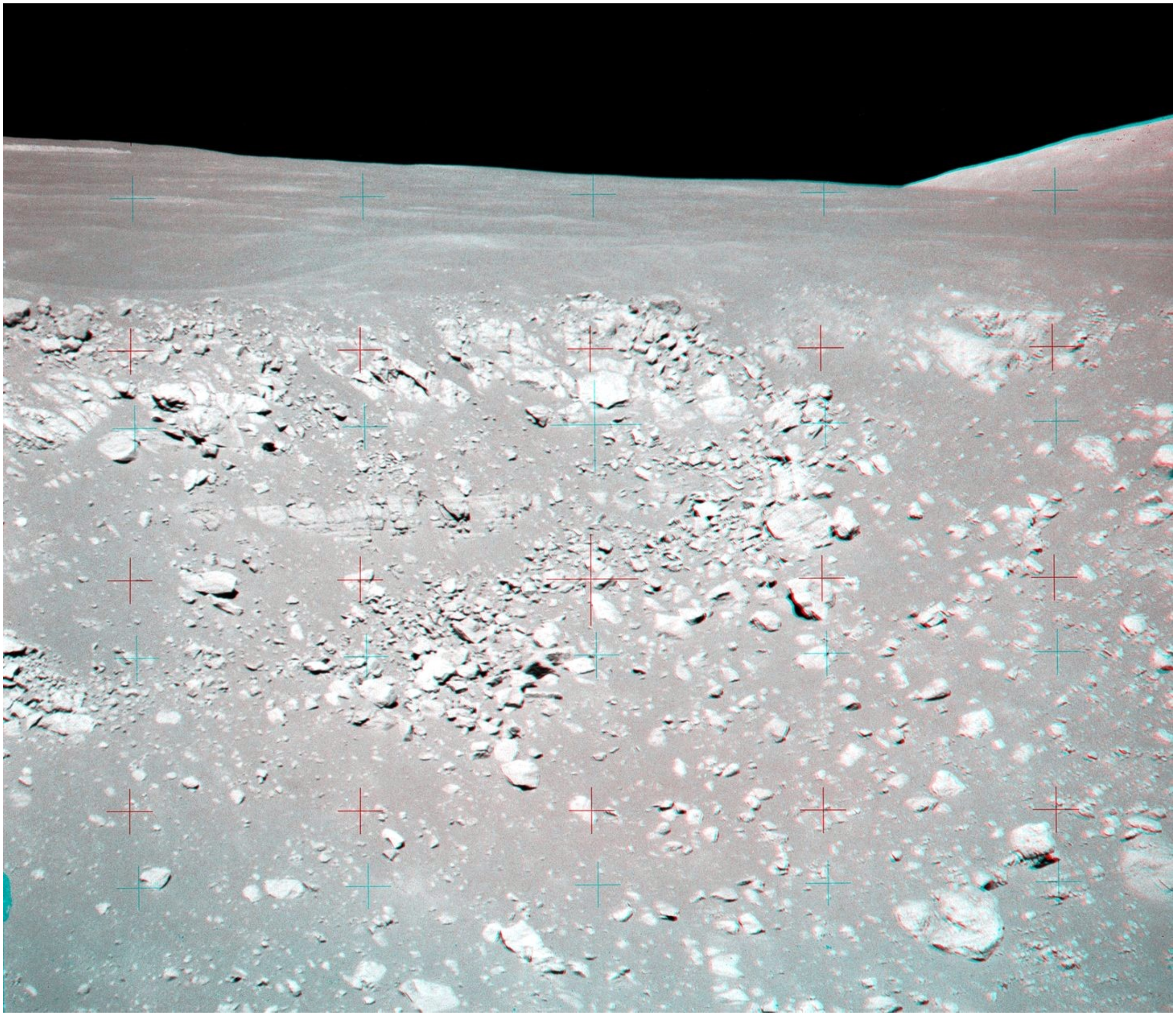


Fig. 29. While at **Station 9A**, Dave Scott used a Hasselblad with a 500 mm lens to make a series of vertical and horizontal overlapping photos of the stratigraphic layers of bedrock in the far western wall on the other side of Hadley Rille (ca. 1 km away). Because of the narrow angle **fov** and the fact that Scott did not move much between shots, there is not much separation as can be seen by the fact that the above photo looks almost like an ordinary photograph. Of particular interest in this view is the strata of straight, close layers just left of the center, almost like those of a cake. (From NASA photos AS15-89-12045, and -46).

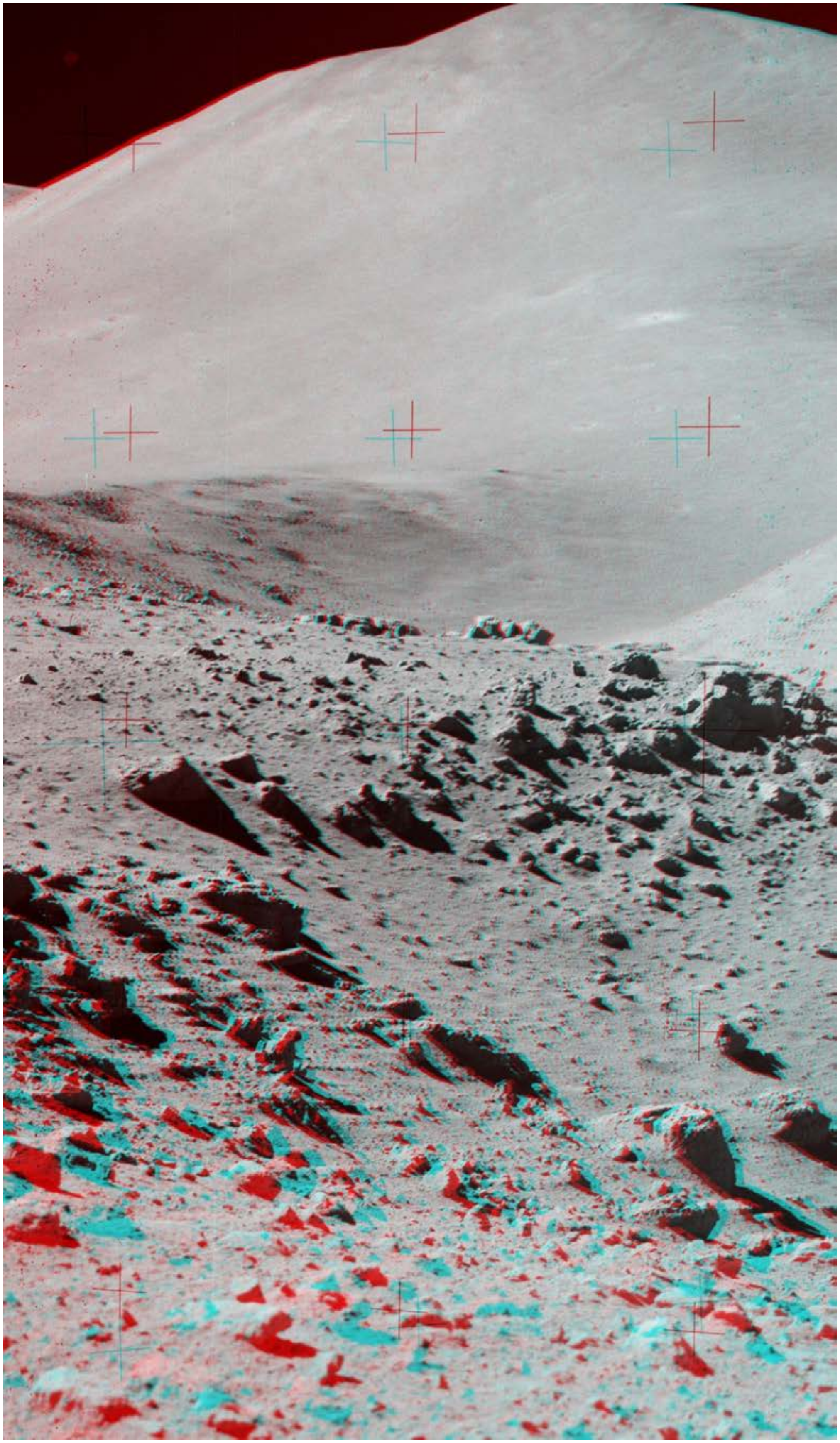


Fig. 30. View similar to **Fig. 26,** but slightly further north at **Station 10**. (From NASA photos AS15-82-11178, and -79).

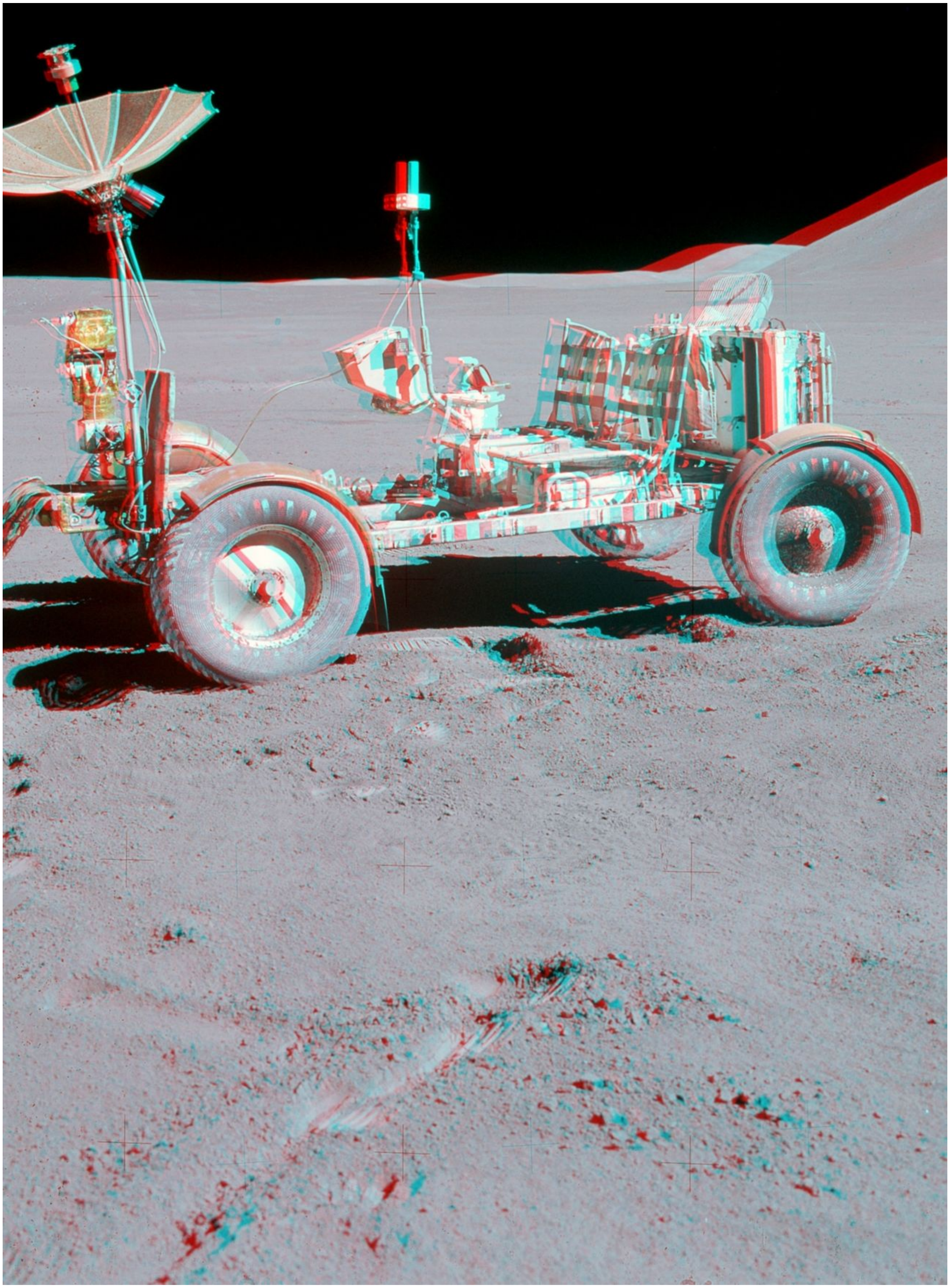
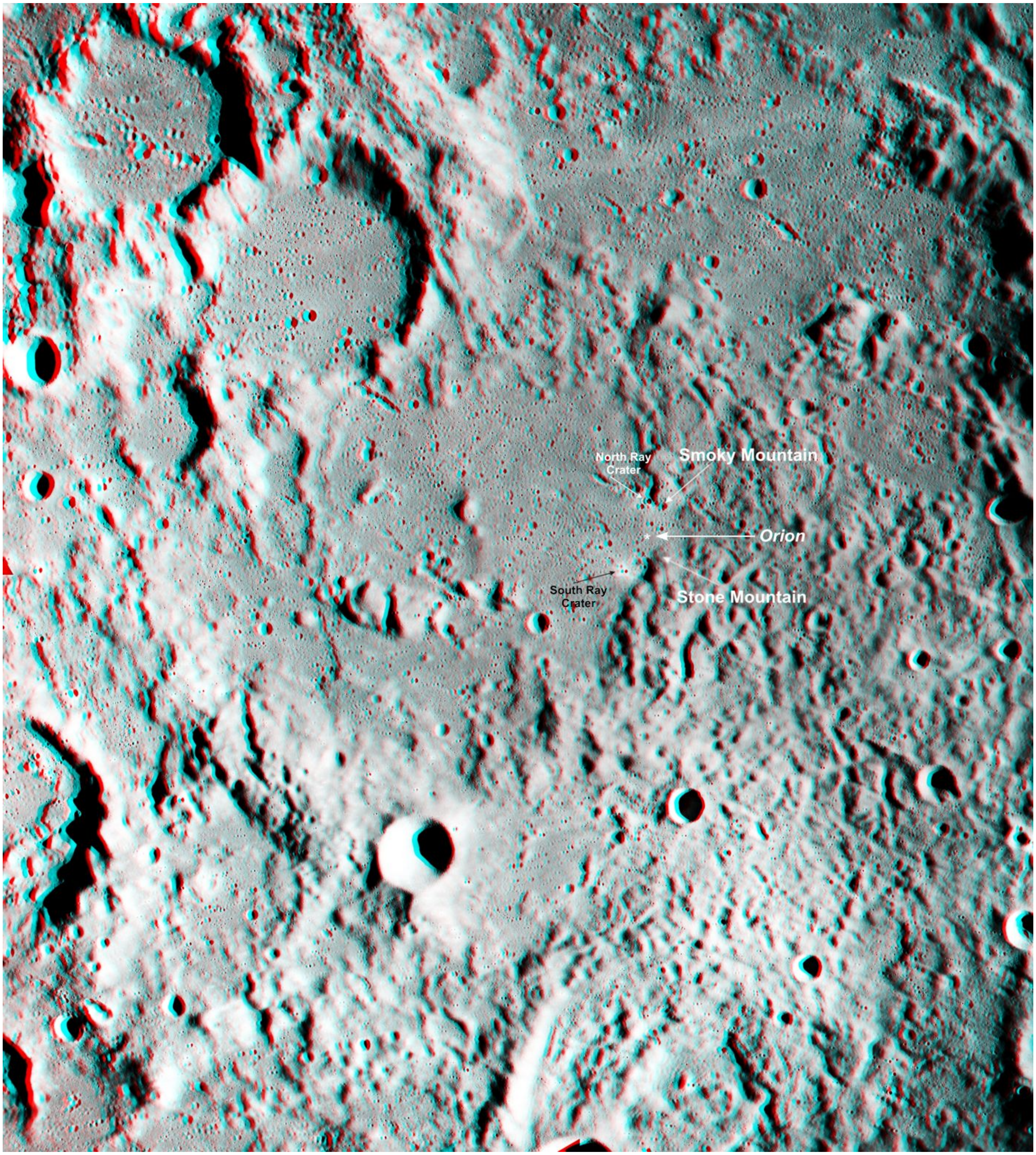


Fig. 31. Before closing out **EVA3**, Dave Scott drove the **LRV** to a parking spot, called the **VIP** site, ca. 100 m from the **LM** so that the TV camera could follow the launch. An enlargement of the hand controller shows that Dave Scott left a red covered bible on the console. (From NASA photos AS15-88-11901, and -02).



APOLLO 16

***Orion* Lands; the Mathematics of *Descartes* Prevails**

April 20, 1972

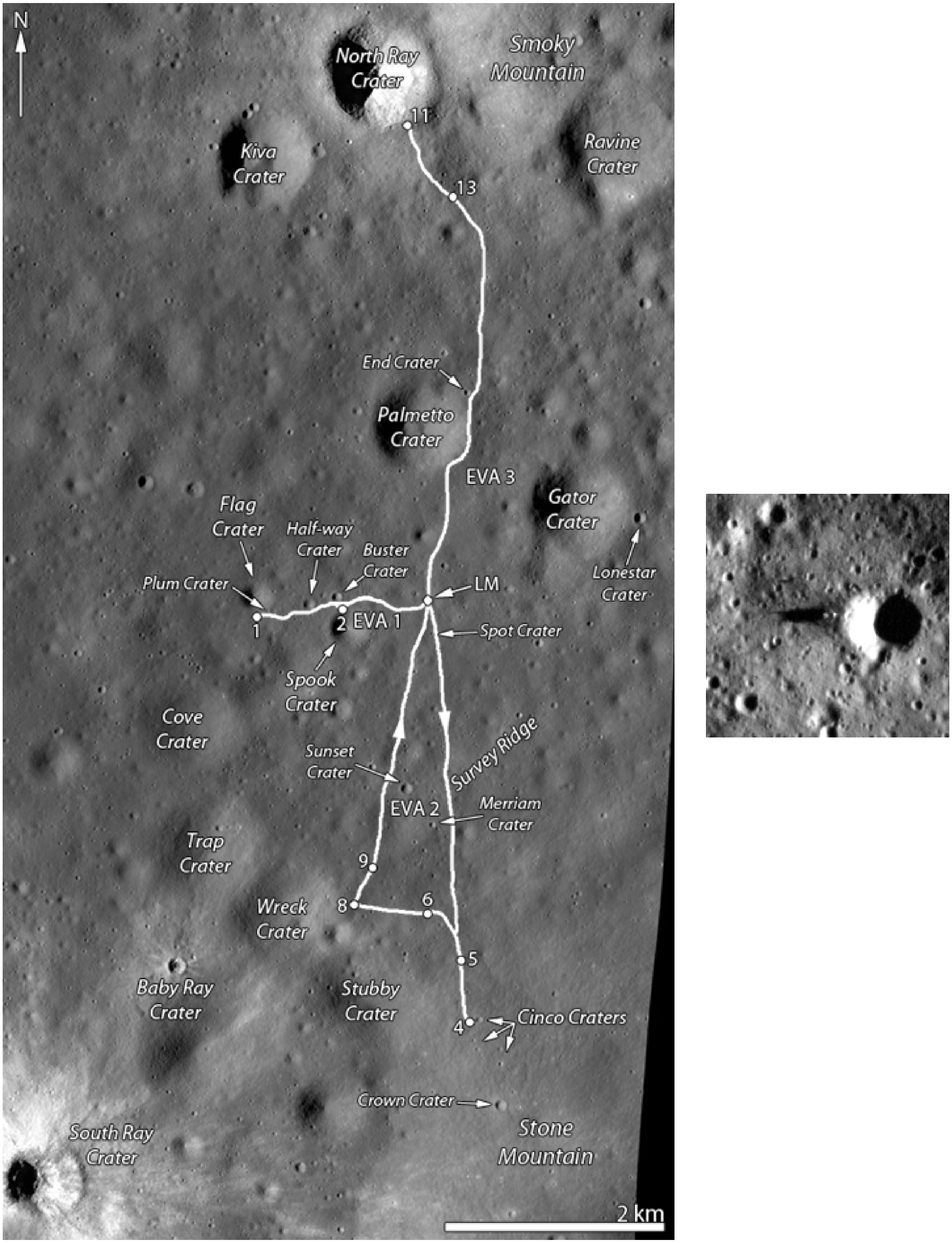


Fig. 1. The Apollo 16 landing site and EVAs marked out on an LRO photo of the area. At right is a recent view of the descent stage in M116215545. (NASA/ASU/GSFC photos).

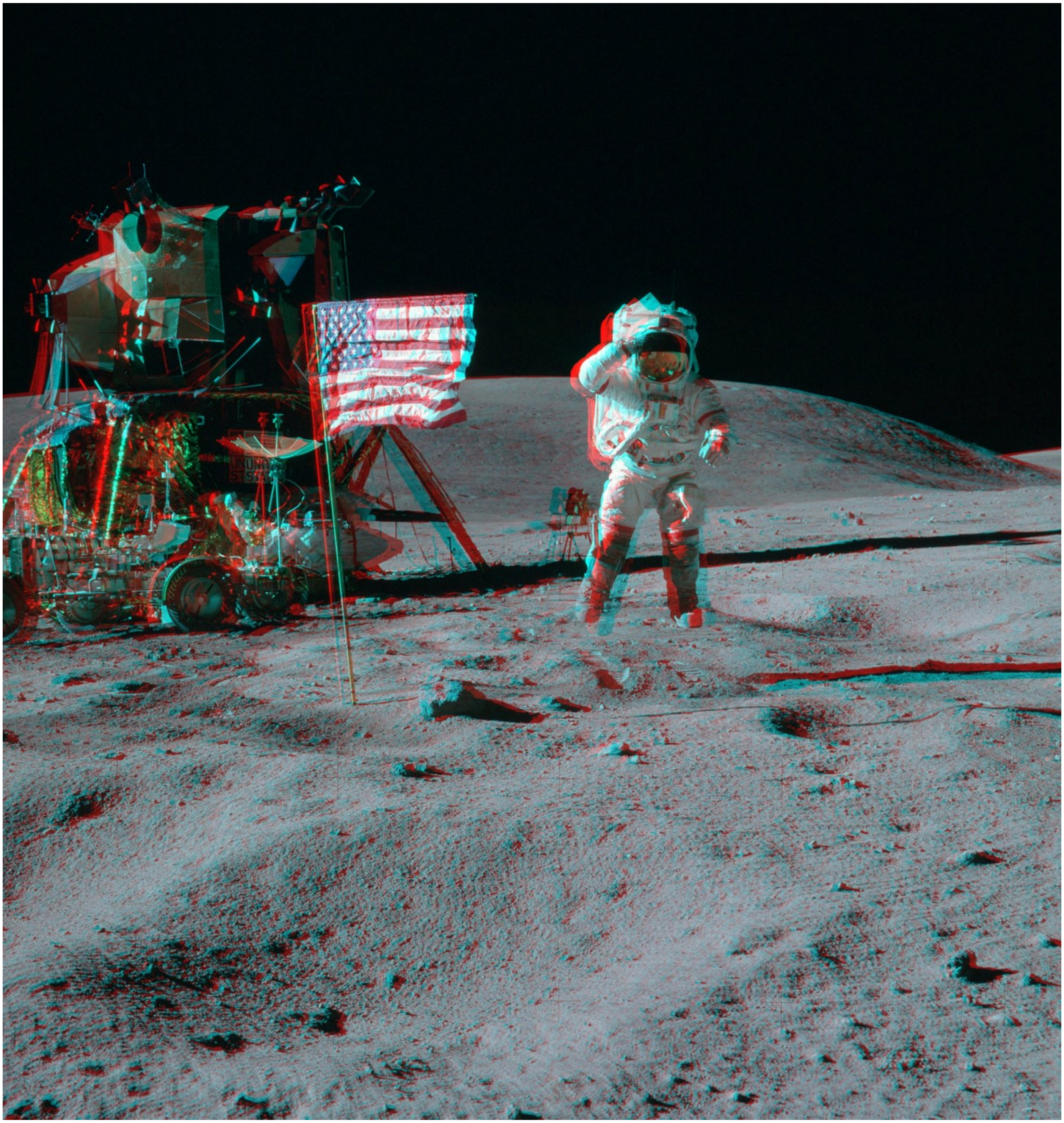


Fig. 2. The famous leaping salute (also cover photo) captured by Charlie Duke on **EVA** 1 as John Young jumped up twice with almost the exact same pose each time although at slightly different heights. The **UV** telescope-camera can be seen behind Young in the shadow of the **LM**. This view is one of the best 3D scenes from all the missions; however, the author adjusted his leap in one of the photos so that the height matched that in the other because the eye/brain has difficulties interpreting mismatched vertical coordinates in stereo photos. (From NASA photos AS16-113-18339, and -40).

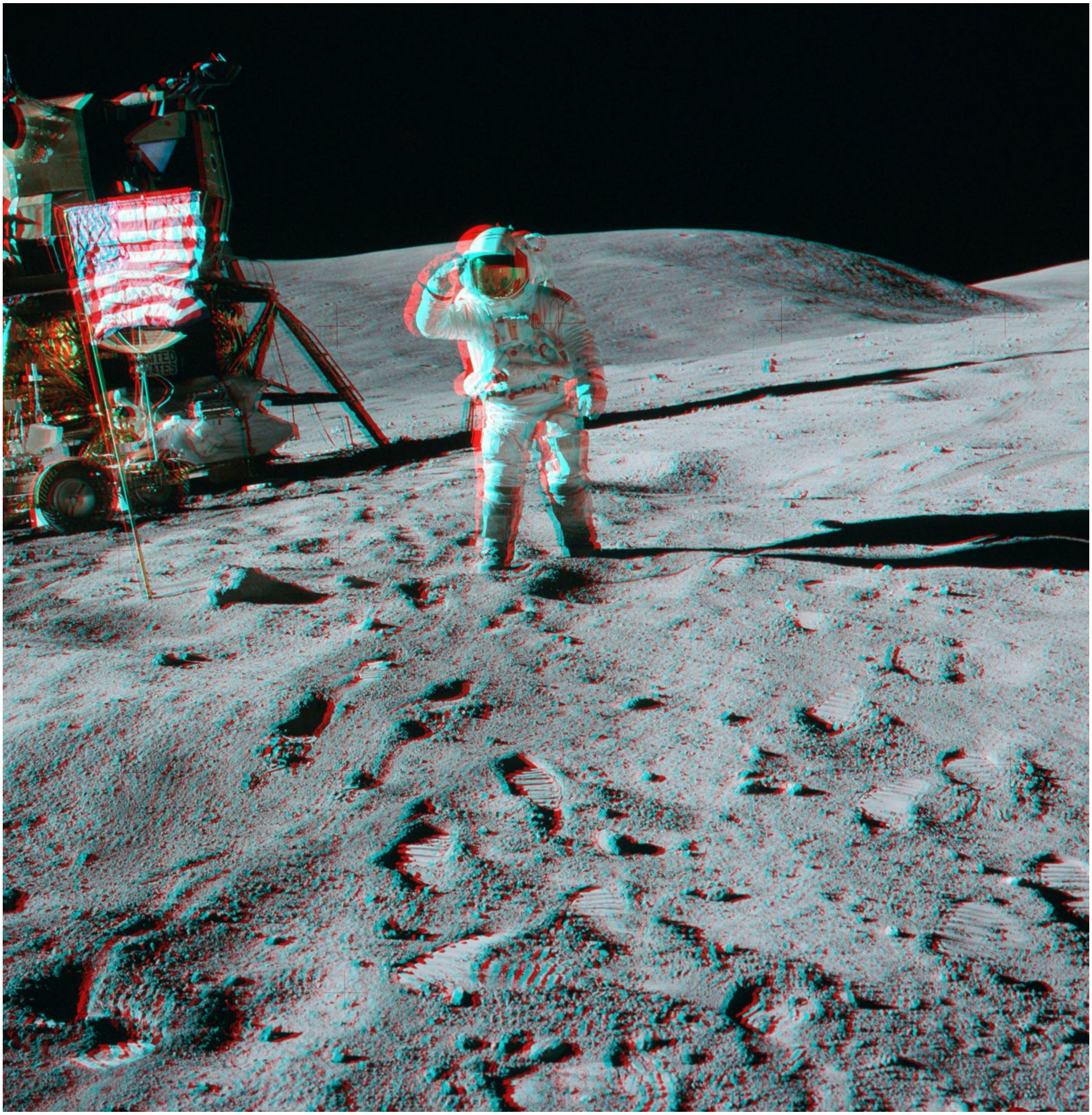


Fig. 3. Charlie Duke was not as energetic in his salute to the flag, choosing to remain ground-bound at this point although later at the end of EVA 3 he managed a 1.2 m leap, but falling on his back as a result! Duke did manage to maintain the same pose in the above scene while Young moved slightly in order to make the 2nd photo. Note that the TV camera on the rover (immediately adjacent to the right and about halfway up the flag pole) is pointing towards Duke. Ed Fendell, the remote camera operator in Houston, also captured Young's famous leap on TV. Stone Mountain is the ridge behind Duke, up which they will drive on EVA 2. (From NASA photos AS16-113-18341, and -42).

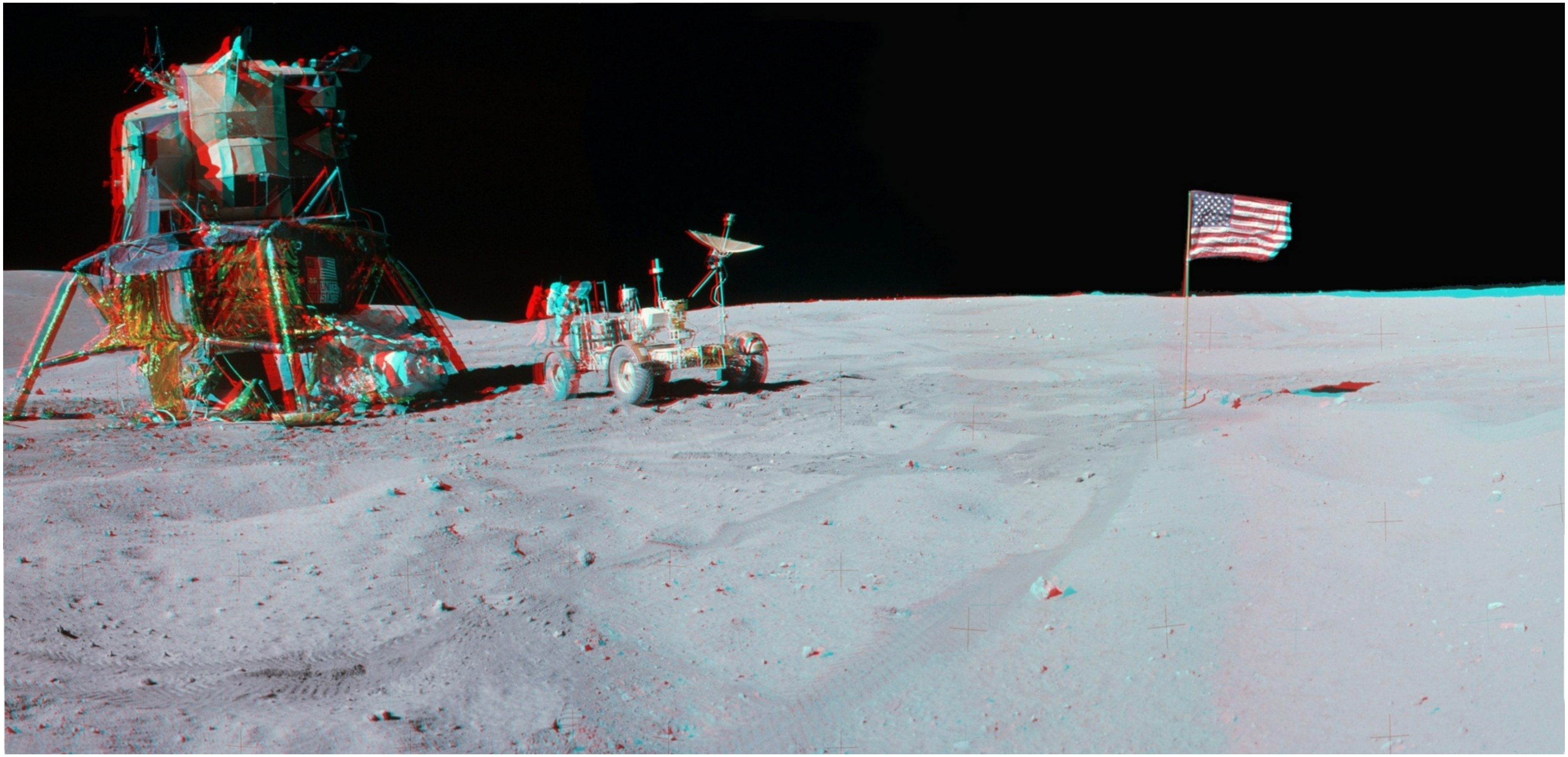


Fig. 4. Charlie Duke made a series of photos for a panorama at the start of EVA 2. Since the view is at right angles to the previous anaglyphs, the relative distance of the flag to the **LM** is easier to see here. John Young is beyond the rover at left and is preparing to get a rock sample. This anaglyph was composed from the overlapping panels of 6 photos. (From NASA photos AS16-107-17435, -36, -37, -38, -39, and -40 inclusively).

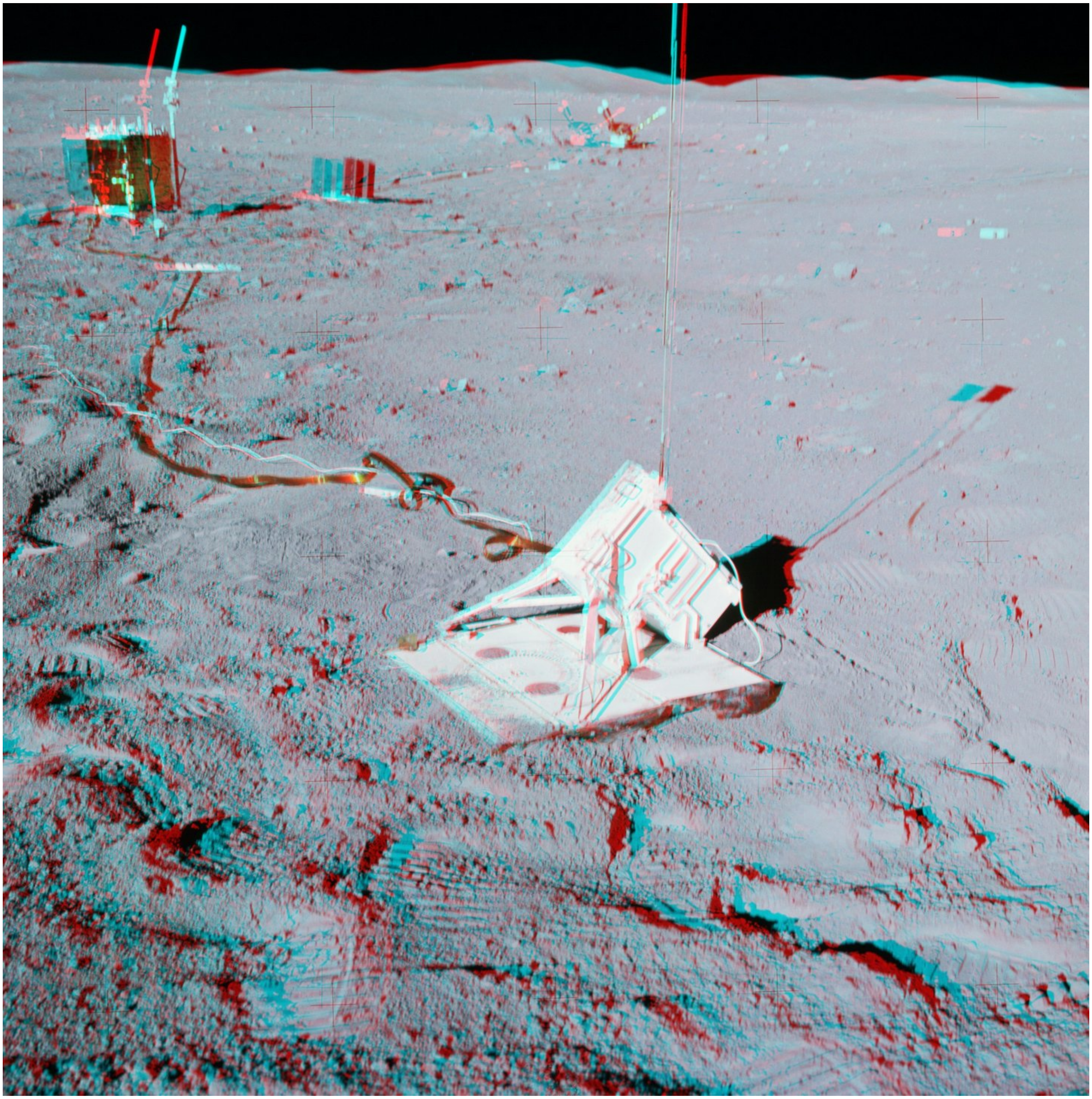


Fig. 5. The **ALSEP** after deployment as photographed by Charlie Duke. In the distance to the right of the rocks is the magnetometer. Coming forward to the left is the **RTG** (Radioactive Thermal Generator, the power source). To the left of that is the Central Station with antenna pointing towards the Earth. In the immediate foreground is the mortar which was used to fire charges that would explode at a distance to be recorded by the seismometer. The seismic data would provide information on the depth and structure of the regolith. (From NASA photos AS16-113-18379, and-78).

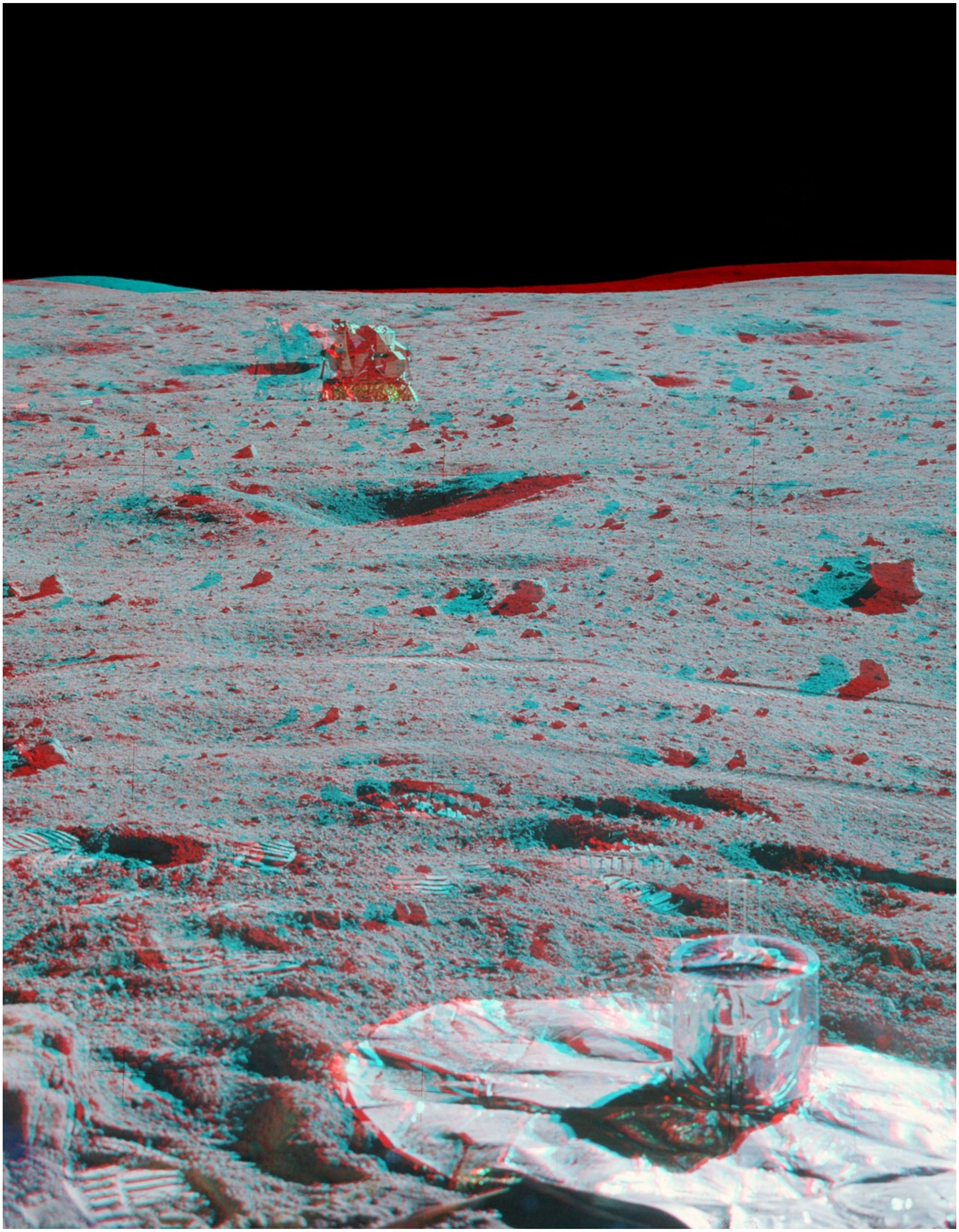


Fig. 6. An excellent view by Charlie Duke showing the undulating terrain between him and the **LM**. Also note the rover tracks and bootprints. The instrument in the foreground is the Passive Seismic Experiment (**PSE**). (From NASA photos AS16-113-18359, and -60).

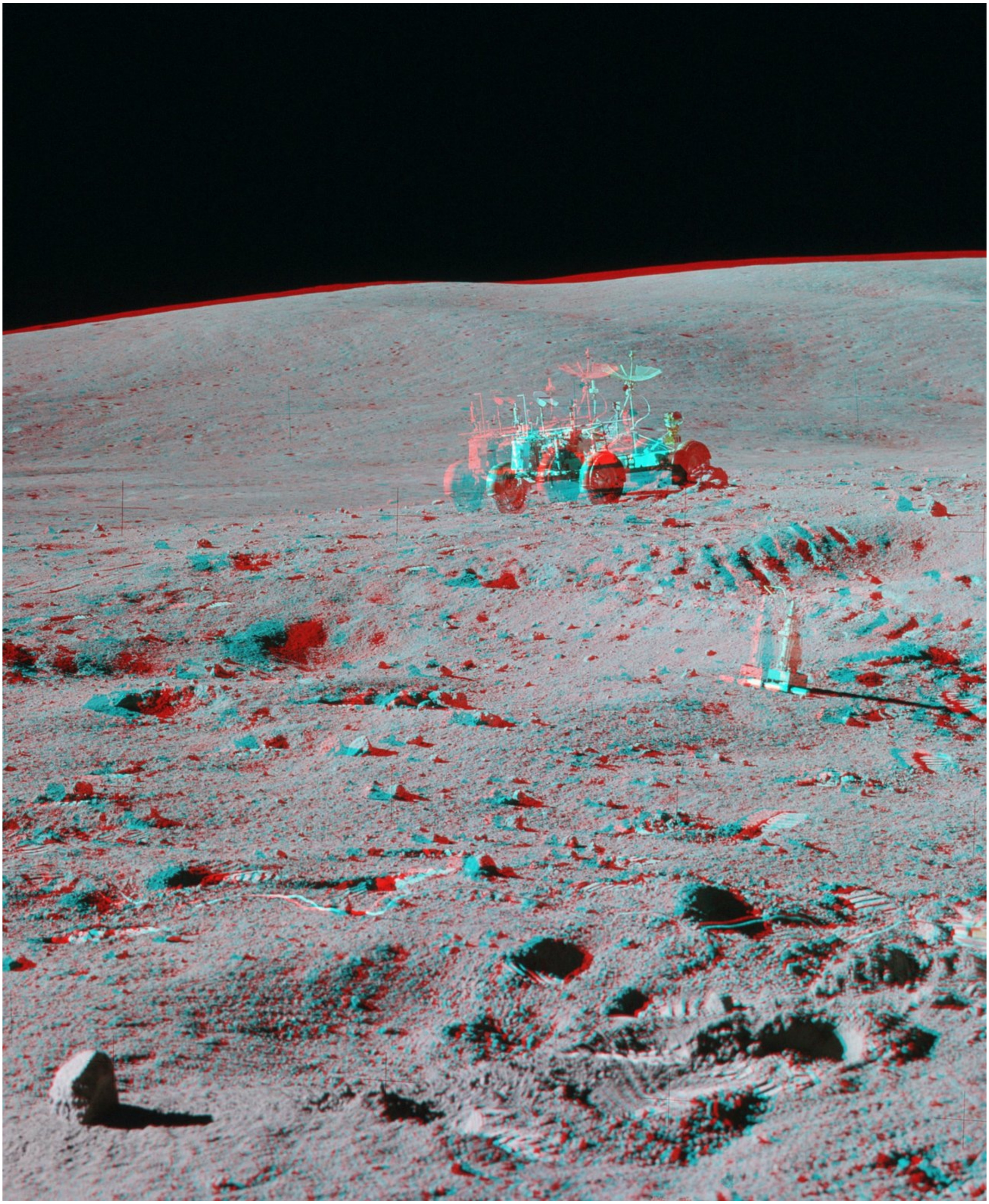


Fig. 7. The rover parked at the **ALSEP** site. At right is the lunar electric drill used with core tubes to bore into the regolith to remove core samples. (From NASA photos AS16-113-18365, and -66).

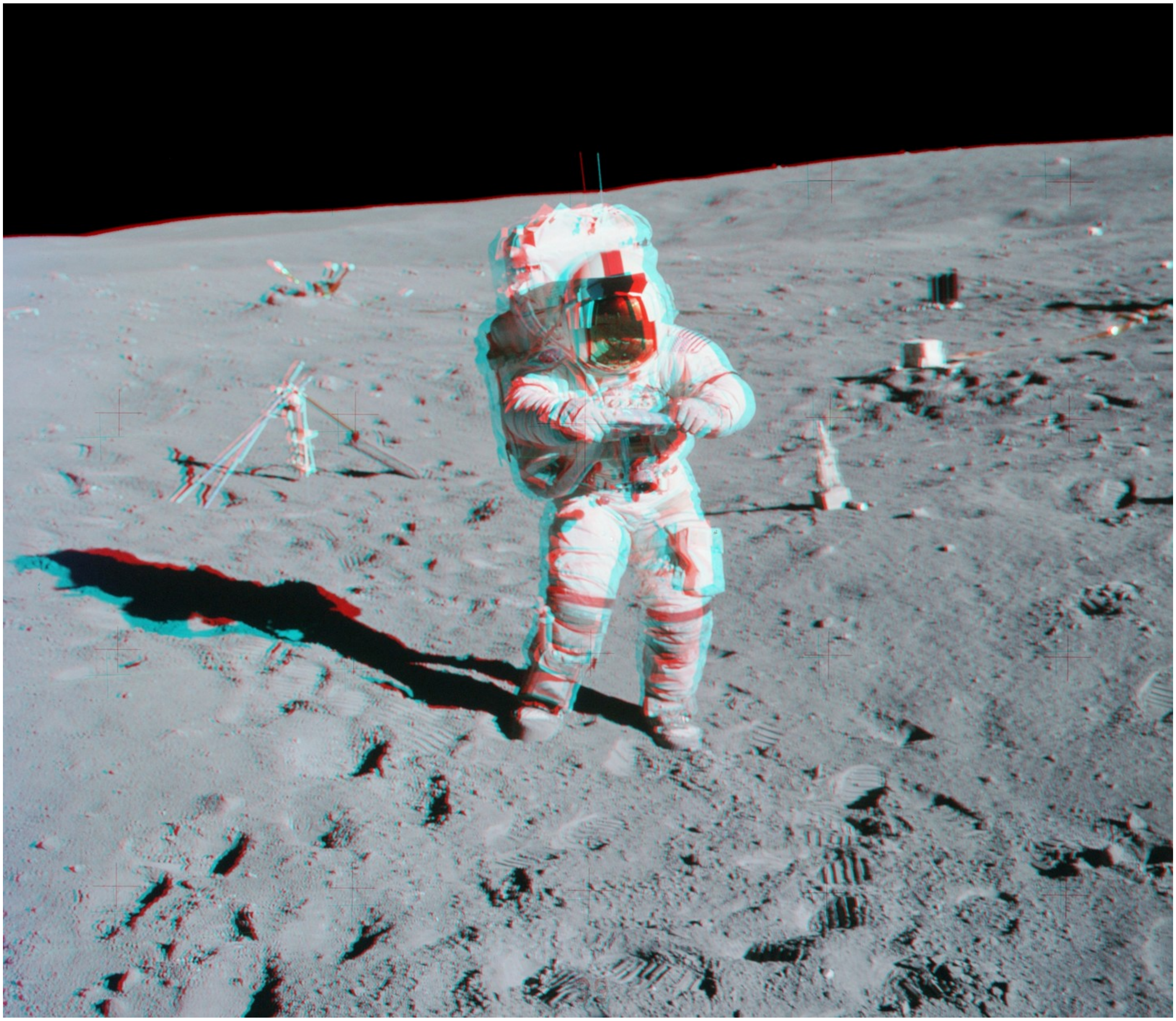


Fig. 8. A reverse view from the previous **Fig. 7**. John Young is walking back to the Rover. He is fixing a rock sample in a sample bag. The battery-powered lunar drill is at right. Some of the core tubes can be seen stacked on a holder at left. The Heat Flow Experiment (**HFE**) is the white box above the lunar drill. Note the red stripes on Young's helmet, arms and legs. These were used from Apollo 14 onwards to distinguish the mission commander (**CDR**) from the lunar module pilot (**LMP**). (From NASA photos AS16-114-18387, and -88).

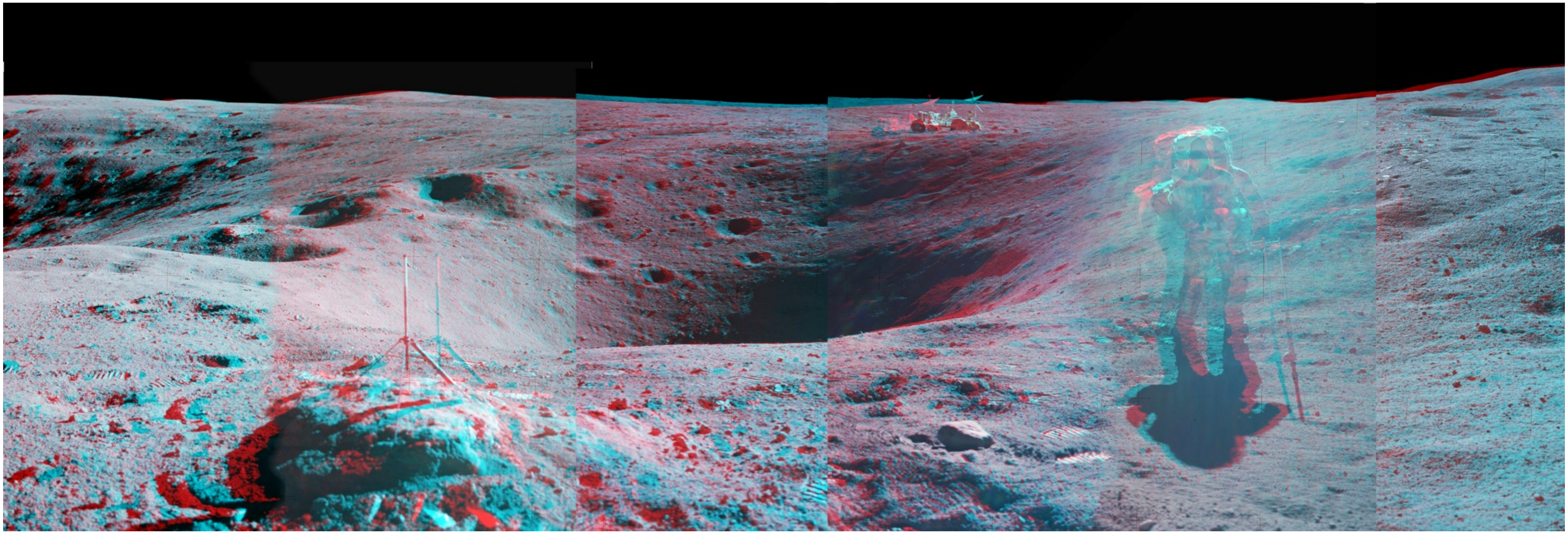


Fig. 9. The first Rover stop on EVA 1 was at Flag and Plum Craters. A portion of Flag Crater can be seen at left. The small, deep crater in the center is Plum Crater. This Station 1 stop is marked on the photo in Fig. 1 by the white circle which has been placed on top of Plum Crater. This view is a composite of six anaglyph panels made from seven photos in John Young's pan. Charlie Duke is watching as Young is taking the photos. The direction of the sun is immediately behind Duke as is evident from his shadow. (From NASA photos AS16-114-18419, -20, -21, -22, -23, -24, and -25).

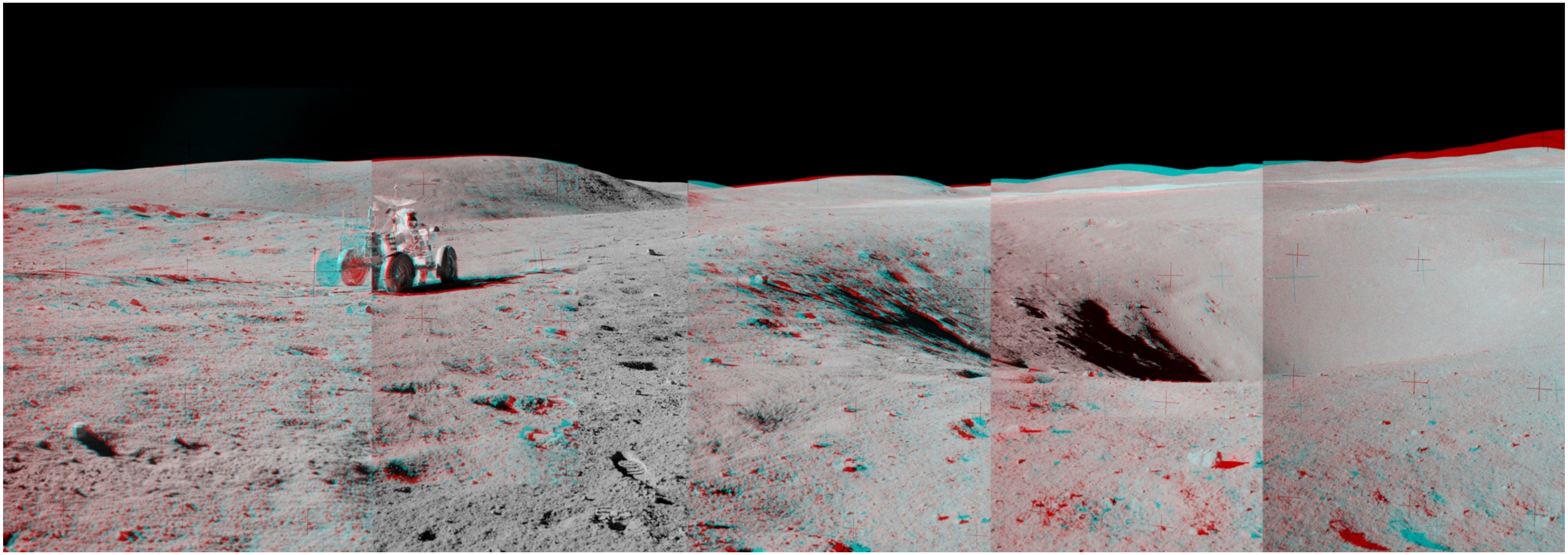


Fig. 10. A reverse view from the direction of **Fig. 9**. The boulder on which the gnomon was placed in **Fig. 9** can be seen here in the rightmost panel on the far side of Plum Crater. The long white area above Plum Crater in the distance is the ejecta blanket of South Ray Crater. Since there was a small gap in the anaglyph panels left of center from Charlie Duke's pan, a regular photo panel was inserted making this a hybrid anaglyph. (From NASA photos AS16-109-17787, -88, -89, -90, -91, and -92).

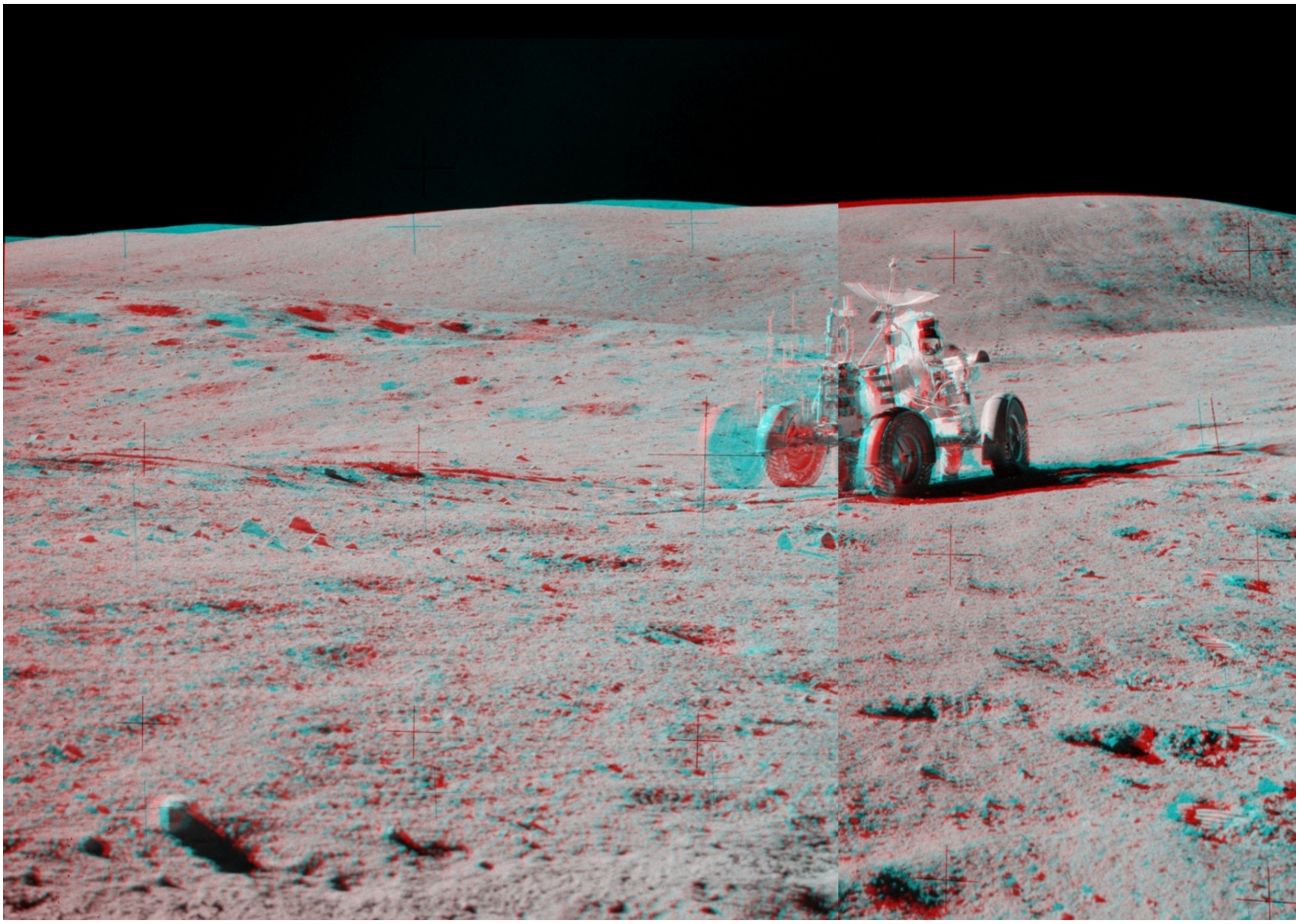


Fig. 11. An enlarged view from **Fig. 10** showing John Young at the front of the Rover. (From NASA photos AS16-109-17787, -88, and -89).

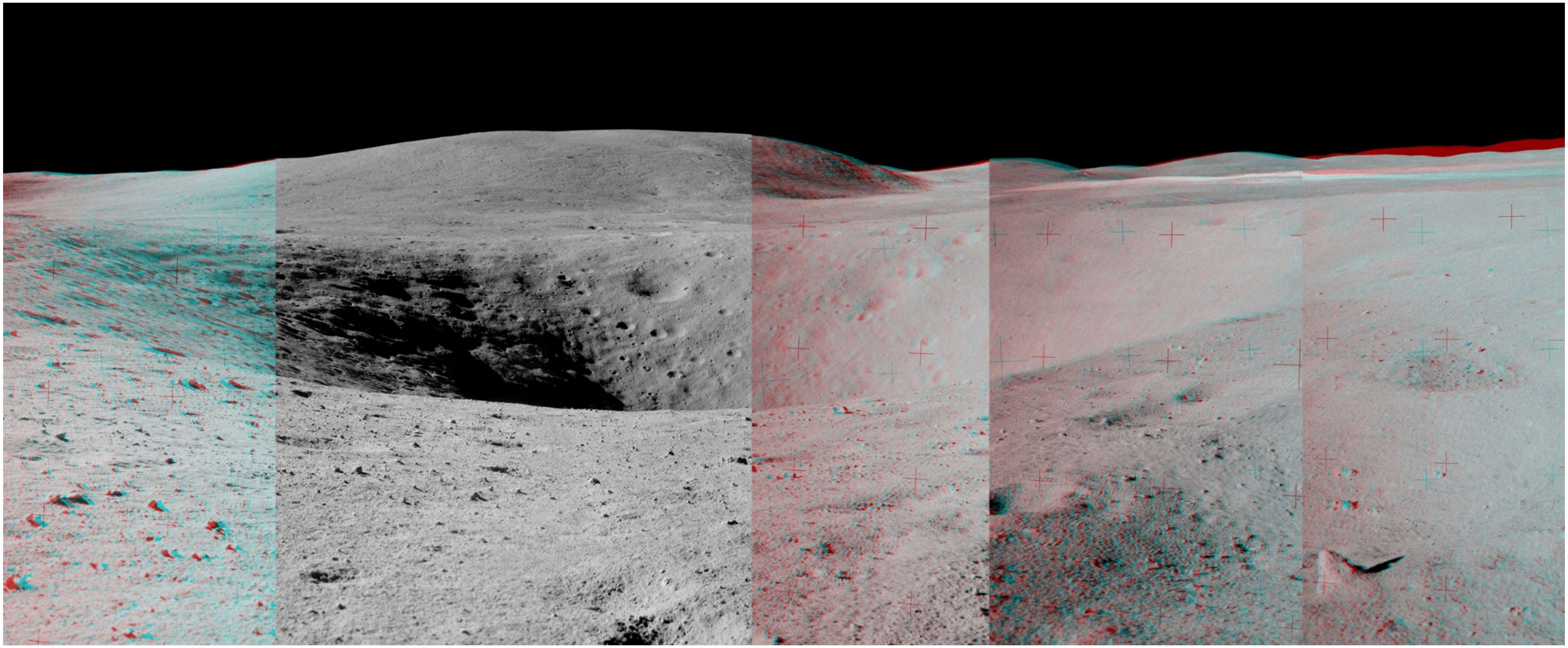


Fig. 12. The astronauts stopped at **Station 2**, Spook Crater, on the way back to the **LM**. South Ray Crater is evident by the white debris blanket in the distance at right. Stone Mountain is at center-left. A somewhat larger gap in overlapping anaglyph panels resulted from the overlaps in the original pan that Charlie Duke made. However, the addition of a regular panel left of center gives this hybrid anaglyph a good sense of overall depth. (From NASA photos AS16-109-17821, -22, -23, -24, -25, and -26, inclusively).

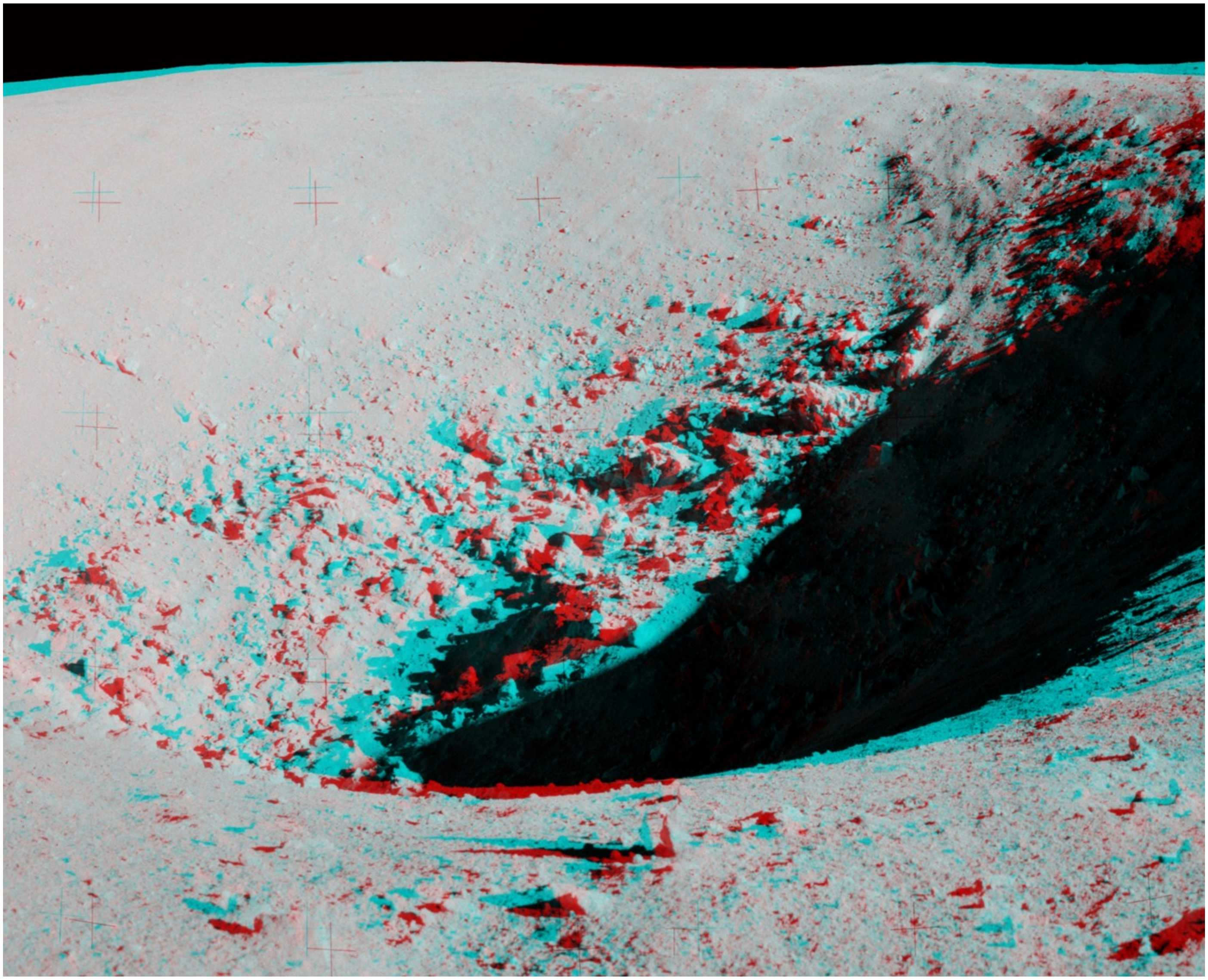


Fig. 13. While at **Station 2**, the astronauts also visited Buster Crater which was quite close. This anaglyph combination was produced from Charlie Duke's pan. (From NASA photos AS16-109-17833, -34, -35, and -36).

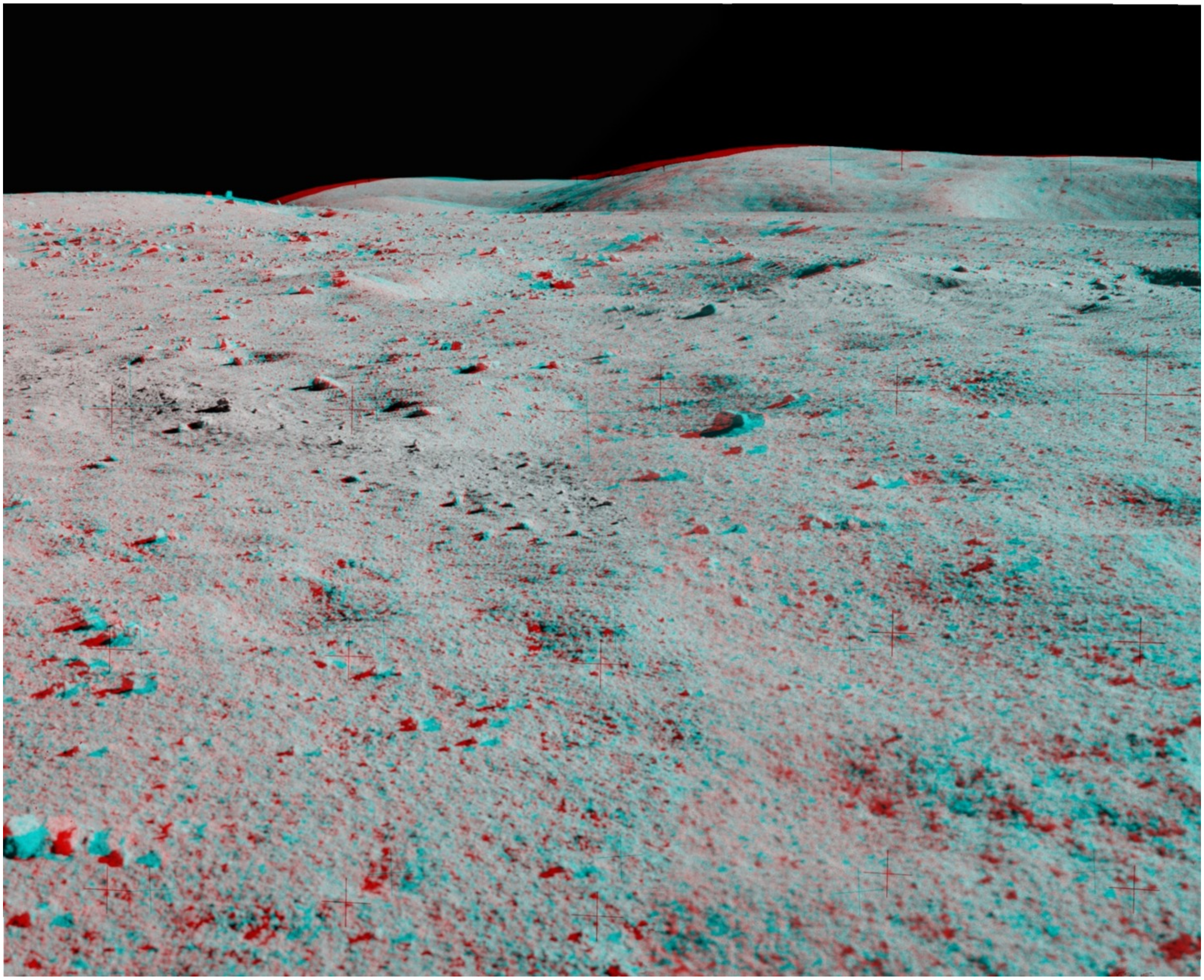


Fig. 14. This anaglyph composite is from the same pan that Charlie Duke made at **Station 2**. The view is looking north towards Smoky Mountain at upper center-right. It is a very good demonstration of the ruggedness of the lunar terrain over which the astronauts had to drive. (From NASA photos AS16-109-17815, -16, and -17).

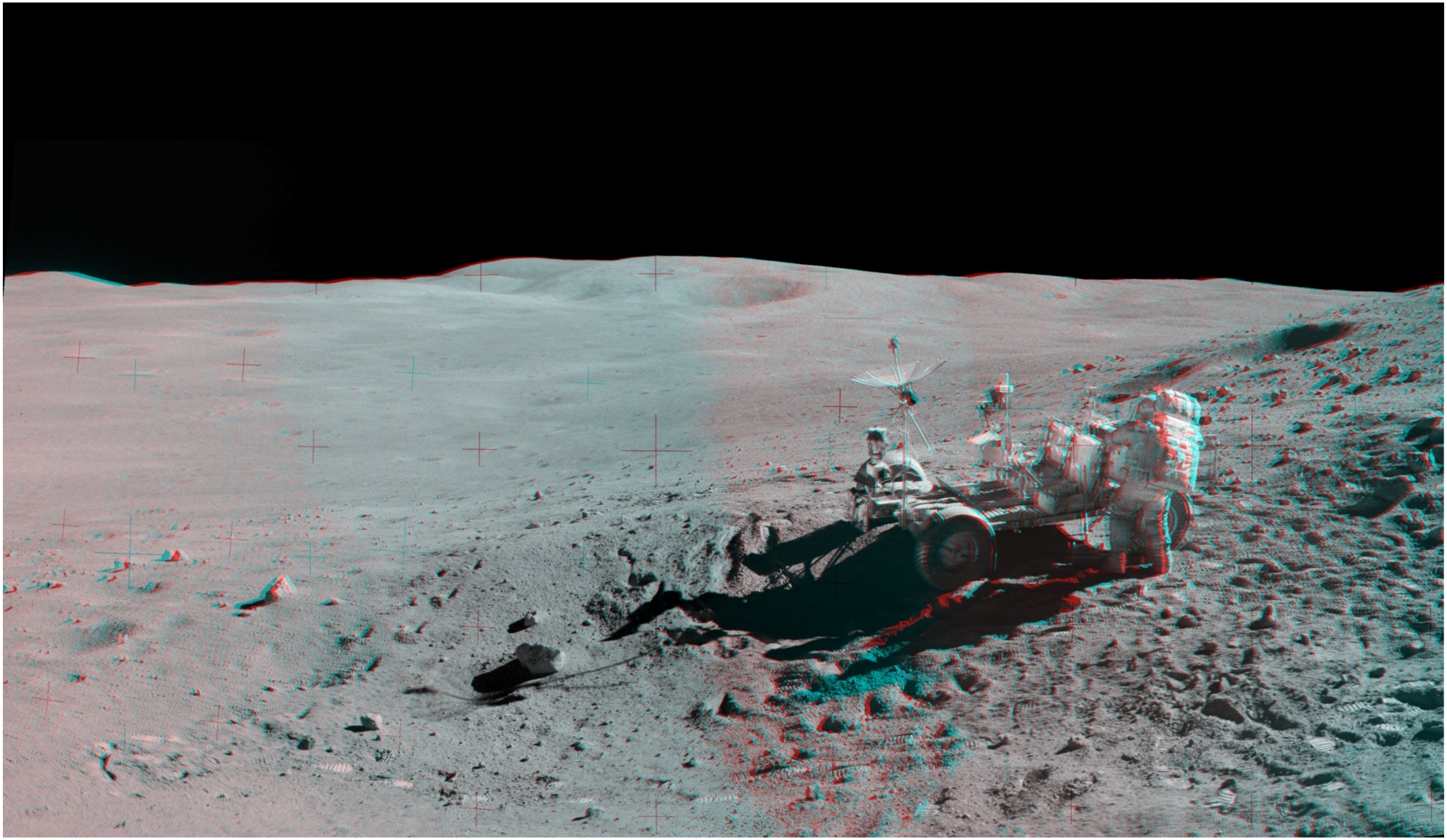


Fig. 15. Part of Charlie Duke's pan at **Station 4** showing John Young working at the back of the LRV. The stop was important because they sampled some very young ejecta material from the impact that formed South Ray crater in one of the **Cinco Craters** located here. In the distance is Smoky Mountain. In its side, Ravine Crater is the dark, wedge shaped object in the upper center of the view to the right of the fiducial cross. South Ray Crater is in the plain behind Duke's left shoulder. (From NASA photos AS16-110-17957, -58, -59, -60, and -61).

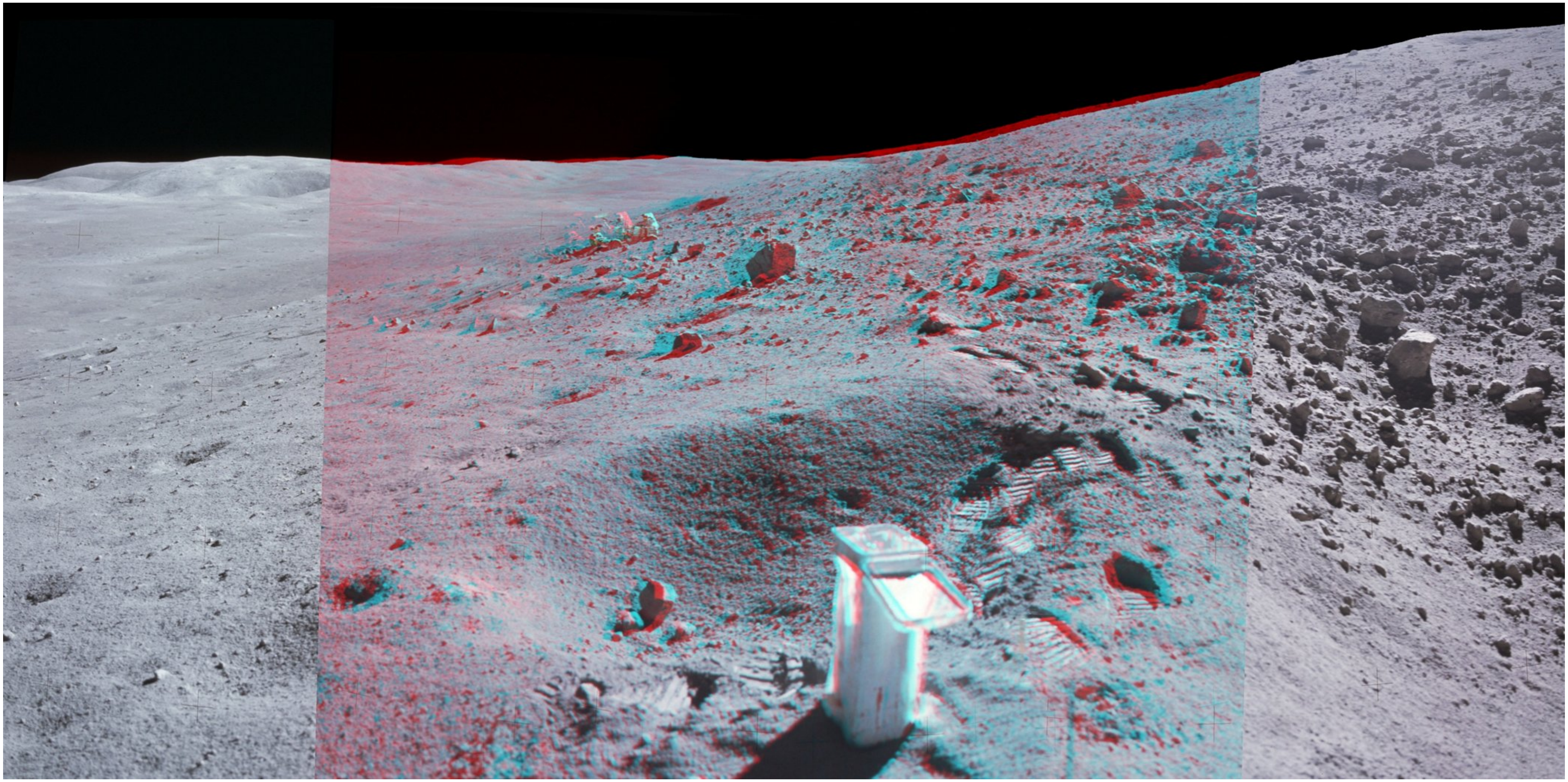


Fig. 16. A hybrid anaglyph made from part of the pan taken by John Young at **Station 4**. The Rover location at which Young was working in **Fig. 15** is seen in the distance where now Charlie Duke is at the back of the **LRV**. Young has placed a Sample Container Box (**SCB**) on the ground while he takes the pan. His footprints next to the **SCB** can be followed coming up from the **LRV**. (From NASA photos A16-107-17472, -73, -74, and -75).

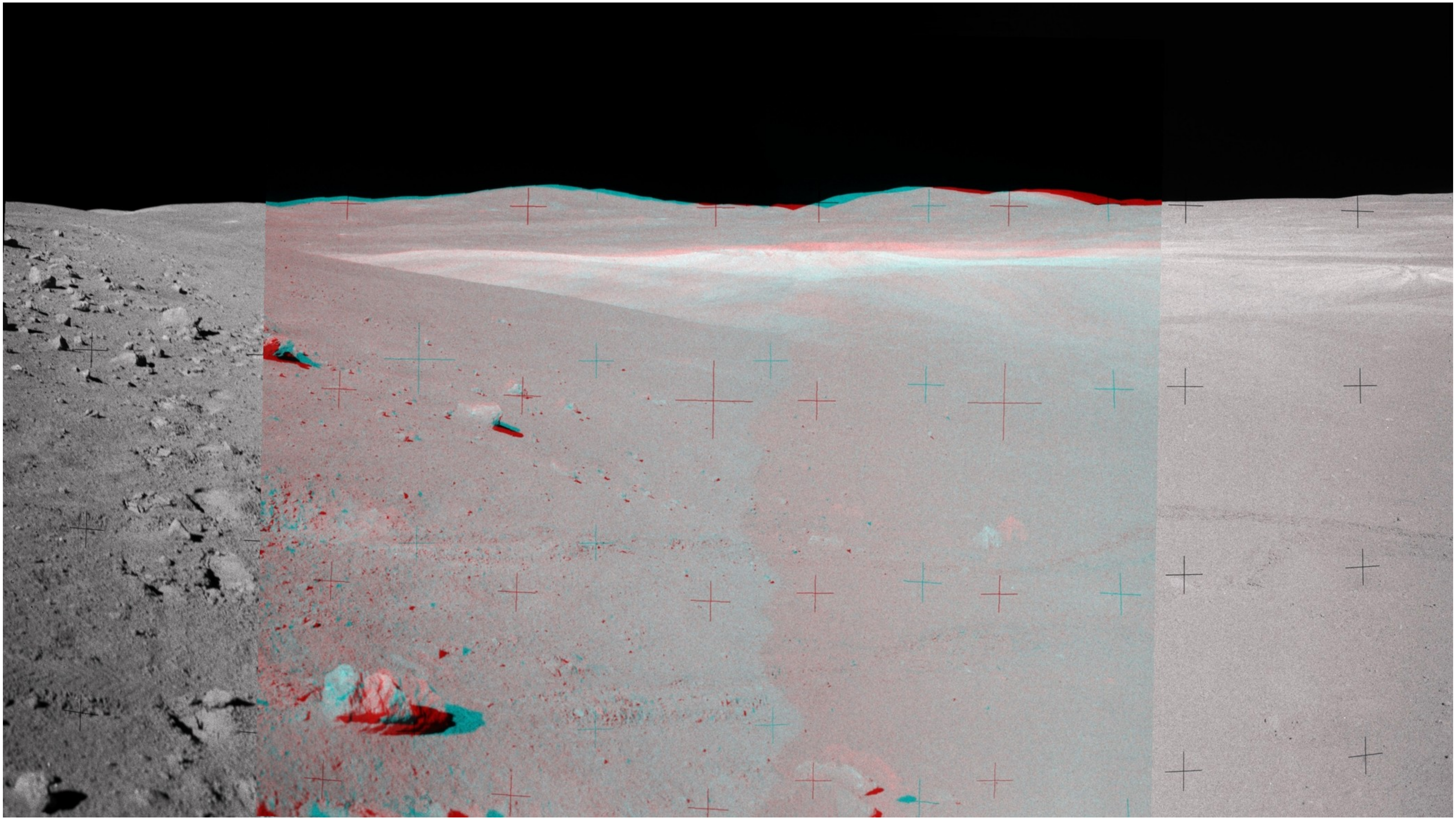


Fig. 17. A hybrid anaglyph from part of the **Station 4** pan behind Charlie Duke's left shoulder (with respect to **Fig. 15**). On the plain in the distance is South Ray Crater near the center. At far right is part of Baby Ray Crater. (From NASA photos AS16-110-17972, -73, and -74).

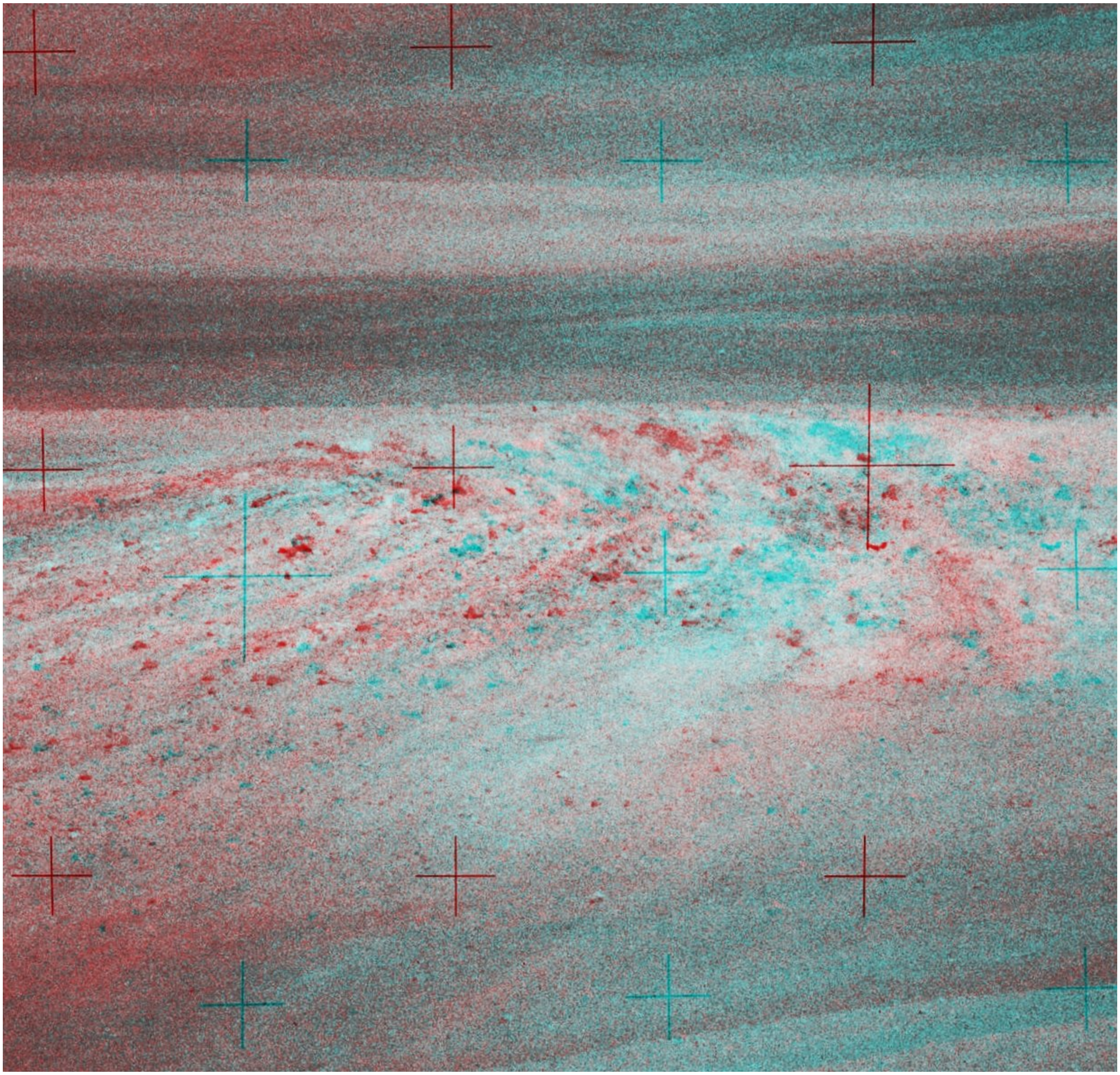


Fig. 18. Anaglyph from Charlie Duke's two 500 mm Hasselblad photos at **Station 4** of Baby Ray Crater. The regular 60 mm Hasselblad view of Baby Ray from that position is at the far right in **Fig. 17**. The white ejecta material in both Baby Ray and South Ray Craters is an indication of the short term exposure to the solar wind and micrometeorite bombardment of the fresher material brought to the surface by the impacts that formed the craters. (From NASA photos AS16-112-18253, and -54).

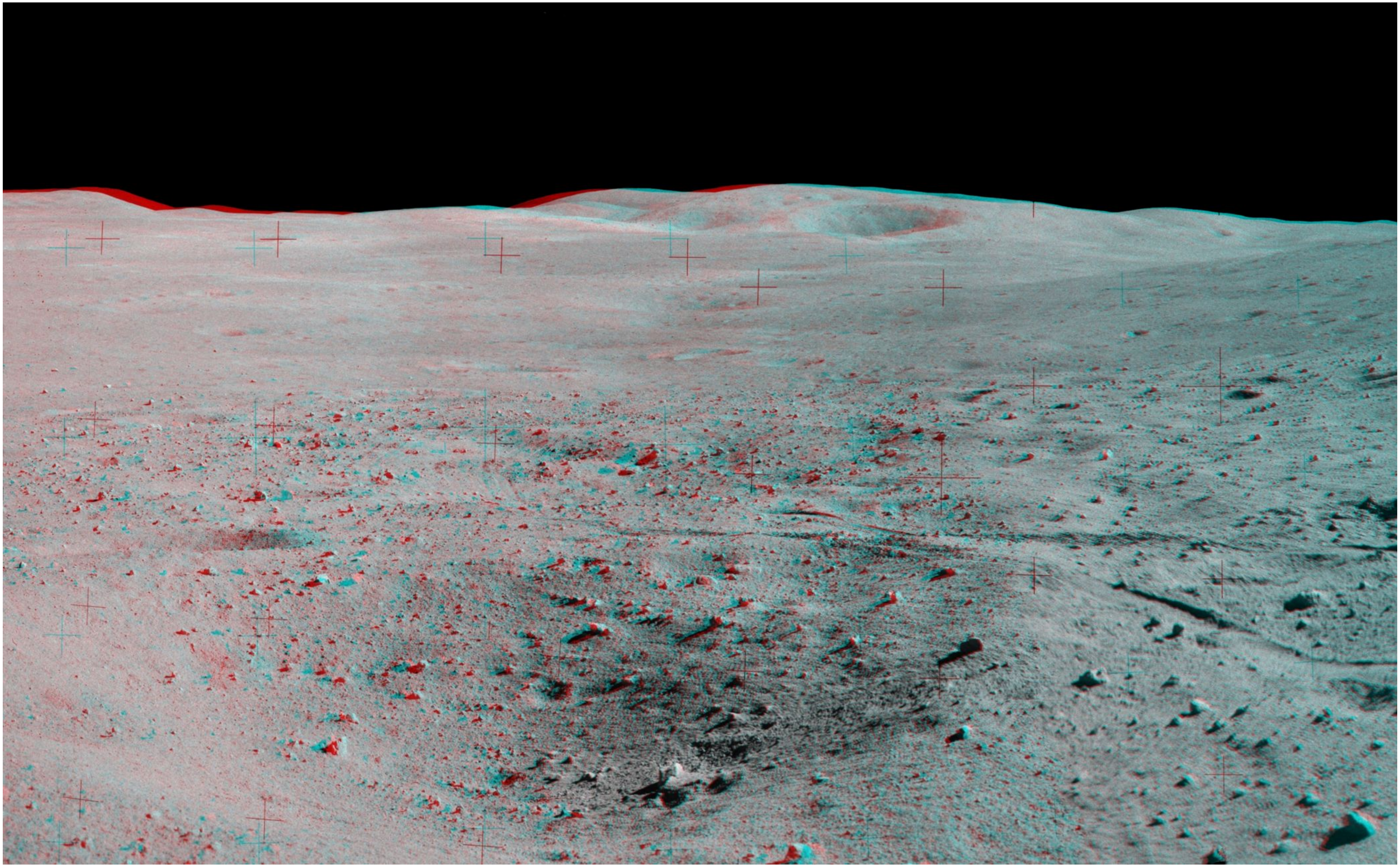


Fig. 19. Anaglyph from part of Charlie Duke's pan at **Station 5**. Smoky Mountain with Ravine Crater dominates the horizon right of center. The **LRV** tracks at right and proceeding downhill are from the outbound traverse to Station 4. (From NASA photos AS16-110-17997, -98, -99, -00, and -01).

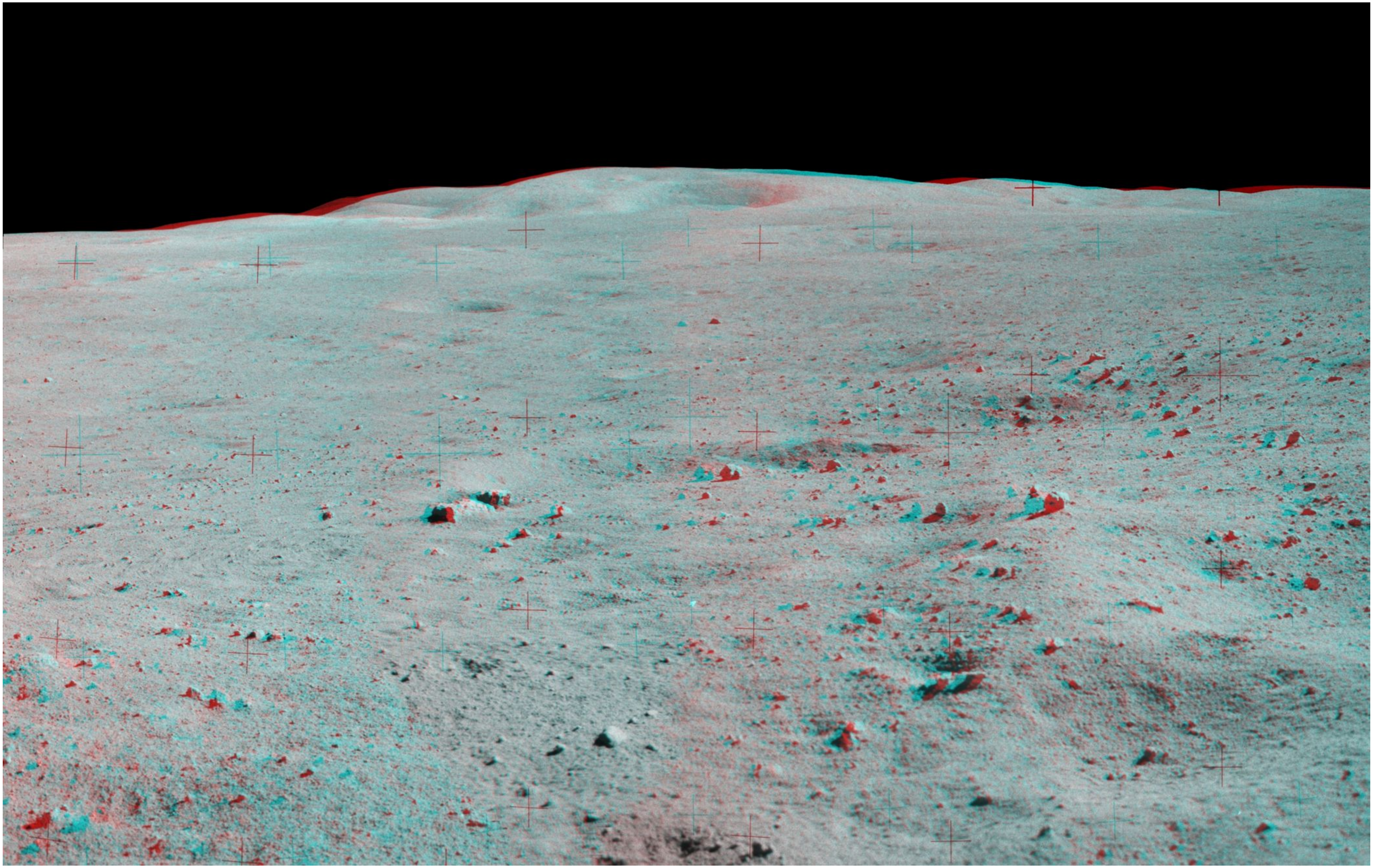


Fig. 20. Similar to **Fig. 19**, but from Charlie Duke's pan lower down at **Station 6**. (From NASA photos AS16-108-17611, -12, -13, -14, and -15).

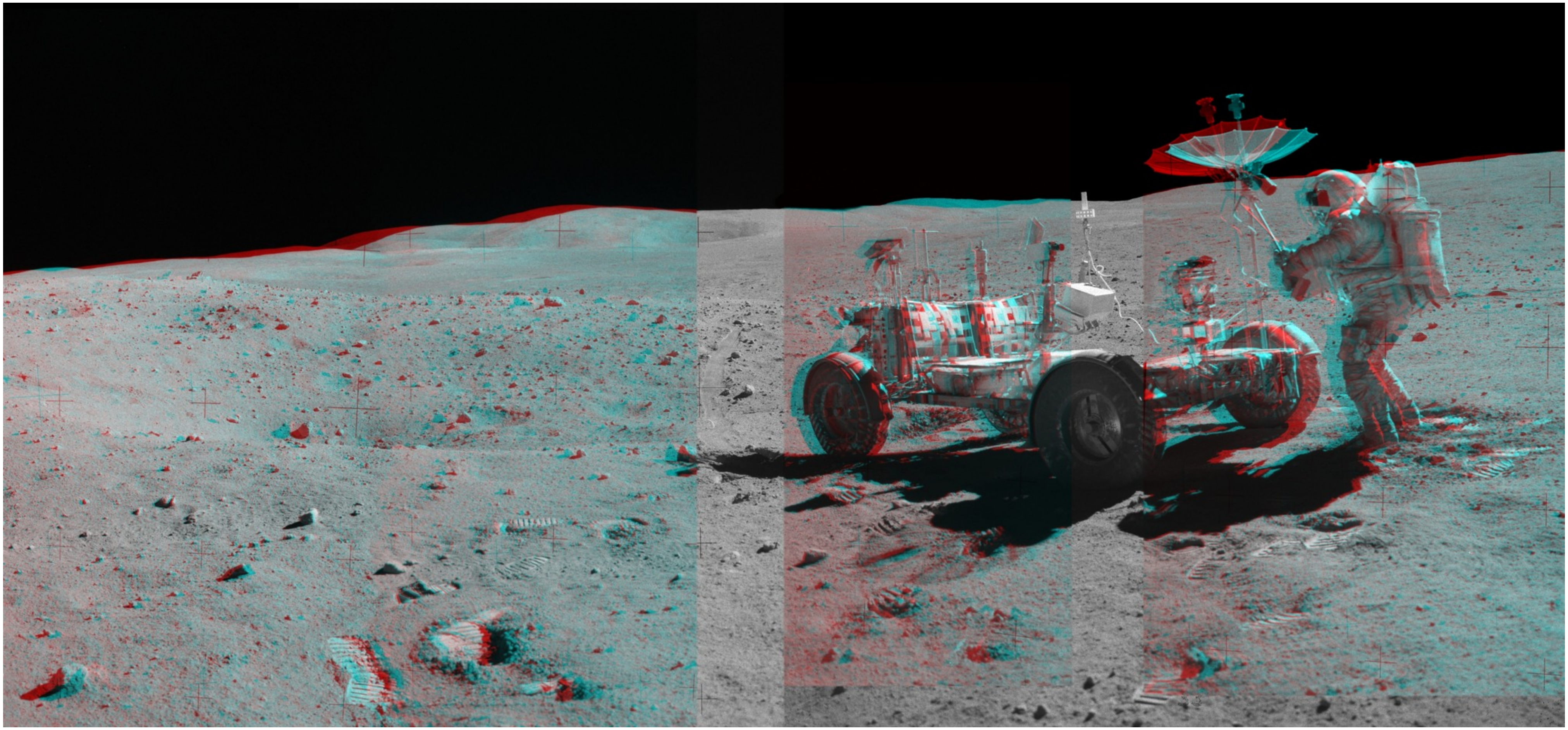


Fig. 21. A hybrid anaglyph from Charlie Duke's **Station 8** pan showing the LRV parked at the edge of a crater with John Young aligning the high gain antenna towards the Earth. Smoky Mountain and Ravine Crater are seen on the horizon at center left. (From NASA photos AS16-108-17666, -67, -68, -69, -70, and 71).

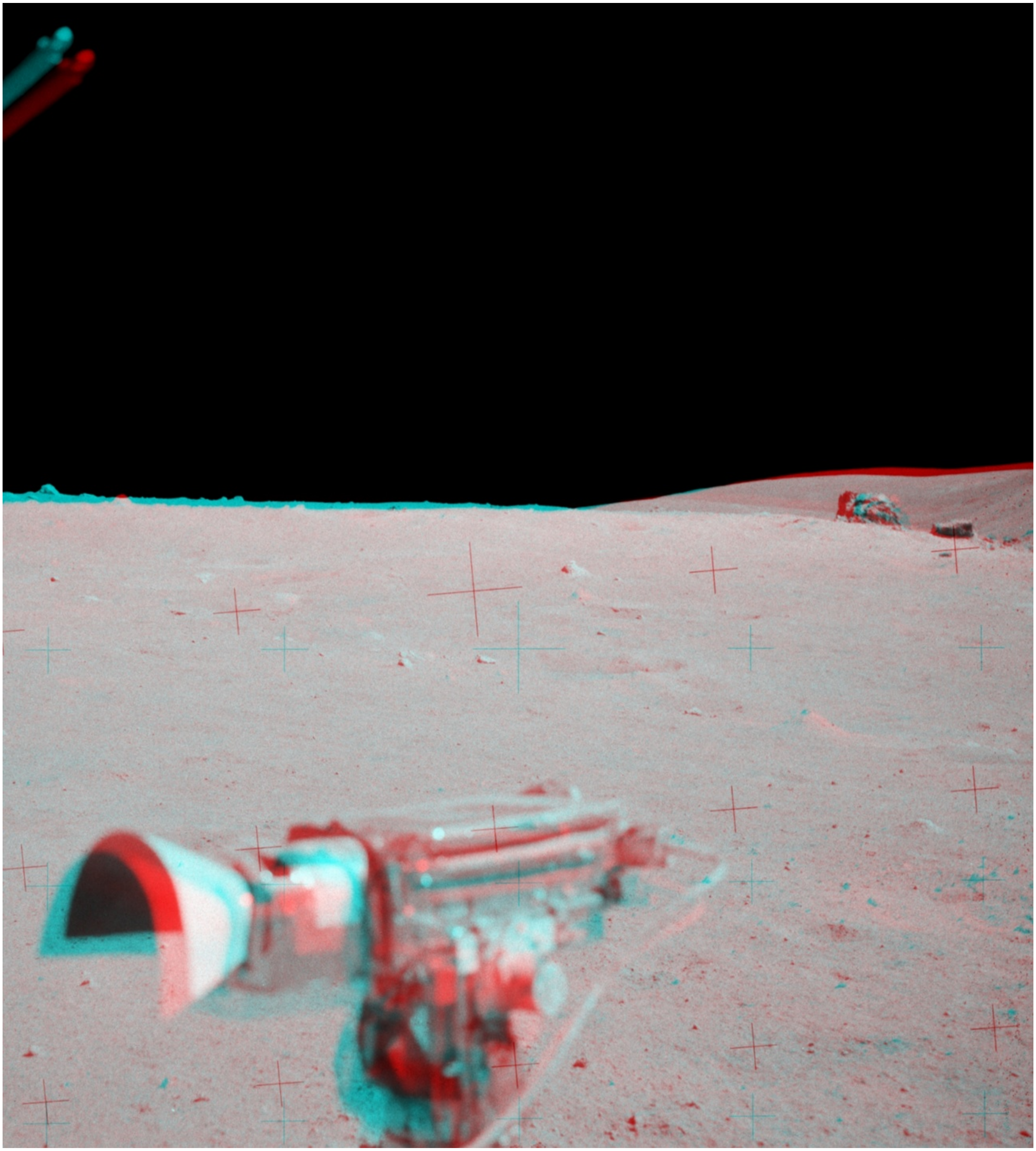


Fig. 22. On the long drive to North Ray Crater at **Station 11** during **EVA3**, Charlie Duke made many photos of the traverse by angling his body to his right (camera was attached to his chest). Generally there weren't many overlaps because the LRV moved too far between shots. But as they approached the top of the crater up a steep slope, Duke made two photos close enough together to allow this anaglyph view of House Rock (large boulder at right) to be made. The TV camera is out of focus— the Hasselblad camera setting was for a greater distance. (From NASA photos AS16-111-18178, and -79).

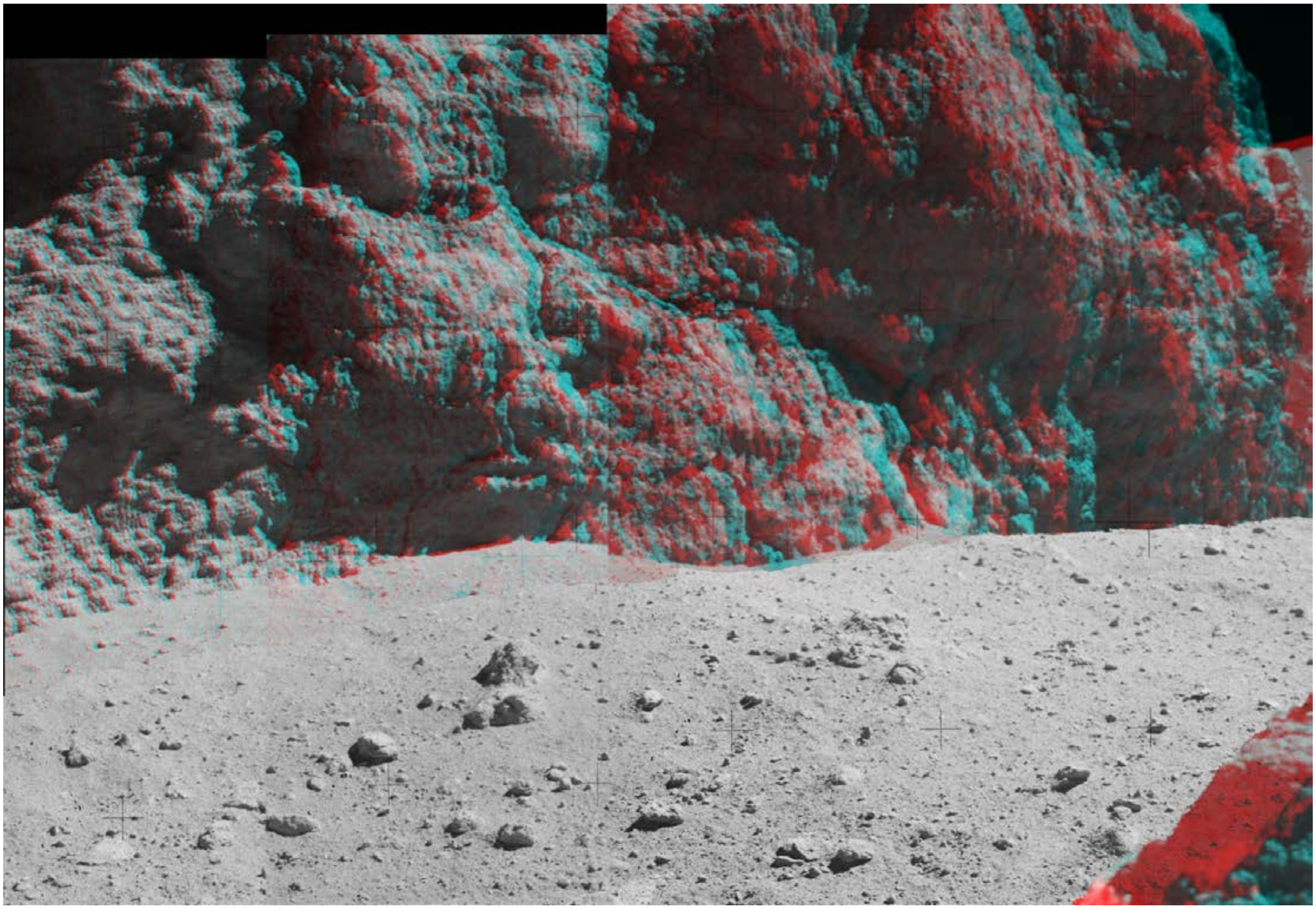


Fig. 23. A hybrid anaglyph of the base of House Rock at **Station 11** composited from 4 photos made by Charlie Duke. The original photos provided the gap between House rock and the small boulder at right. (From NASA photos AS16-106-17341, -42, -43, and -44).

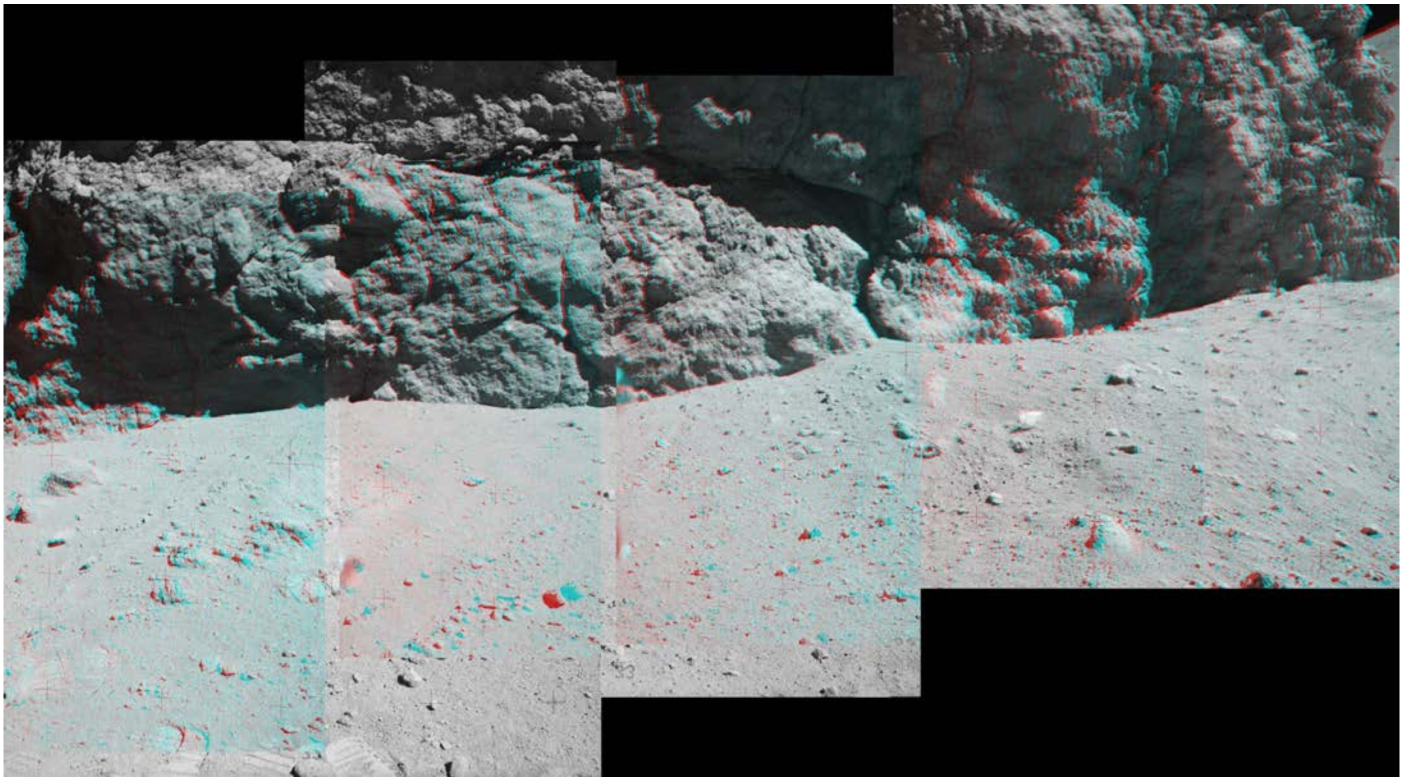


Fig. 24. Charlie Duke made a second series of so-called “flightline” photos of the base of House Rock. The above is a hybrid composite of the anaglyph panels. Two very thin gaps at left were filled in with the original photos. (From NASA photos AS16-106-17349, -50, -51, -52, -53, and -54).

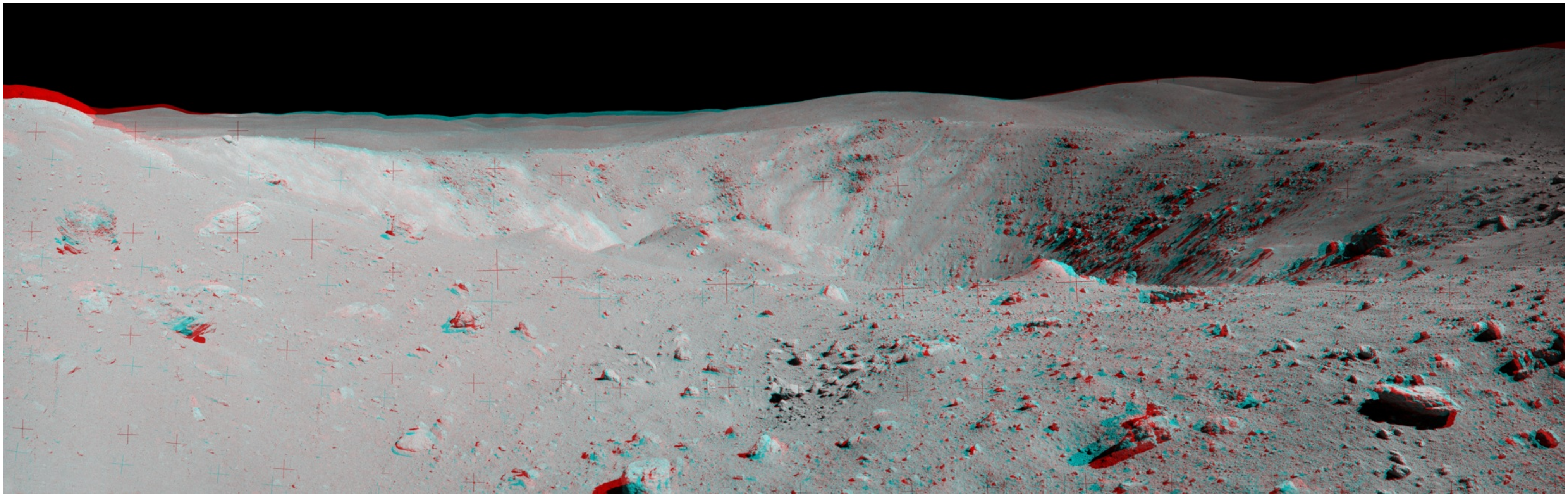


Fig. 25. While at North Ray Crater, **Station 11**, Charlie Duke made a series of six panoramas of the crater using a polarizing filter set at different orientations. The anaglyph presented here is from the first position where he made three panoramas. The above was composed from panels of the second and third pans. House Rock is at right out of the frame. (From NASA photos— 2nd pan: AS16-106-17249 to 17262; 3rd pan: AS16-106-17263 to 17276).

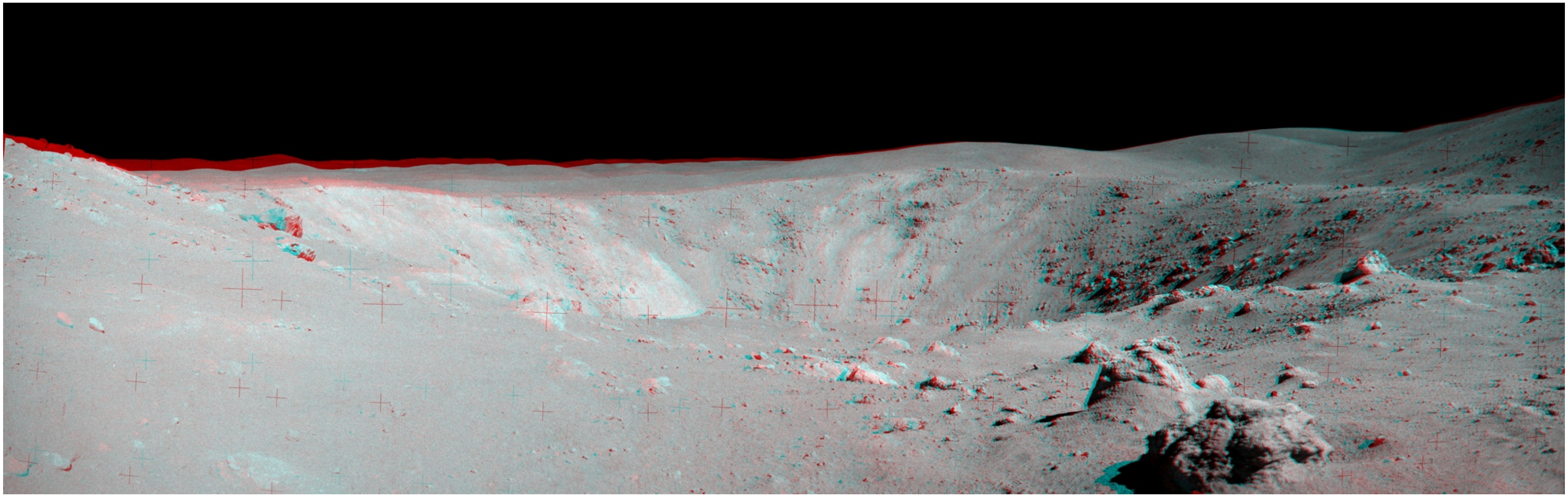


Fig. 26. Charlie Duke has moved ca. 80 m counterclockwise along the rim from the position in [Fig. 25](#). The above anaglyph is composited from panels taken from the fifth and sixth panoramas. (From NASA photos─ 5th pan: AS16-106-17290 to 17303; 6th pan: AS16-106-17304 to 17317).

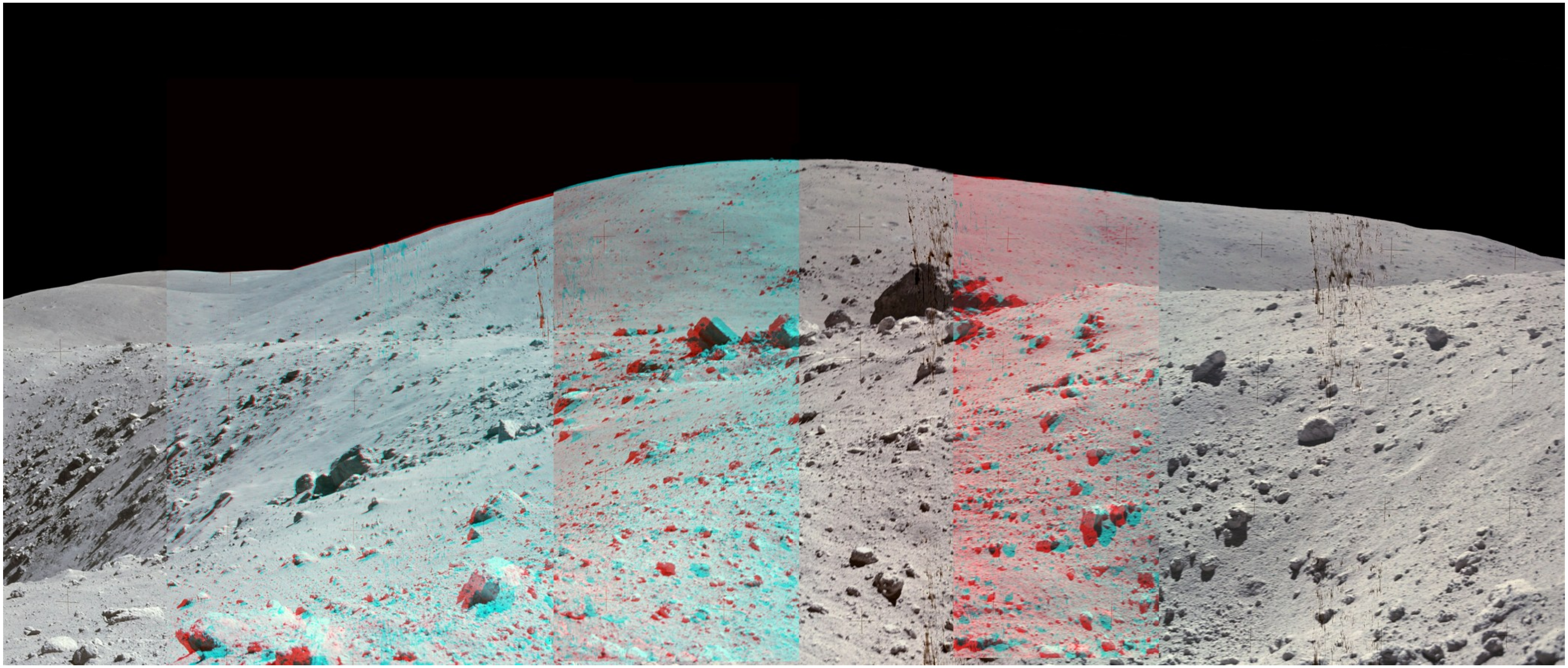


Fig. 27. A hybrid anaglyph composed from parts of John Young's pan at **Station 11**. The view is approximately at right angles to the right of **Fig. 26** showing the east slope of North Ray Crater and House Rock up on the rim. Smoky Mountain is in the background. Unfortunately, there are streak marks on all the frames of this pan which seem to have been deposited sometime after development of the film. (From NASA photos AS16-116-18601 through -604, inclusive).

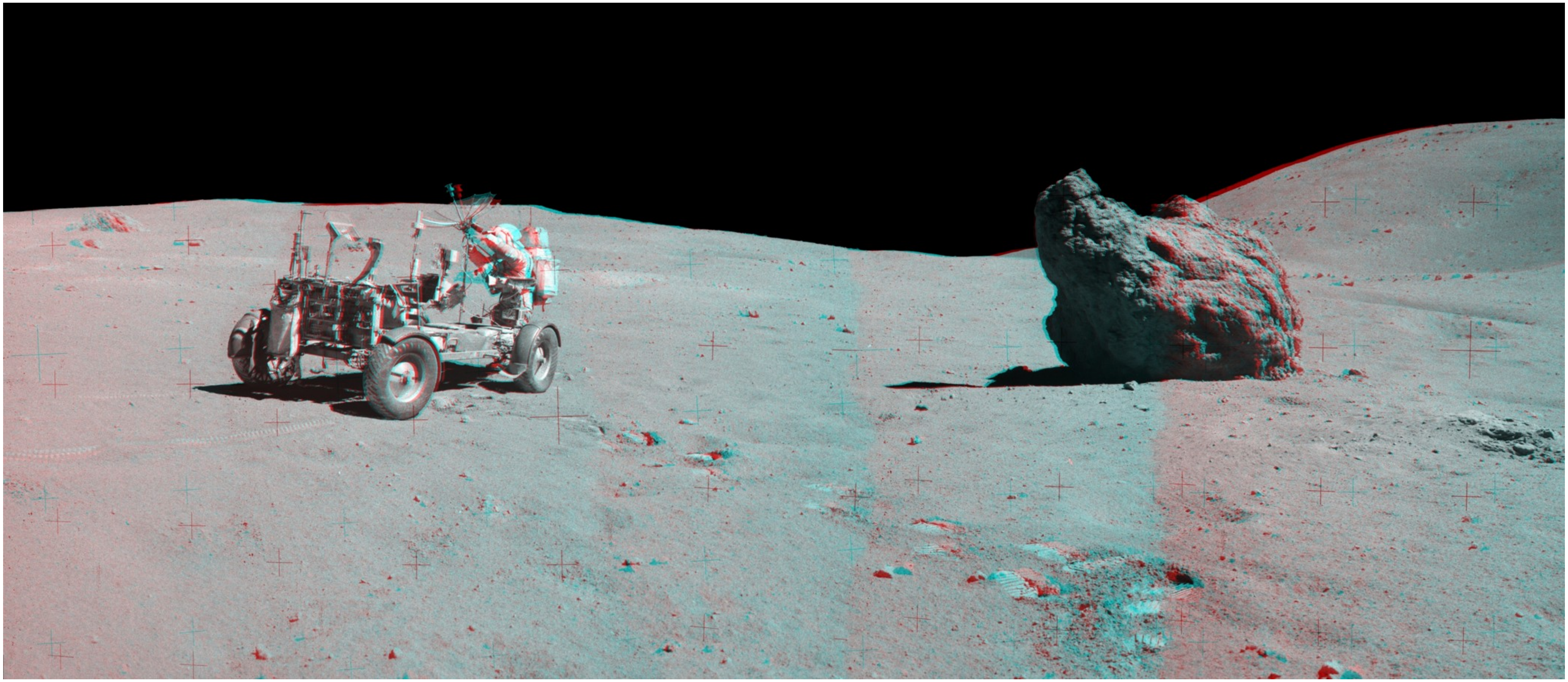


Fig. 28. Part of Charlie Duke's pan at Shadow Rock, **Station 13**, as a complete anaglyph. John Young is aligning the high gain antenna towards the Earth. Shadow Rock's name resulted from the manner in which the overhang at left caused shadowing of the surface. Jack Schmitt had encouraged all the astronauts to obtain soil samples from permanently shadowed areas near boulders in order to assess their cold-trapped volatile content. In this case, Charlie Duke was able to obtain a sample from a cavity at the base of the rock in which he could insert his entire arm. (From NASA photos AS16-106-17389, -90, -91, -92, -93, and -94).

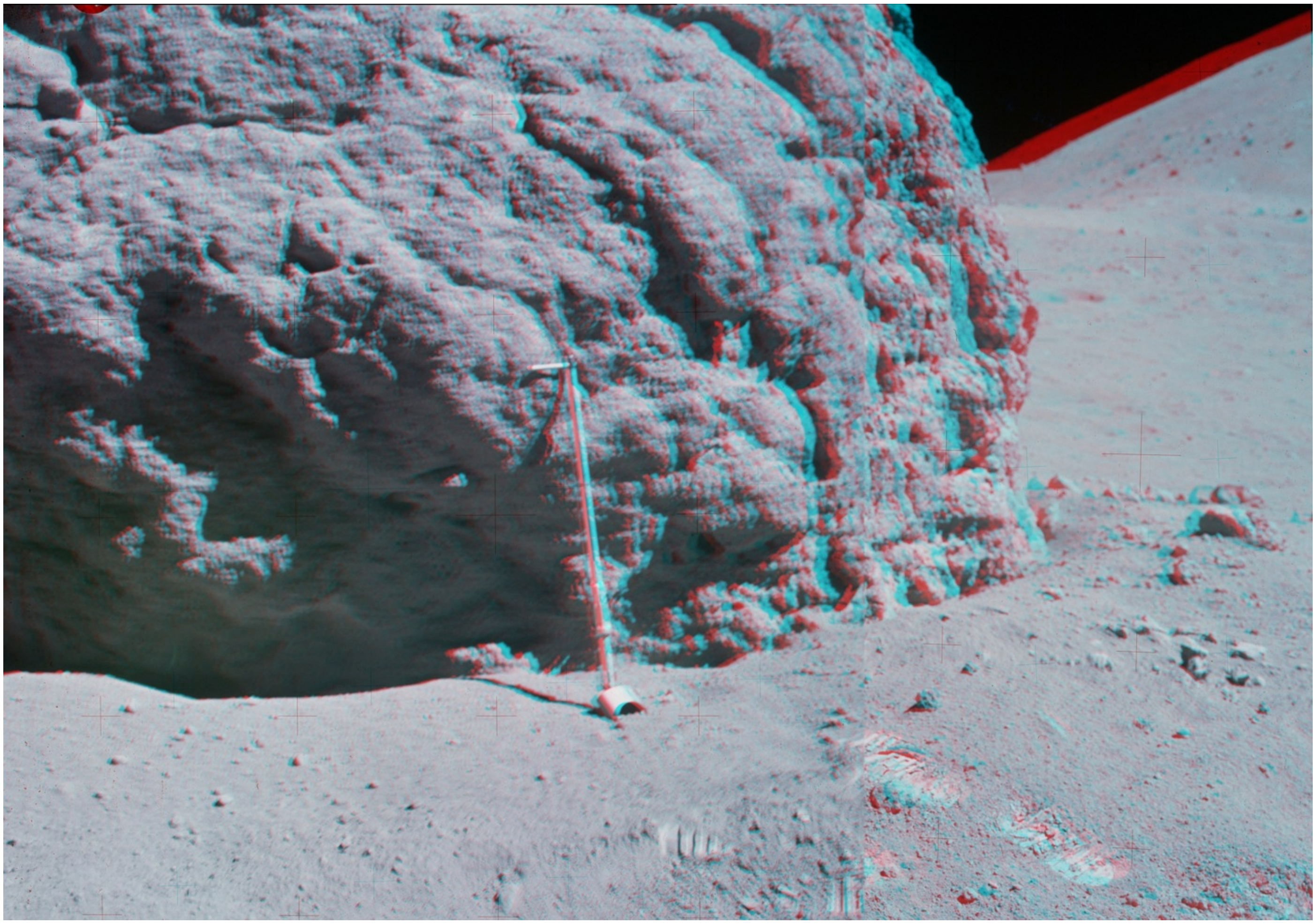


Fig. 29. Anaglyph of the rounded end of Shadow Rock from a “flightline” pan taken by Charlie Duke. He has leaned a sample scoop against the rock. (From NASA photos AS16-117-18727, -28, -29, and -30).

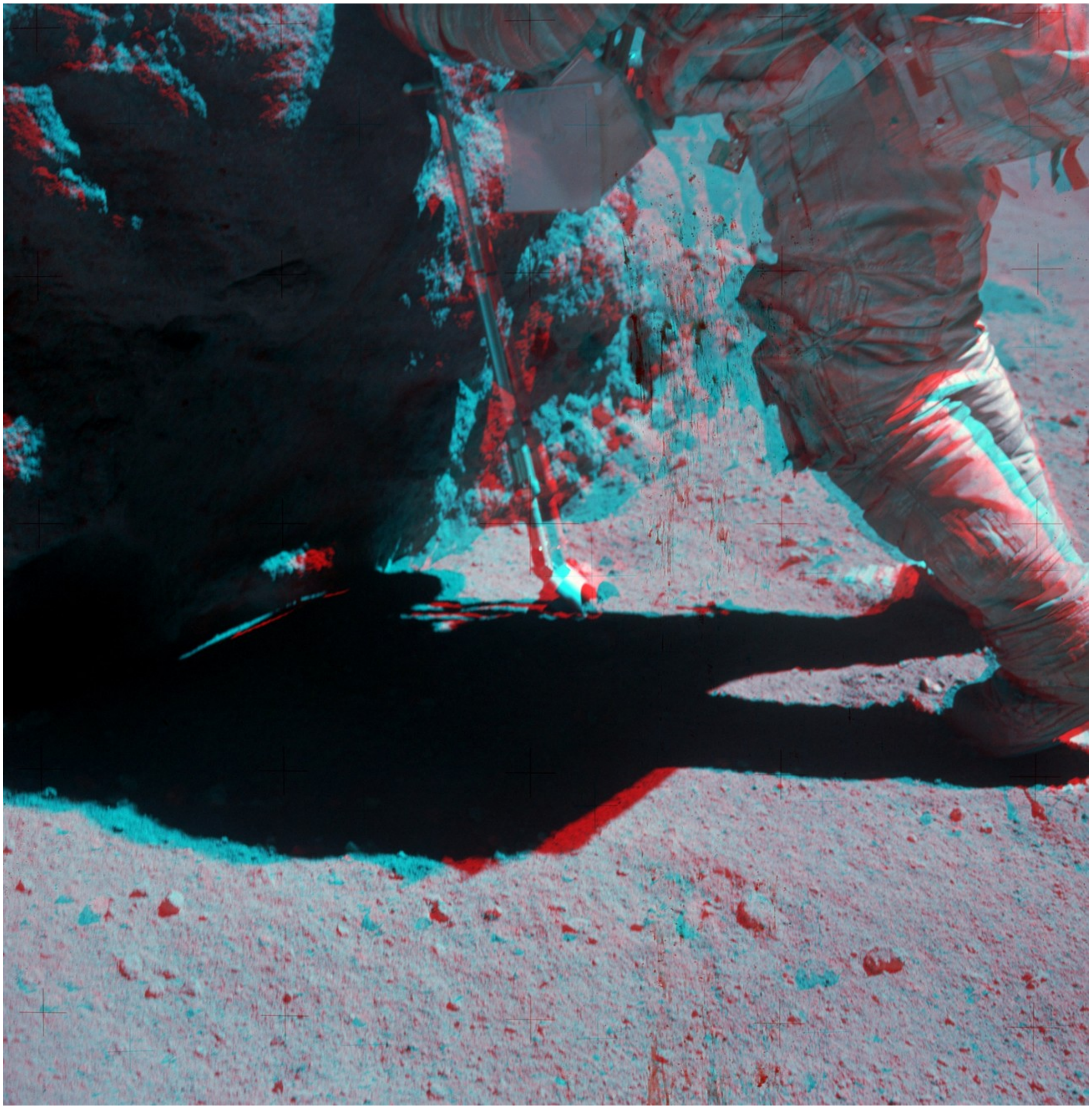
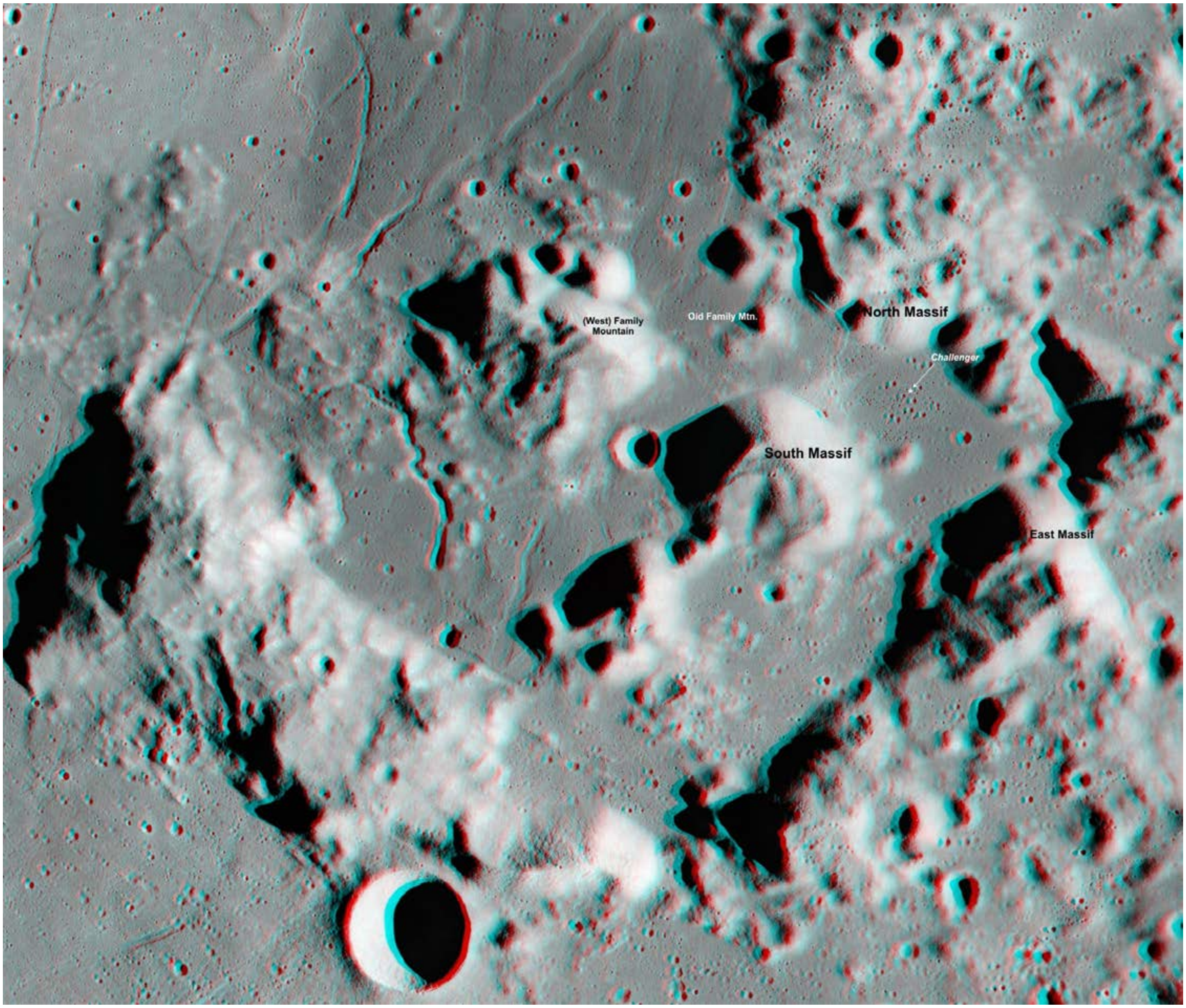


Fig. 30. Charlie Duke is examining the rock face of Shadow Rock as John Young takes a pair of photos of him, stepping to the side for the second one. After this stop, the astronauts headed back down the slope on the long journey back to the **LM**. (From NASA photos AS16-116-18670, and -71).



APOLLO 17

Challenger*, the Final Landing in the Valley of *Taurus-Littrow

December 11, 1972

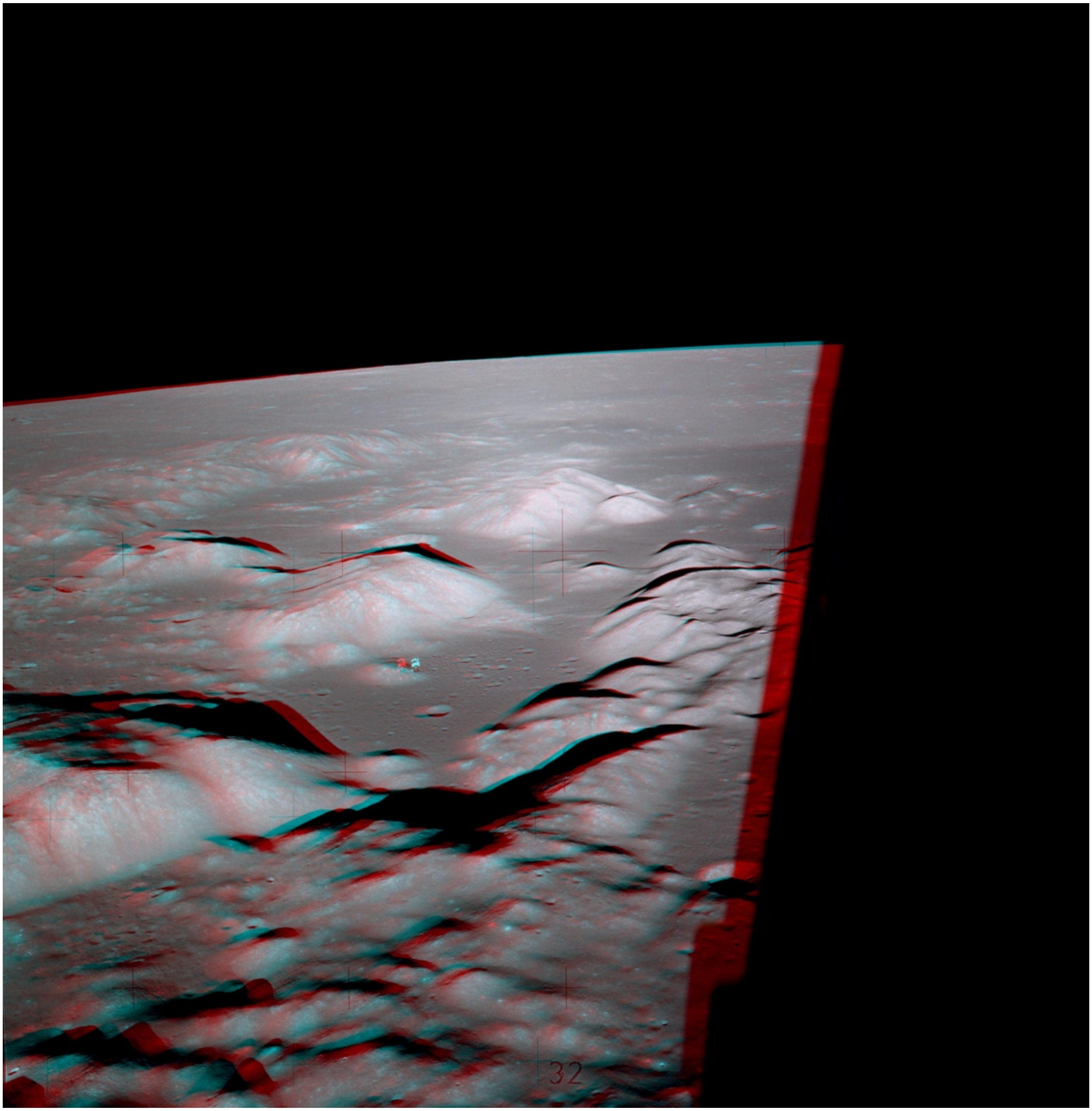


Fig. 1. On the final orbit of the **LM** ***Challenger*** at an altitude of ca. 12 km prior to initiation of powered descent to their landing site, Gene Cernan made four photos of the view directly from his window as they approached the valley. These have been used to provide the anaglyphs in this and the next figure. Directly ahead and below, the Command & Service Module (**CSM**) ***America*** can be seen in an apparent relative position above a small hill in the valley called Bear Mountain by Jack Schmitt. Beyond it is a large mountain known as the South Massif; and a landslide of white material can be seen coming from it about halfway across the valley entrance. (From NASA photos AS17-147-22464, and -65).

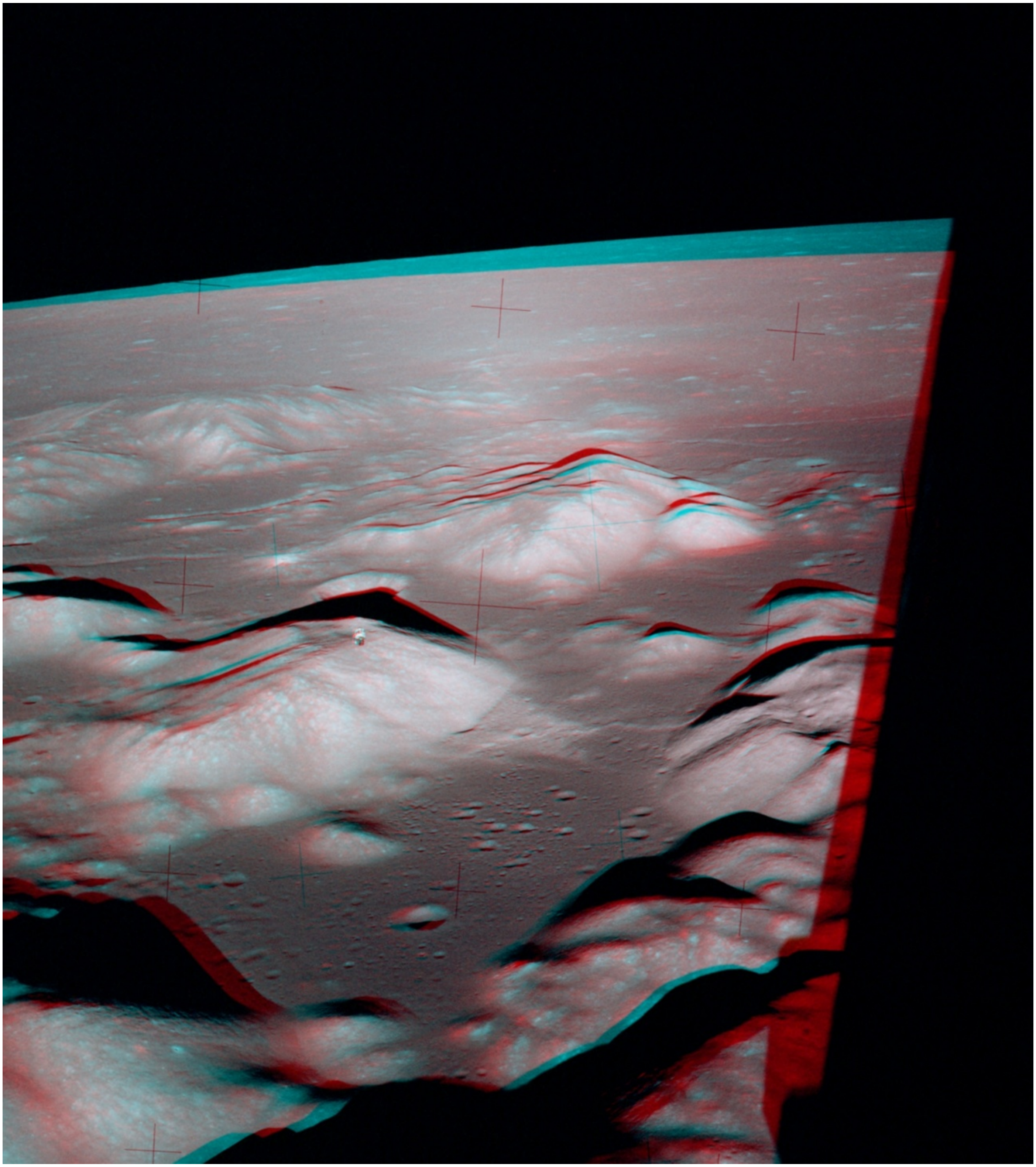


Fig. 2. Moments later, the **CSM** has apparently moved above the South Massif. Here the craters on the floor of the valley are plainer to see. Across the valley at the foot of the North Massif at right is a triplet of three moderately large craters named Henry, Shakespeare, and Cochise (top to bottom, respectively). The landing site is left of Henry in the middle of the valley. (From NASA photos AS17-147-22466, and -67).

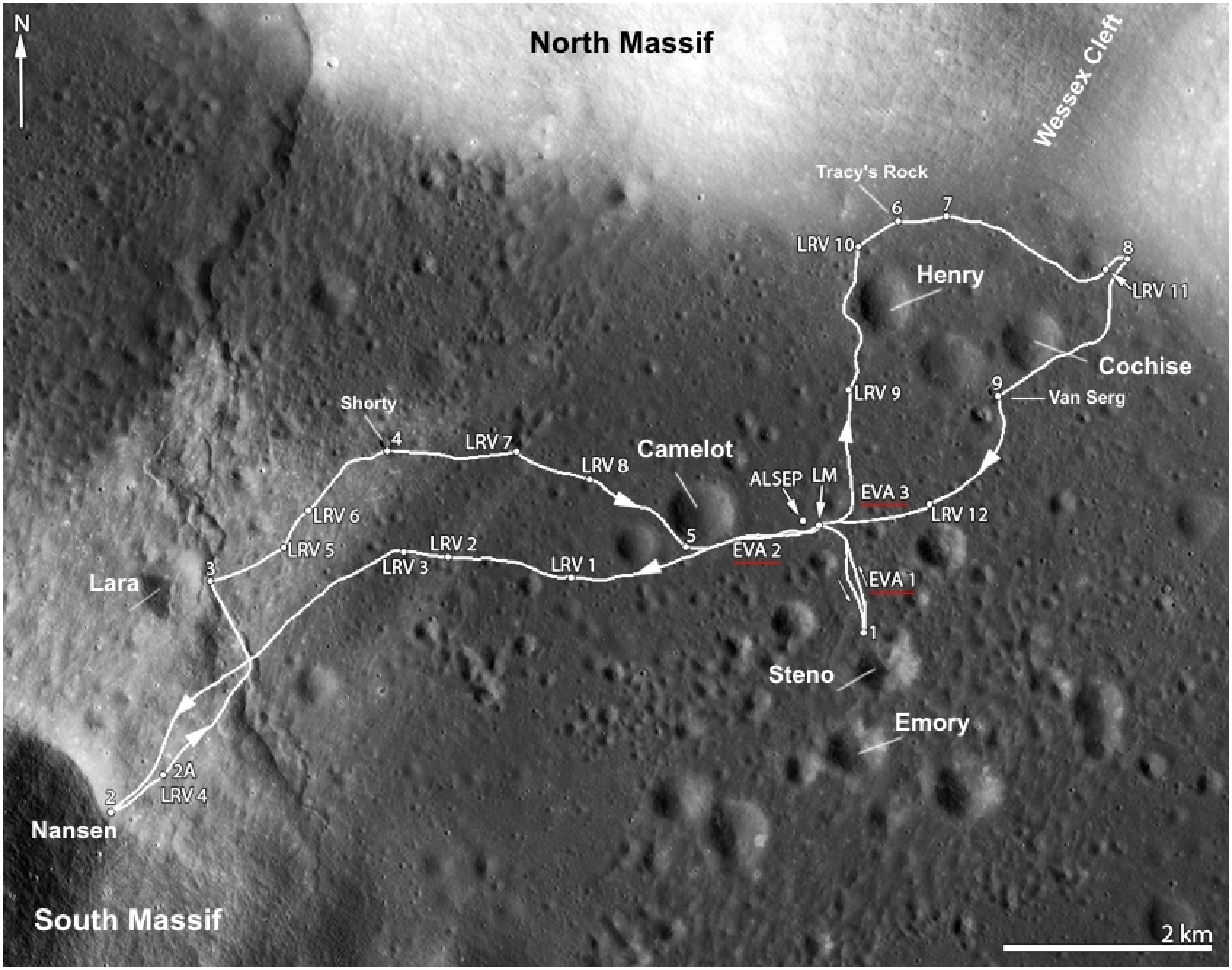


Fig. 3. Gene Cernan and Jack Schmitt spent ca. 75 hours in the Valley of Taurus-Littrow. The three **EVAs** during this period lasted more than 7 hours each. Day 1 was spent assembling the rover, emplacing and positioning the **ALSEP** components, and making the short drive to Station 1 at Steno Crater. They had planned to go as far south as Emory Crater, but extra time was required in deploying the ALSEP central station and gimbaled antenna. EVA 2 was the longest drive of the mission to Nansen at Station 2 at the base of the South Massif with major stops at Shorty and Camelot craters on a different return route. Numbers preceded by 'LRV' refer to very brief stops in which neither astronaut dismounted from the rover, but Schmitt used tools to lean out and pick up interesting geological samples that caught his trained eye. Since such a wide area of the valley was planned to be covered, geologists wanted to make sure that a good representation of rock types was obtained. Numbers by themselves represent the major Station stops. Day 3 was spent on a clockwise circuit onto the slopes of the North Massif around Station 6 and a large split boulder seen there in orbital photos (later called "Tracy's Rock by Astronaut Al Bean). (NASA/ASU/GSFC photo with label additions by the author).

(For landing site location, click **here**)

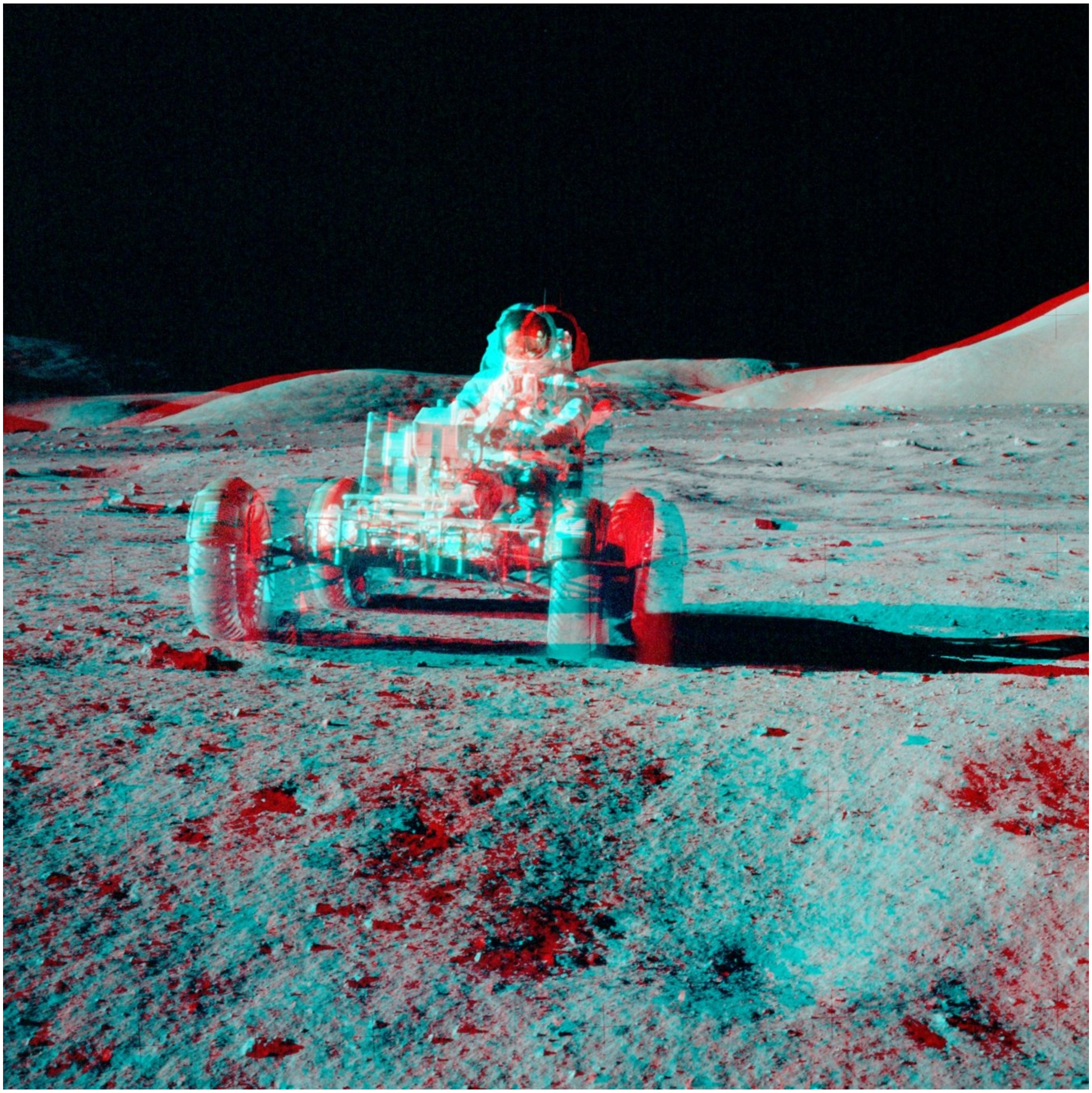


Fig. 4. Even before the astronauts had completely assembled the **LRV**, Gene Cernan wanted to test it out, so he drove it in a wide circle around the **LM** while Jack Schmitt took pictures. Two of them with Cernan driving directly towards Schmitt could be made into this anaglyph although it took adjustments in the frame sizes, perspectives, and vertical displacements before using the StereoPhotoMaker program to produce this scene. Note that the high gain and omni-directional antennae as well as the TV camera have not yet been attached. Also notice the dust kicked up by the front tires. Rover tracks are visible behind the LRV. Bear Mountain is the hill to the left of the rover with a corner of the South Massif at right. (From NASA photos AS17-147-22524, and -25).

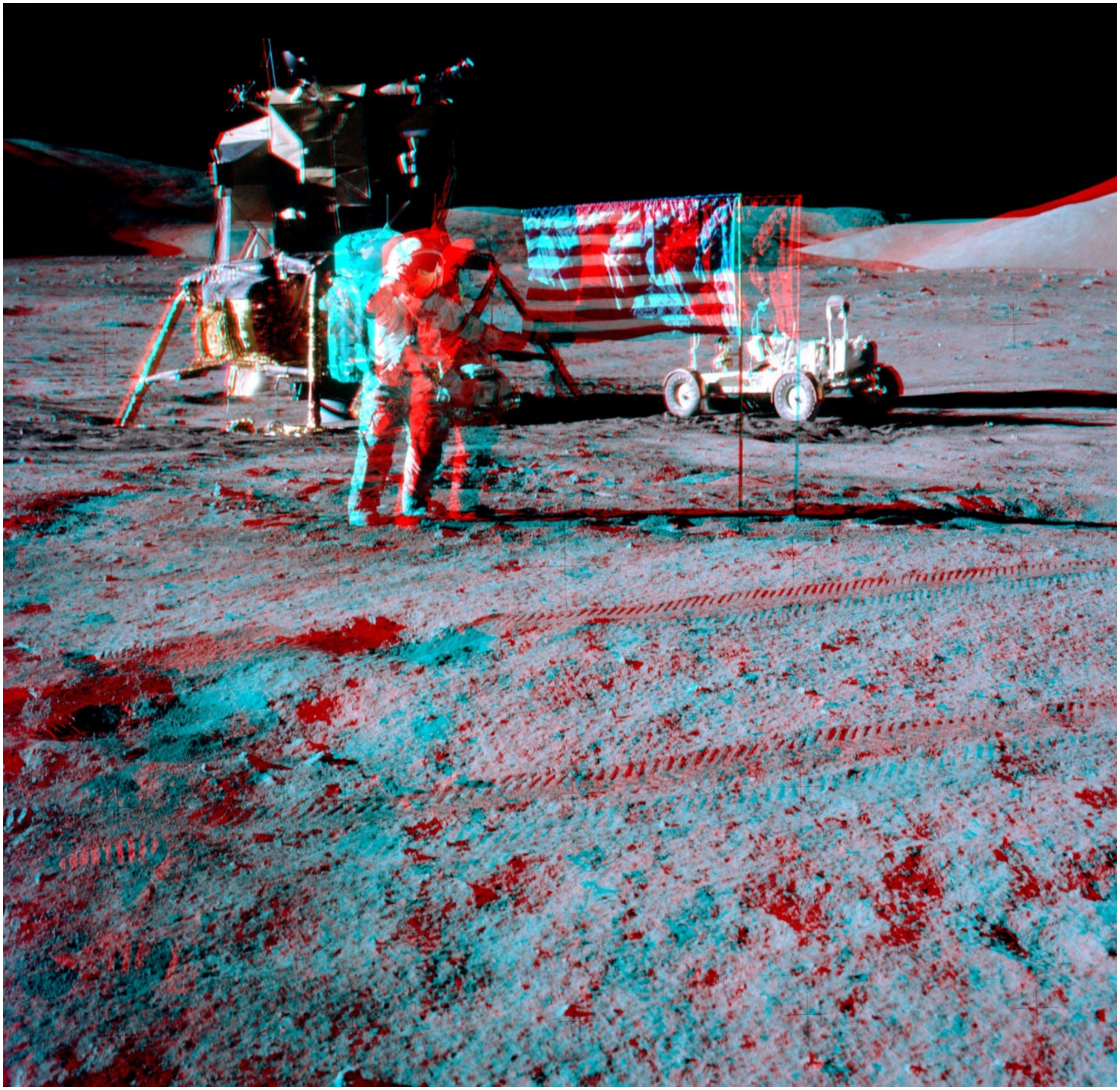


Fig. 5. One of the best anaglyphs of all the Apollo missions is this combination of two photos made by Jack Schmitt of Gene Cernan saluting the flag while holding a corner of it. Schmitt's side-step was perfect to yield dramatic depth from his position all the way to the boulders in the distance. Although the front cover photo of this book of John Young's leap also has astonishing depth, no adjustments were made to the photos that Schmitt took here, apart from balancing the color between them, before running them through the StereoPhotoMaker program. Note that the **LM** is almost perfectly vertical. On a large screen Polaroid monitor, this view is so realistic that it seems as though one could reach in and grab a handful of lunar soil! (From NASA photos AS17-134-20378, and -79).

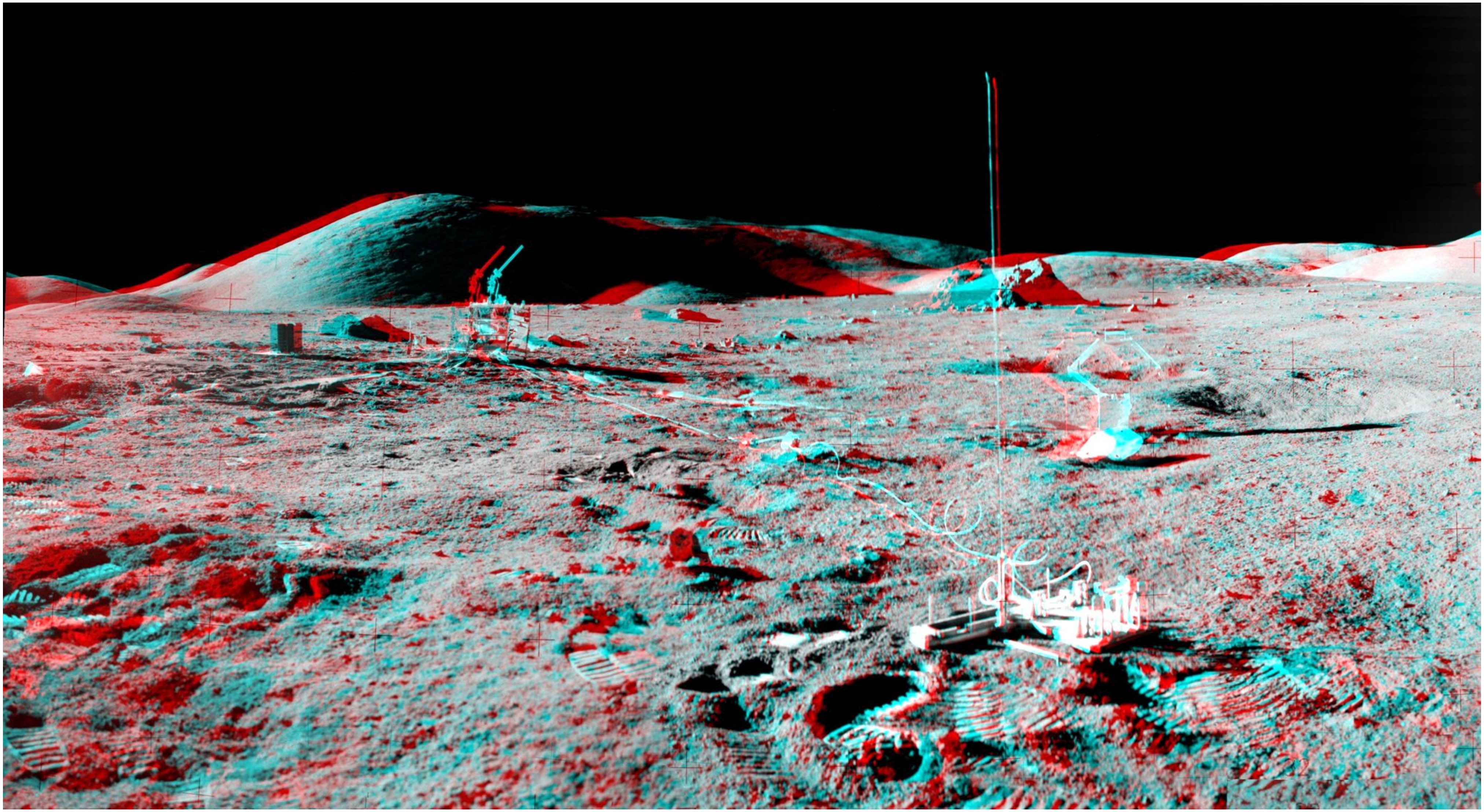


Fig. 6. The first major work away from the **LM** (off the picture to the left) was deploying the **ALSEP**. The above view is composited from Jack Schmitt's pan at the **site**. The large boulder right of center is Geophone Rock, named after some geophones placed nearby. Left of center is the central control station. (From NASA photos AS17-136-20701 through 29707 inclusive).

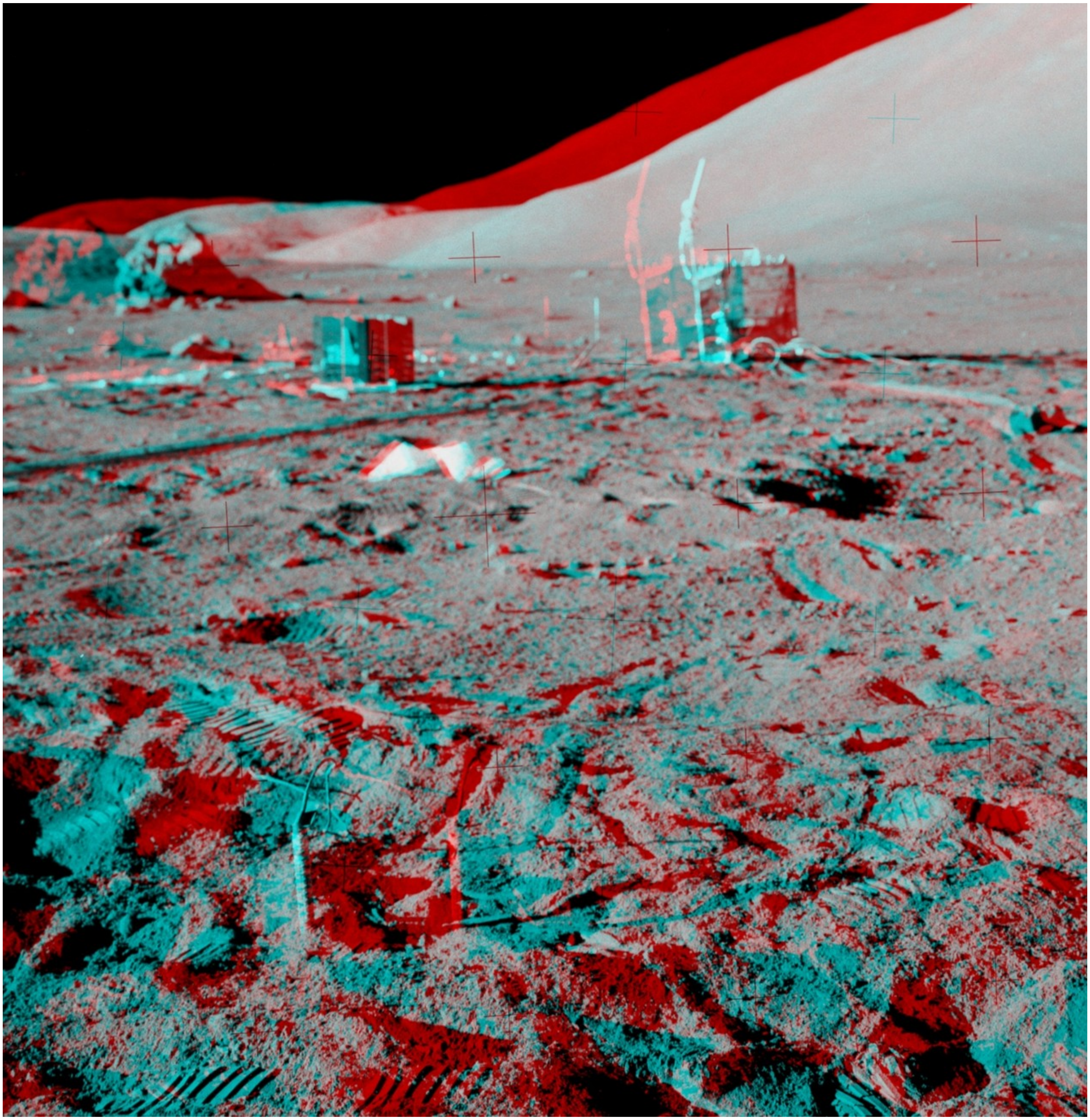


Fig. 7. View from the left of **Fig. 6** looking to its right (south). Geophone Rock is at left, the central station at right; and the Radioisotopic Thermoelectric Generator (**RTG**) to its left. A heat flow probe can be seen sticking out of the ground in the immediate foreground. Jack Schmitt only made two photos at this location, but they provide an excellent stereo view of the area around the central station. (From NASA photos AS17-136-20712, and -13).

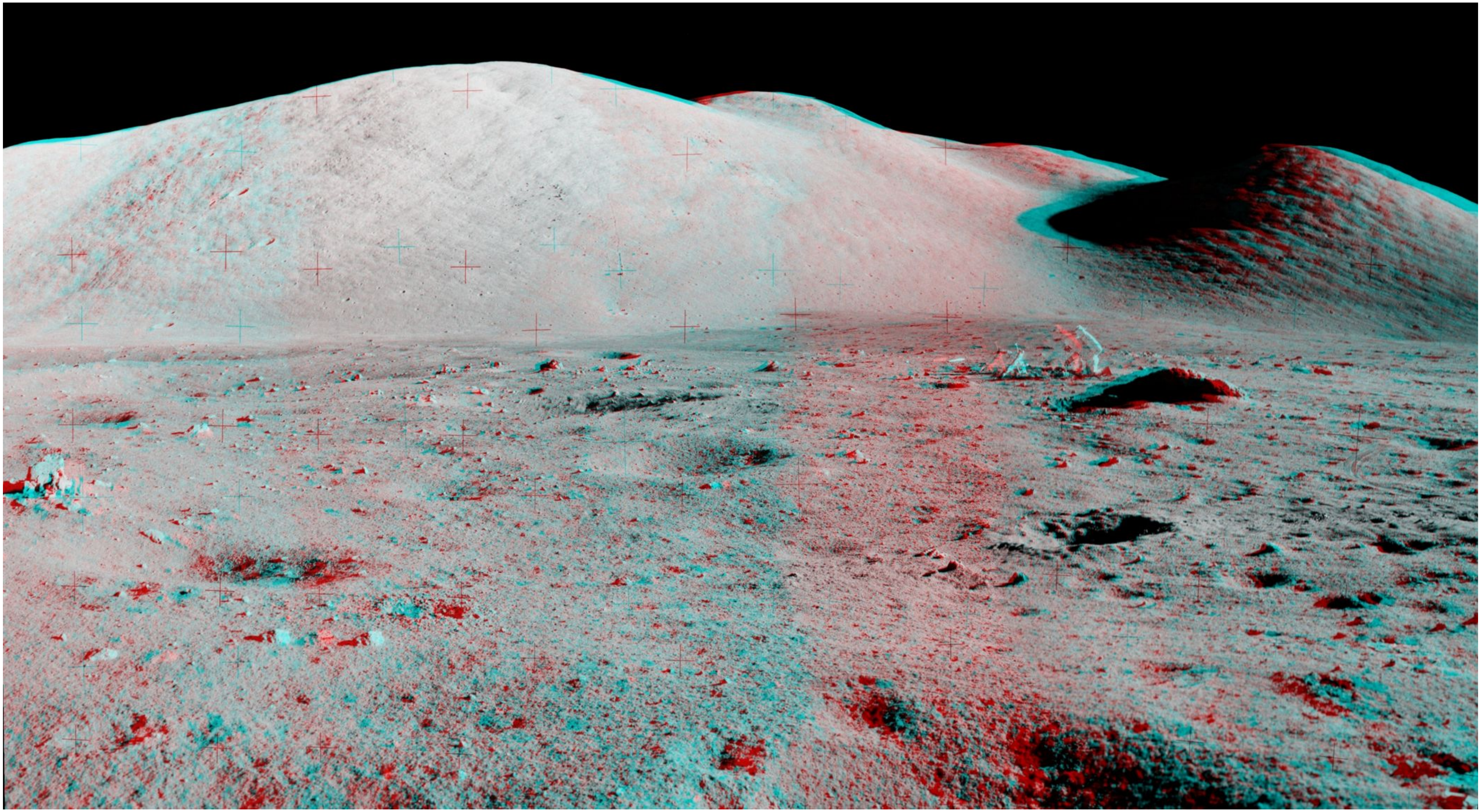


Fig. 8. This anaglyph composite is from Jack Schmitt's pan of Gene Cernan at the Deep Core **site**. Cernan is in the process of removing the deep core tube and inserting a neutron probe in the same hole. The core hole and boulder to the right are in line with the **RTG** so that the boulder will shield the probe. Wessex Cleft behind Cernan separates the North Massif (left) from the Sculptured Hills (right). From NASA photos AS17-136-20691 through 20696, inclusive).

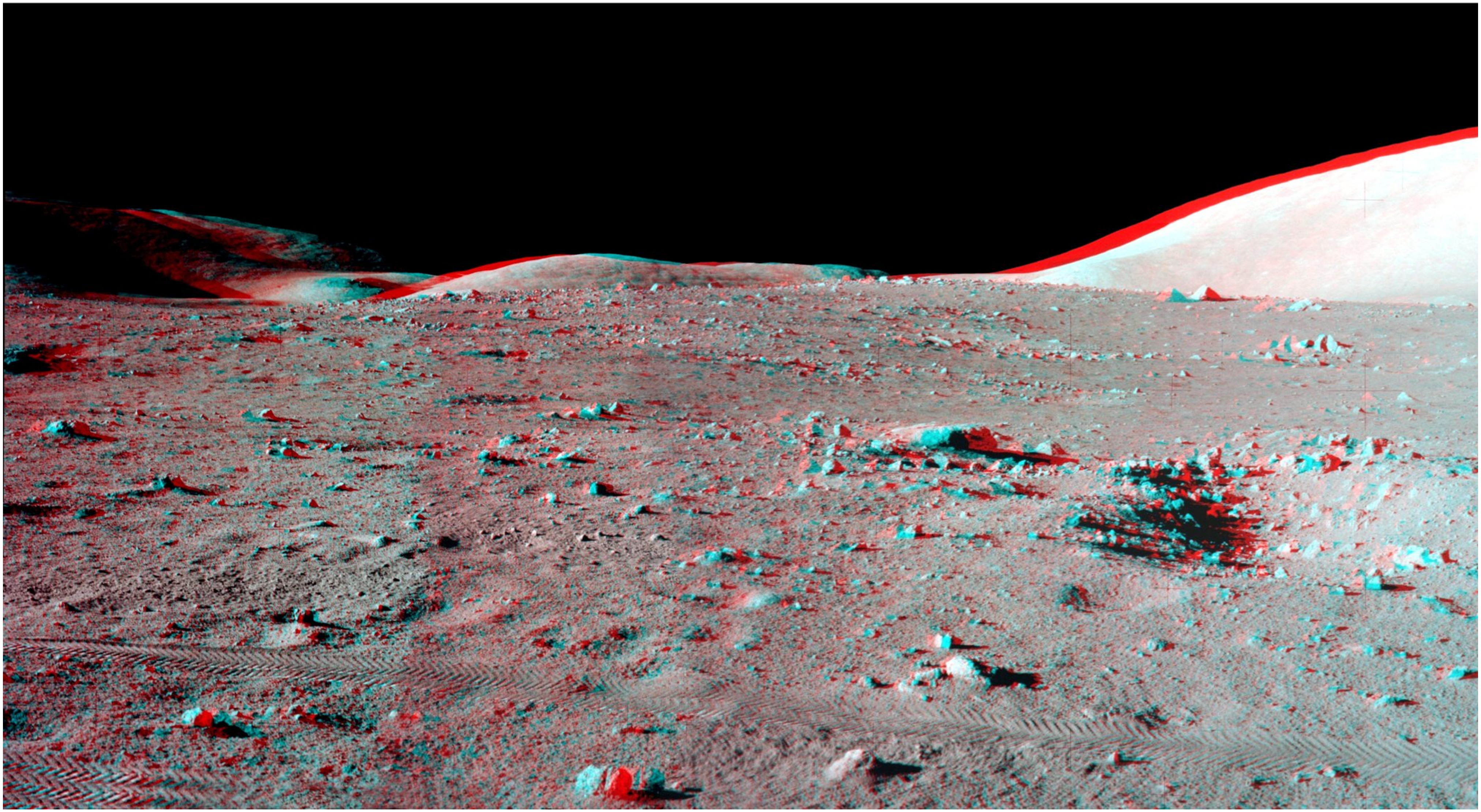


Fig. 9. Part of the pan made by Gene Cernan at **Station 1** where the astronauts stopped just short of Steno Crater. Steno Crater itself is in the upper center of the view. The line of boulders running from left to right mark the crater rim. The two large boulders in the distance at right lie on the outer slope of Steno. (From NASA photos AS17-134-20416, -417, -418, -419 and -420).

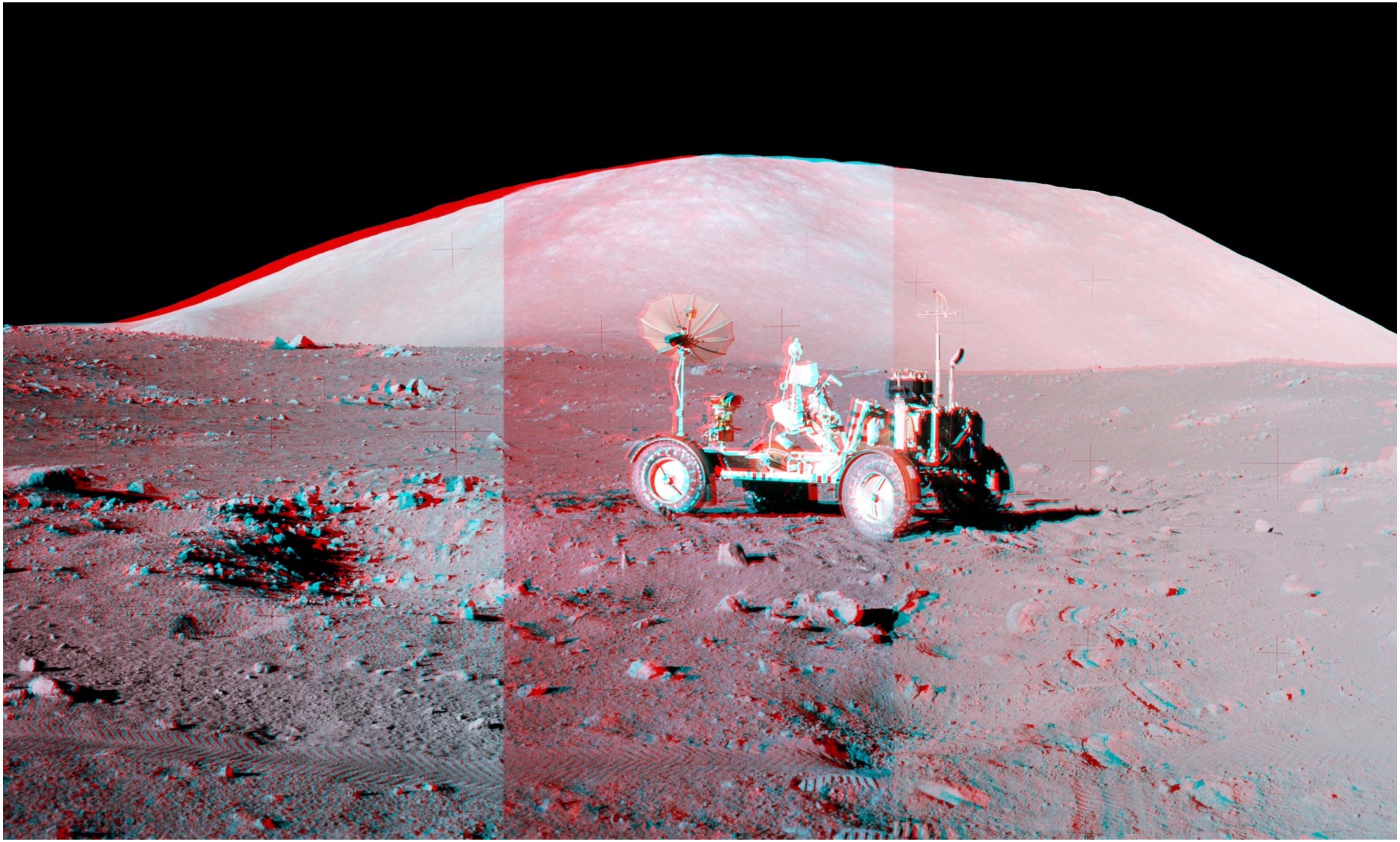


Fig. 10. Continuation of the previous [Fig. 9](#) to the right showing the parked rover. The South Massif is in the background. (From NASA photos AS17-134-20419, -420, -421, and -422).

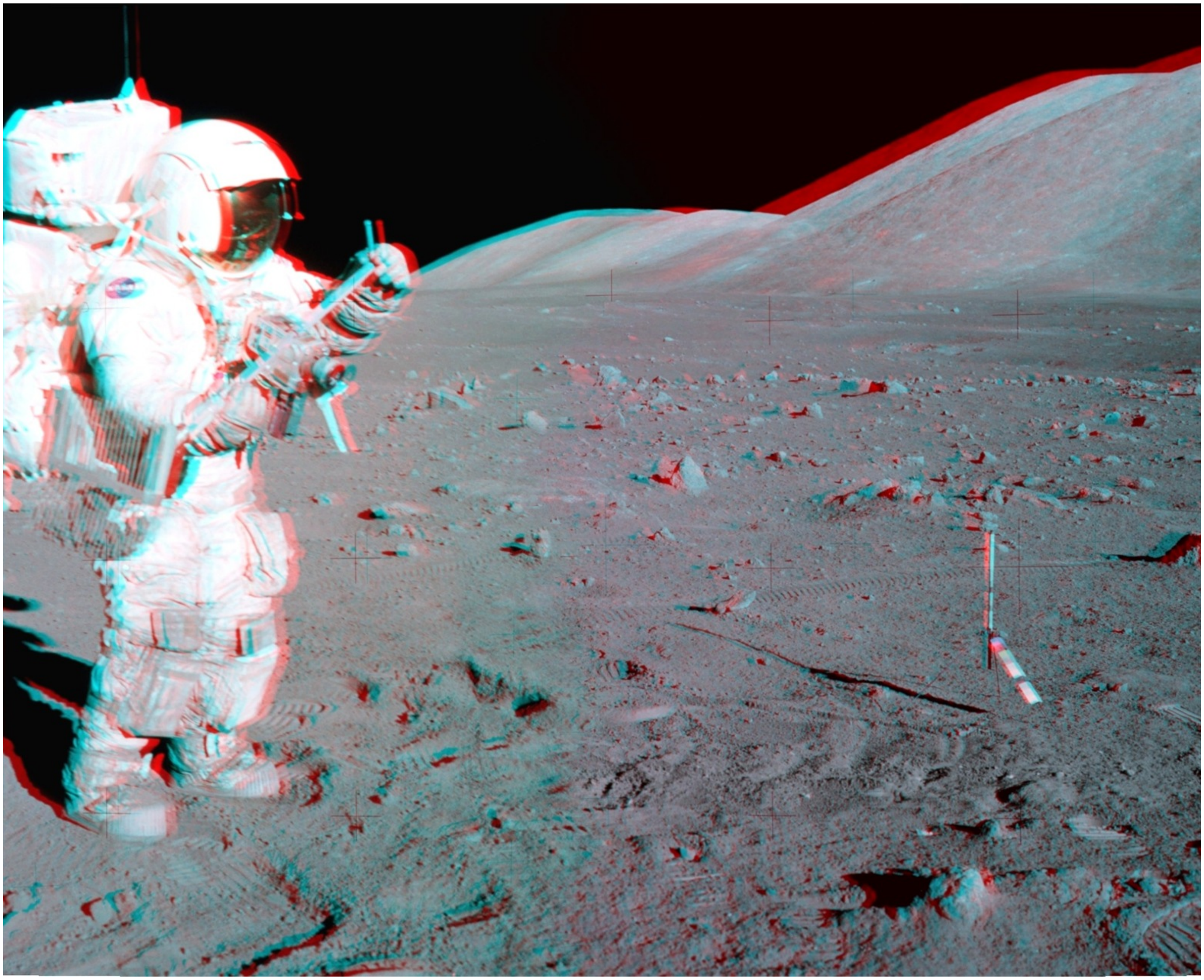


Fig. 11. Continuing the pan of **Fig. 9** and **Fig. 10**, Gene Cernan found Jack Schmitt raking the soil. The special rake, which Schmitt designed, permitted smaller grains to fall through, while retaining pebbles. Note that in this swing of the rake, a portion of the soil is dropping through the tines on its way to the ground. There were 3 frames in this photo sequence of Schmitt. The first showed only his life support backpack. The second showed him with the rake just past vertical, with the soil beginning to drop through the rake tines. And the third had the above view of the upward swing. Al Bean used the second photo as the basis for his painting of Schmitt: ***Playing in a Four Billion Year Old Rock Garden***. Since the two full figure poses were different, the above anaglyph was composited as described in the **Prologue** for the **Frontispiece**. The North Massif is at right. (From NASA photos AS17-134-20425, -26, and -27).

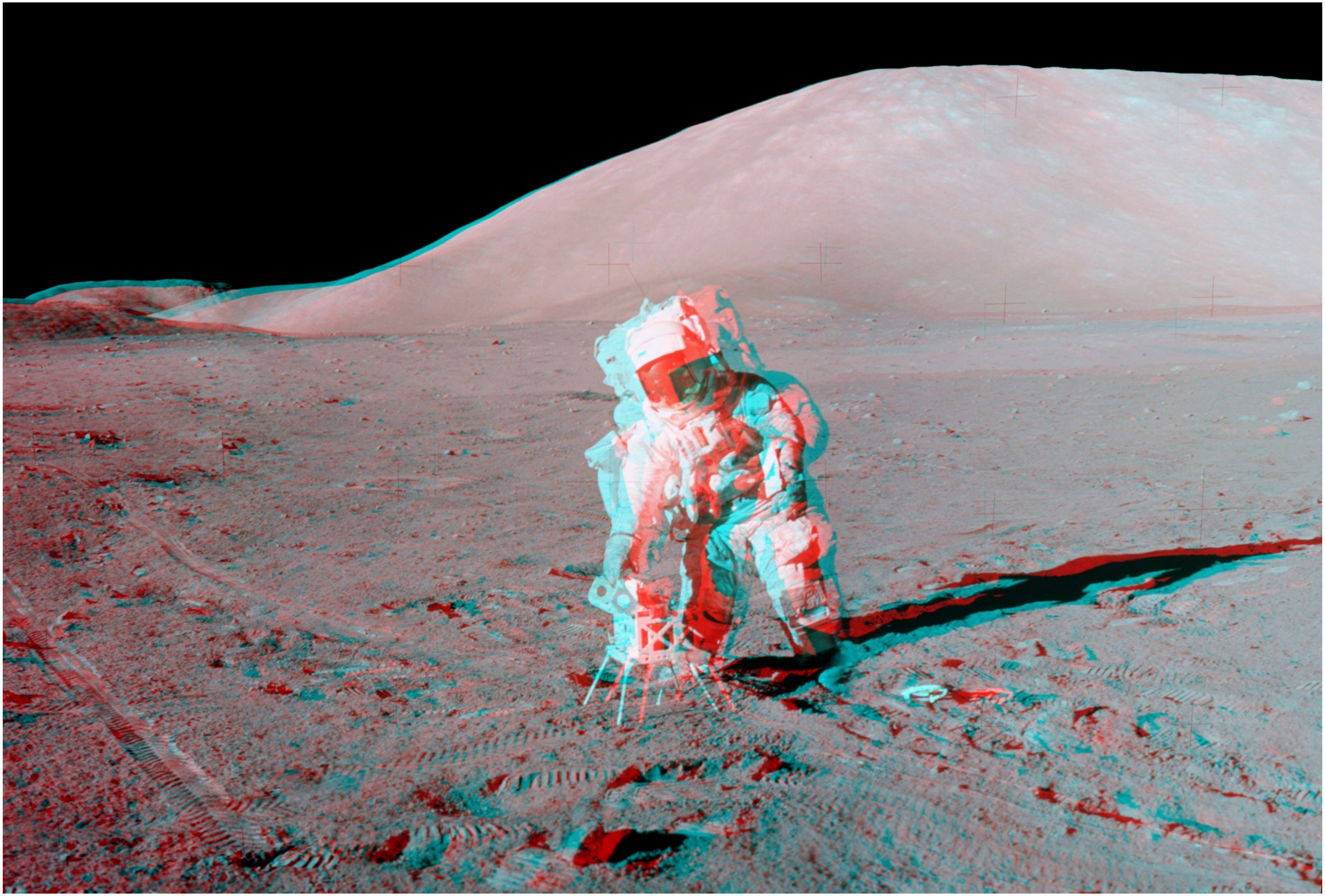


Fig. 12. Jack Schmitt reaching towards the Surface Electrical Package (SEP) experiment. Part of another pan made by Cernan after they left Sta. 1. (From NASA photos AS17-134-20437, -38, -39, -40 and -41).

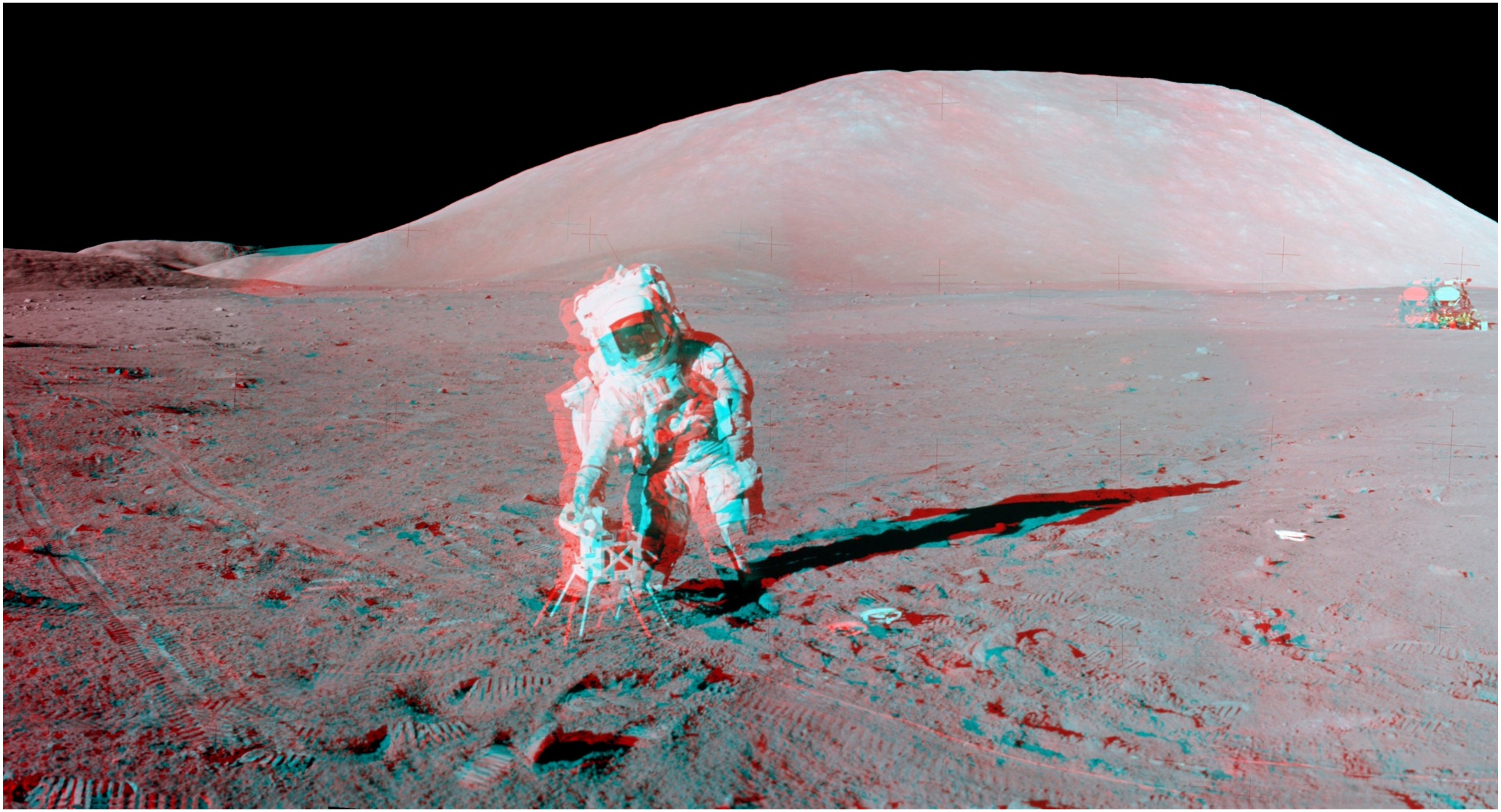


Fig. 13. Same as **Fig. 12**, but showing the SEP site relative to the location of the **LM** at right. The site is about 600 m NNW of **Station 1** off the frame at left. (From NASA photos AS17-134-20437, -38, -39, -40, -41, and -42).

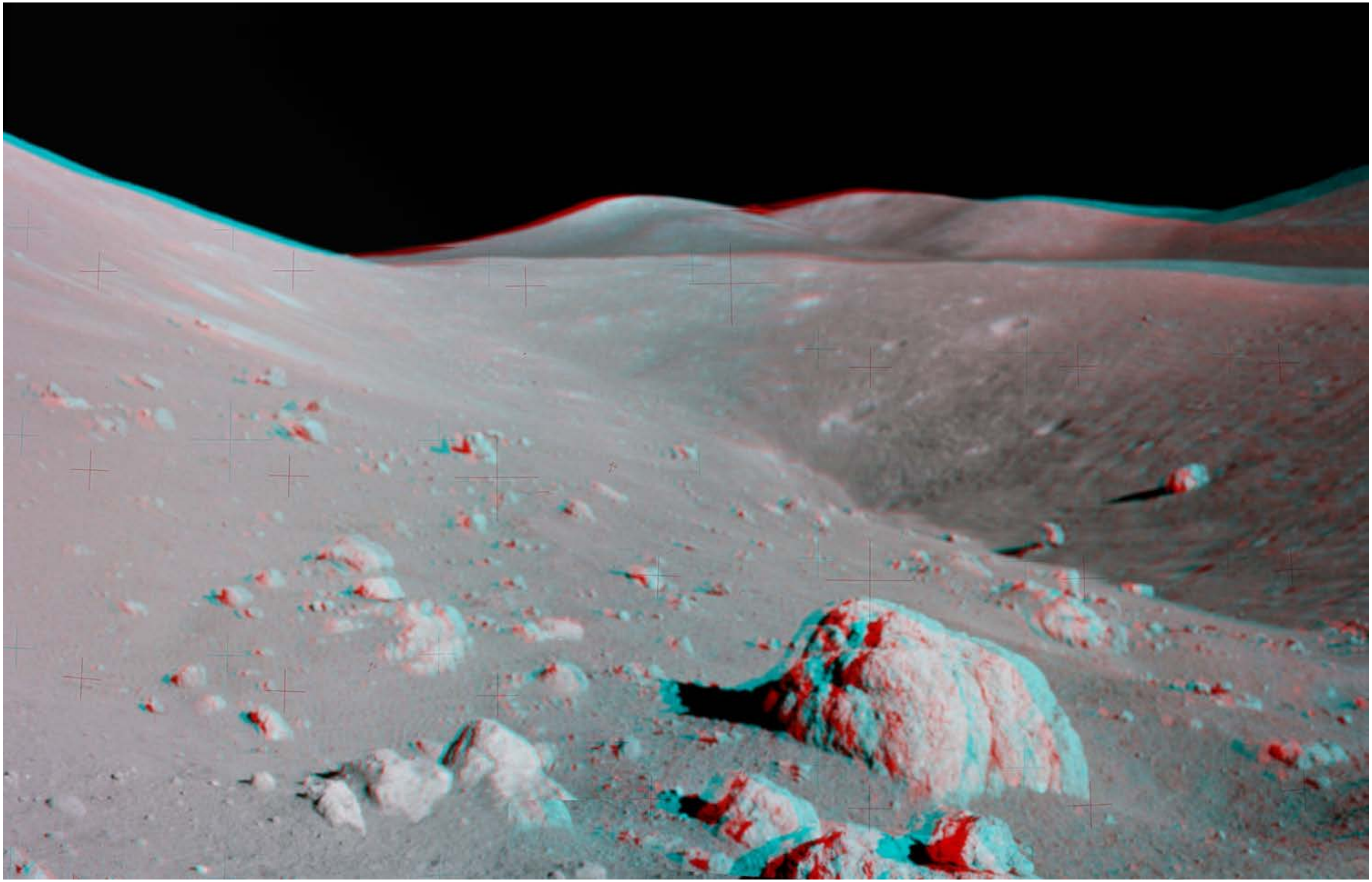


Fig. 14. The trough at the base of the South Massif at **Station 2** named Nansen by Jack Schmitt after the Norwegian Arctic explorer. This stop was the first major geology investigation on **EVA2** after the long drive from the **LM**. (From NASA photos AS17-137-20938, -39, -40, -41, and -42).

Fig. 15. This continuation of the Nansen trough to Boulder No. 2 is a partial hybrid in the lower right corner. It shows the location of the **LRV** parked at **Station 2**. (From NASA photos AS17-137-20951, -53, -55, and -56).

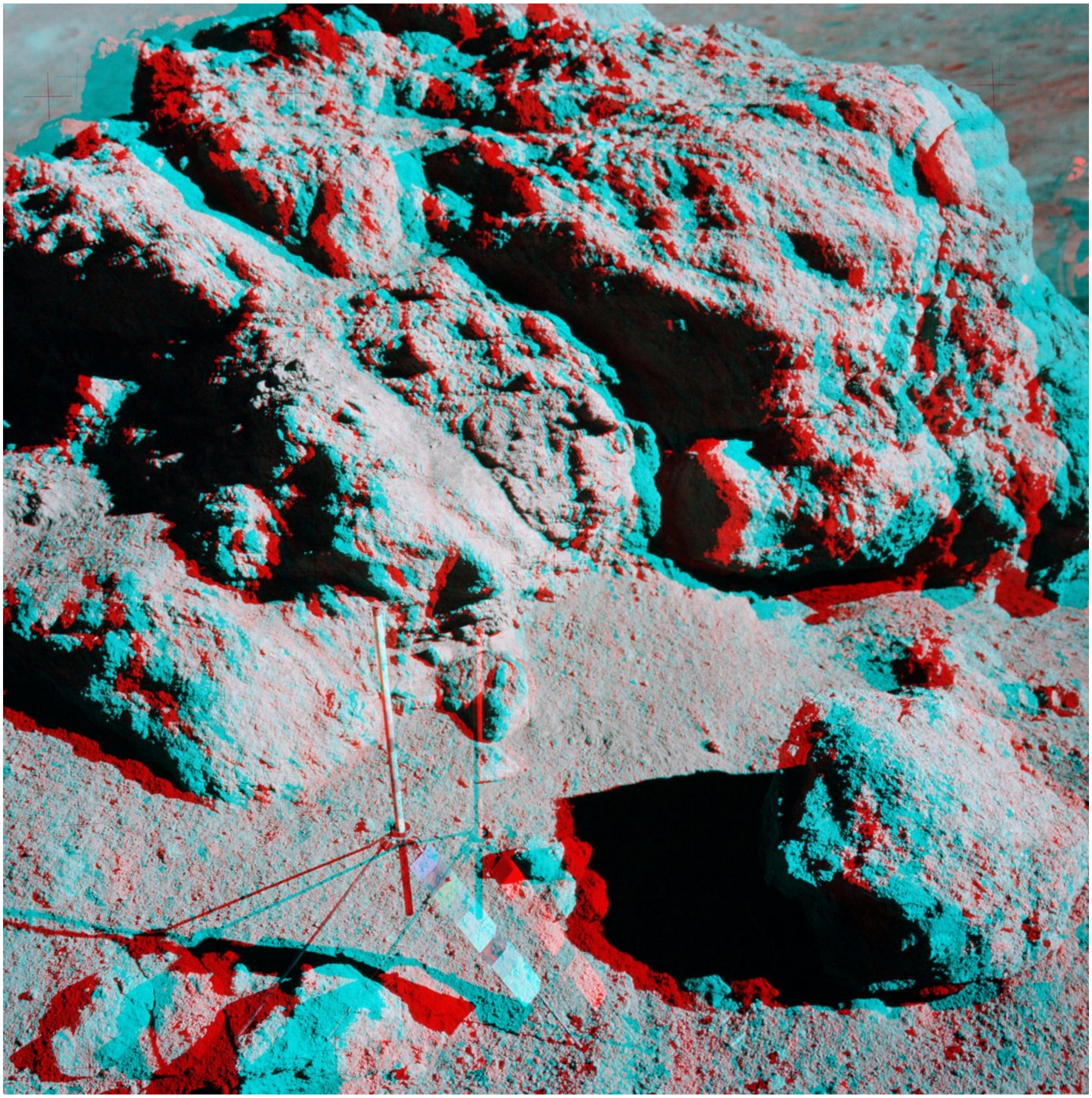


Fig. 16. Boulder No. 1 at **Station 2** taken by Gene Cernan. Jack Schmitt can just be seen inspecting the base of the boulder at the right edge of the photo. Seven samples would be taken from this site. (From NASA photos AS17-137-20900, and -01),

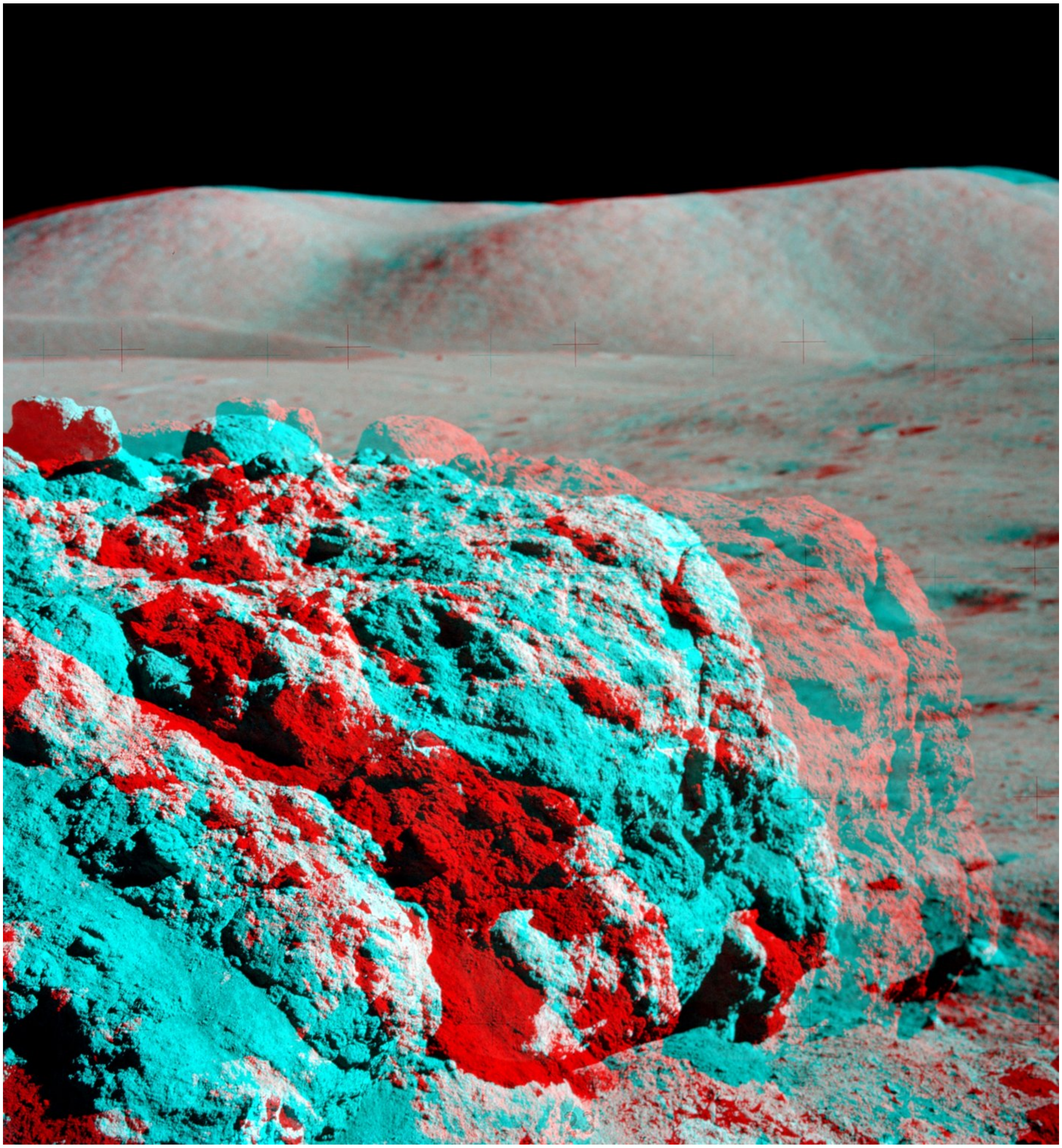


Fig. 17. A different aspect of Boulder No. 1 at **Station 2**. Across the valley, a part of the Lincoln-Lee scarp can be seen as the white streak crossing the base of the North Massif. The visible portion seen here on the northern side of the valley is the Lincoln Scarp. The part on the southern side of the valley at **Station 2** is the Lee Scarp. (From NASA photos AS17-137-20908, and -09).

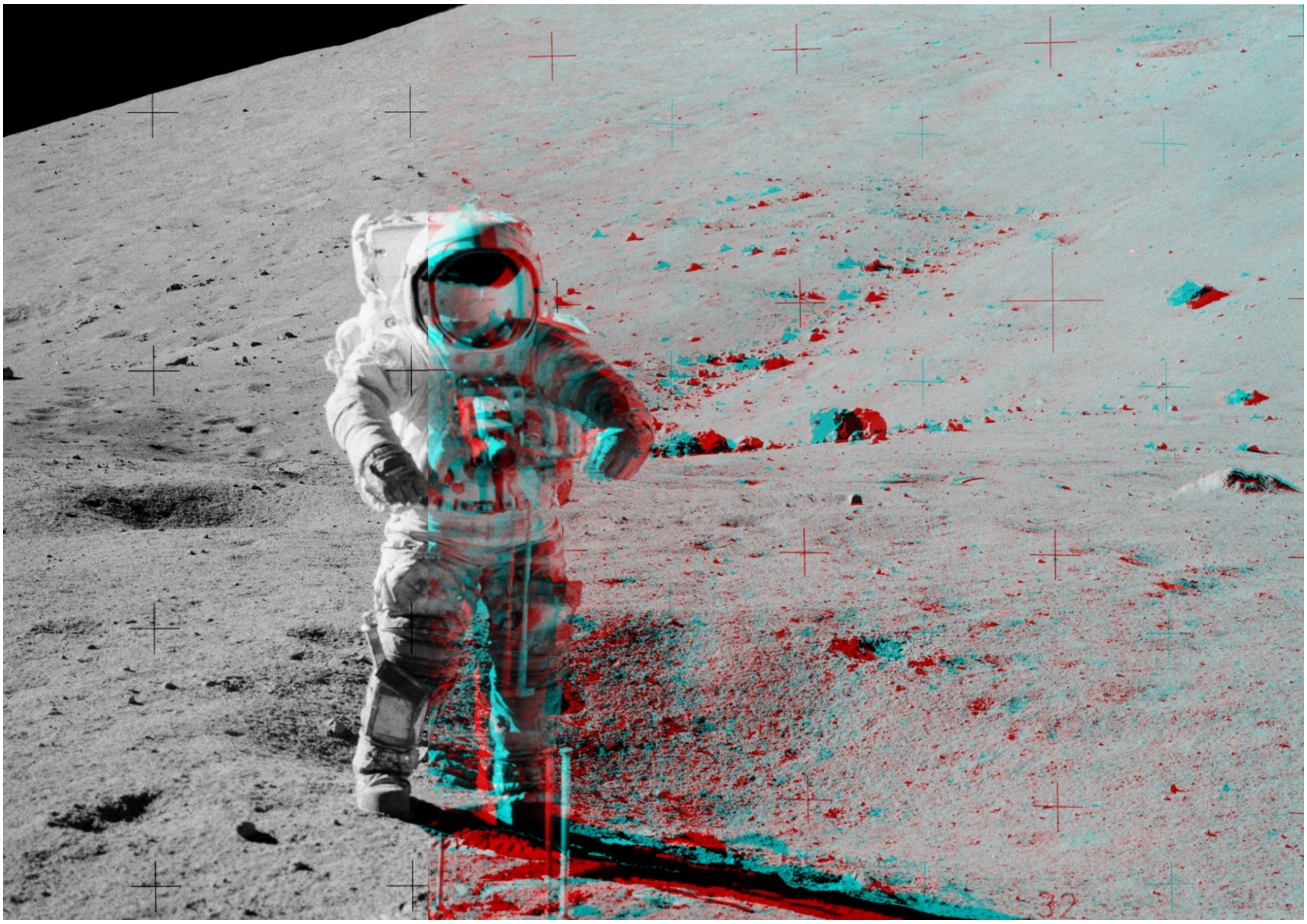


Fig. 18. A hybrid anaglyph of Gene Cernan in the boulder field of **Station 2**. Part of a b&w panorama taken by Jack Schmitt. (From NASA photos AS17-138-21069 and -70).

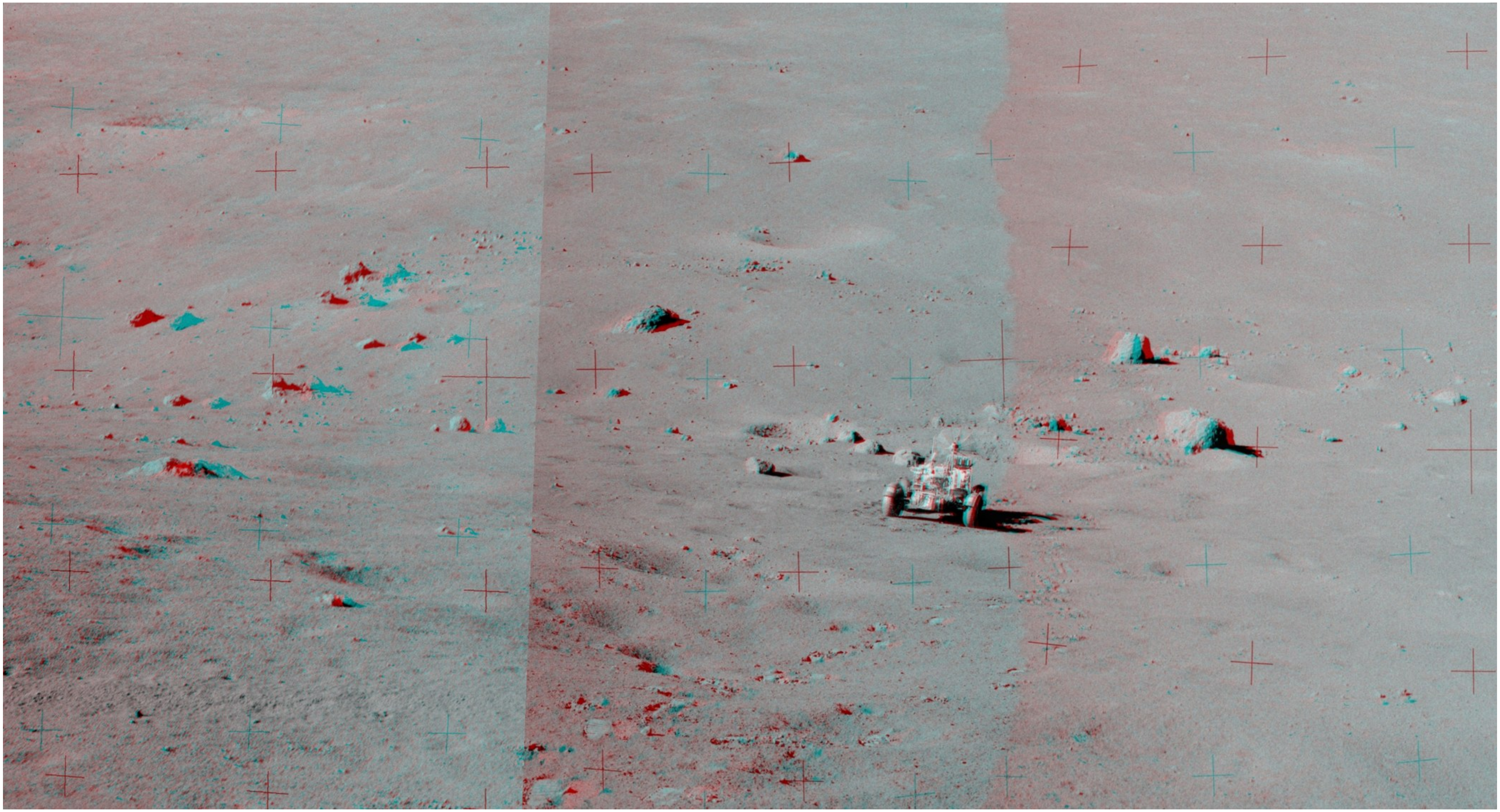


Fig. 19. Continuation of the pan immediately to the right of **Fig. 18** (the buried elongated boulder in the left foreground is at the right in **Fig. 18**). Boulder No. 1 of **Fig. 16** and **Fig. 17** can be seen at the far right. Boulder No. 2 of **Fig. 15** is above and to the left of Boulder No. 1. Nansen begins to the immediate right of Boulder No. 2 and continues out of the field of view. **Fig. 15** was made by Cernan on the other side of Boulder No. 2 looking towards the present position. (From NASA photos AS17-138-21070, -71, -72, and -73).

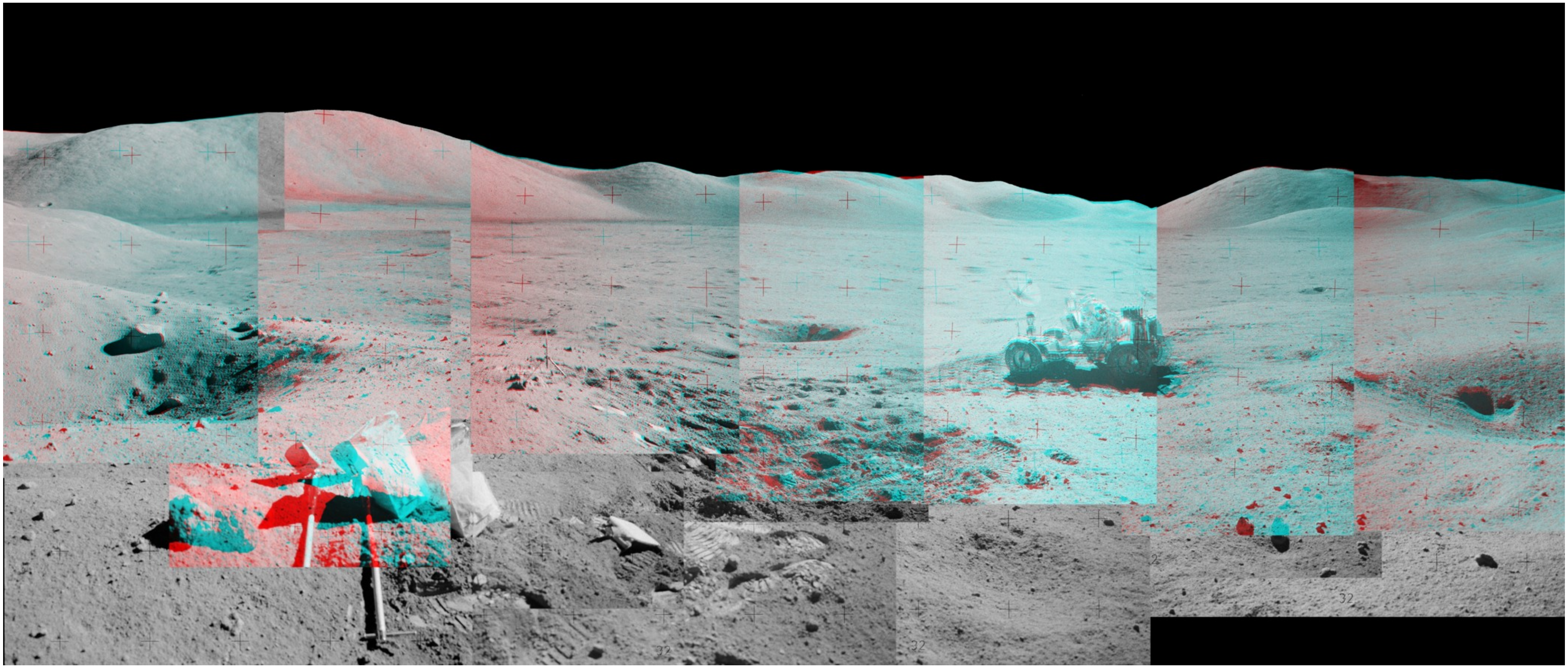


Fig. 20. A hybrid composite of anaglyph and normal photo panels showing the rover parked at **Station 3**. Gene Cernan is working at the **LRV**. This composite was difficult to assemble because of the many panels and the upsun direction of view. The end of Ballet Crater is at left. In the distance at left is the North Massif. The Wessex Cleft is to the right followed by the Sculptured Hills in the center. At right is the East Massif with Bear Mountain below it. Ballet Crater's name, given after the mission, commemorates Jack Schmitt's spectacular spinning fall as he attempted to pick up the rock box towards the end of the stop. As they were preparing to leave, Capcom Bob Parker said: "And be advised that the switchboard here at MSC has been lit up by calls from the Houston Ballet Foundation requesting your services for next season." (From NASA photos AS17-138-21159 through -70, inclusive).

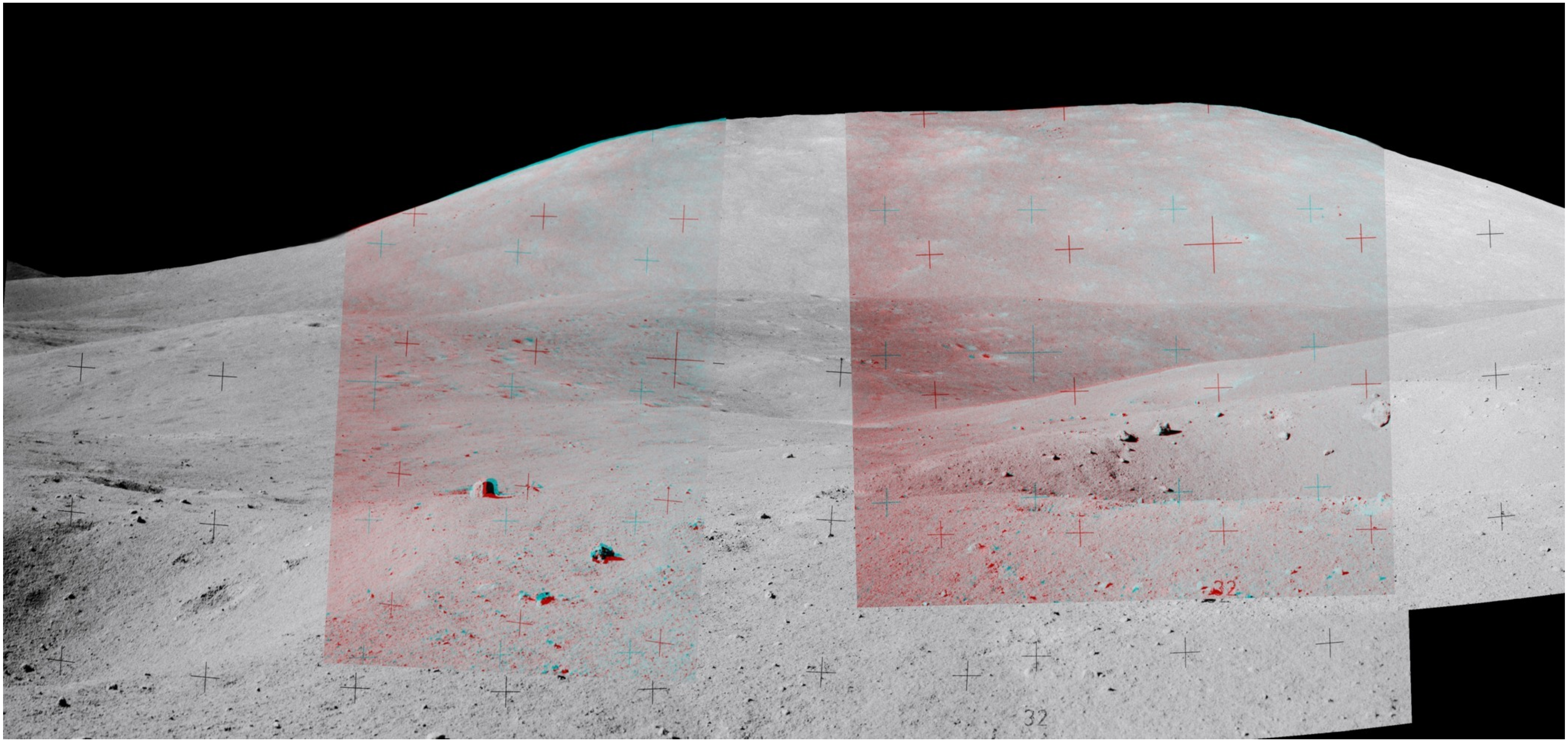


Fig. 21. A hybrid composite of the environs of Lara Crater spreading across the middle of the view, which Jack Schmitt named for the heroine in Pasternak's *Dr. Zhivago*. It is immediately behind Jack's position in **Fig. 20** at **Station 3**. The South Massif is beyond Lara Crater. (From NASA photos AS17-138-21172, -74, -76, and -77).

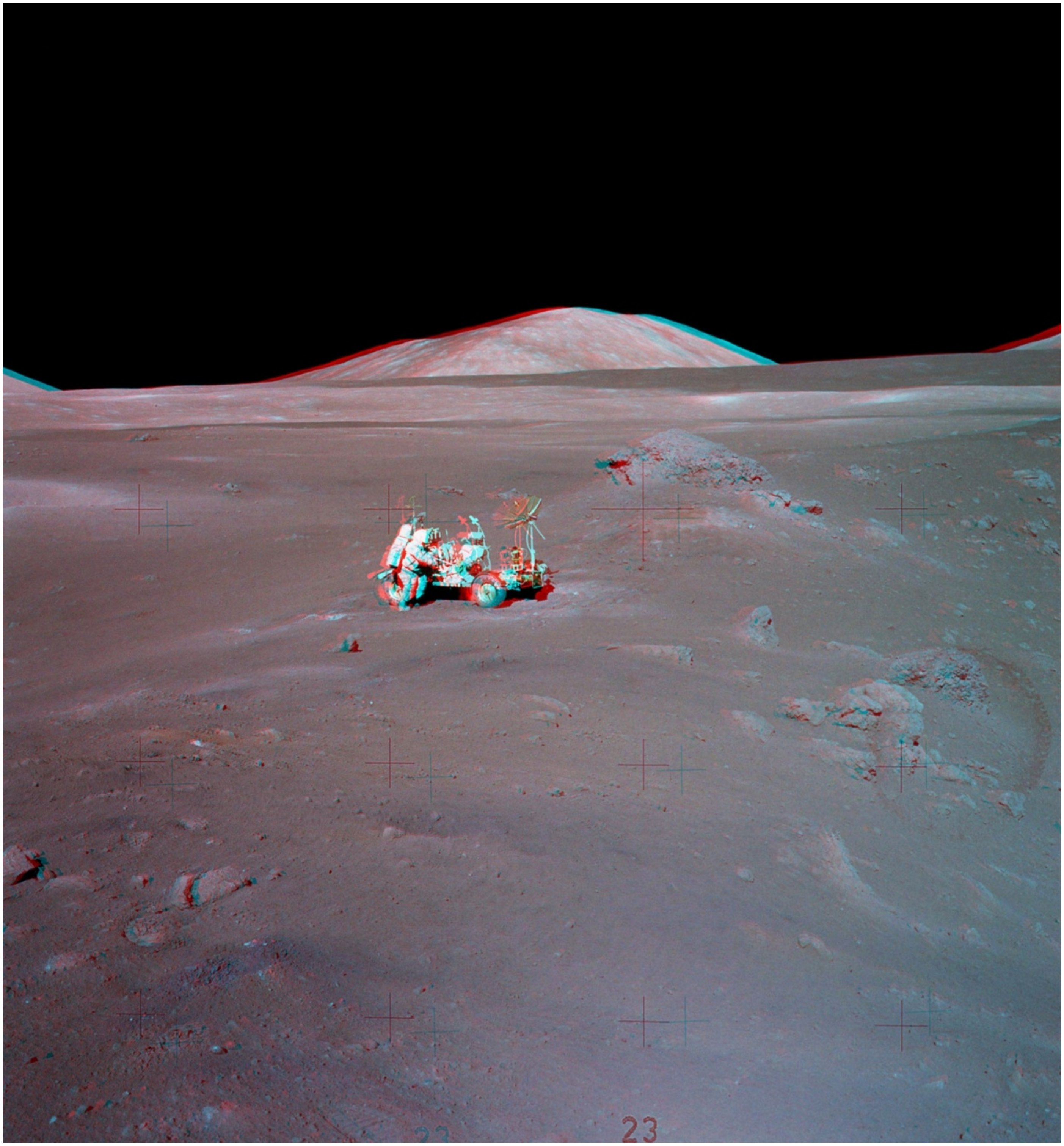


Fig. 22. Jack Schmitt with a double core tube of orange soil at the **LRV** parked on the rim of Shorty Crater at **Station 4**. Jack discovered the orange soil in the bright patch between the rover and the large rocky mound embedded on the crater rim, which slopes down at the right. (West) Family Mountain, named for all the astronaut families, at the entrance to the valley is in the upper center of the photo (see **Fig. 53** for (Old) Family Mountain). Some of the bright debris from the landslide off the South Massif can be seen crossing the photo. (From NASA photos AS17-137-21011, and -10)

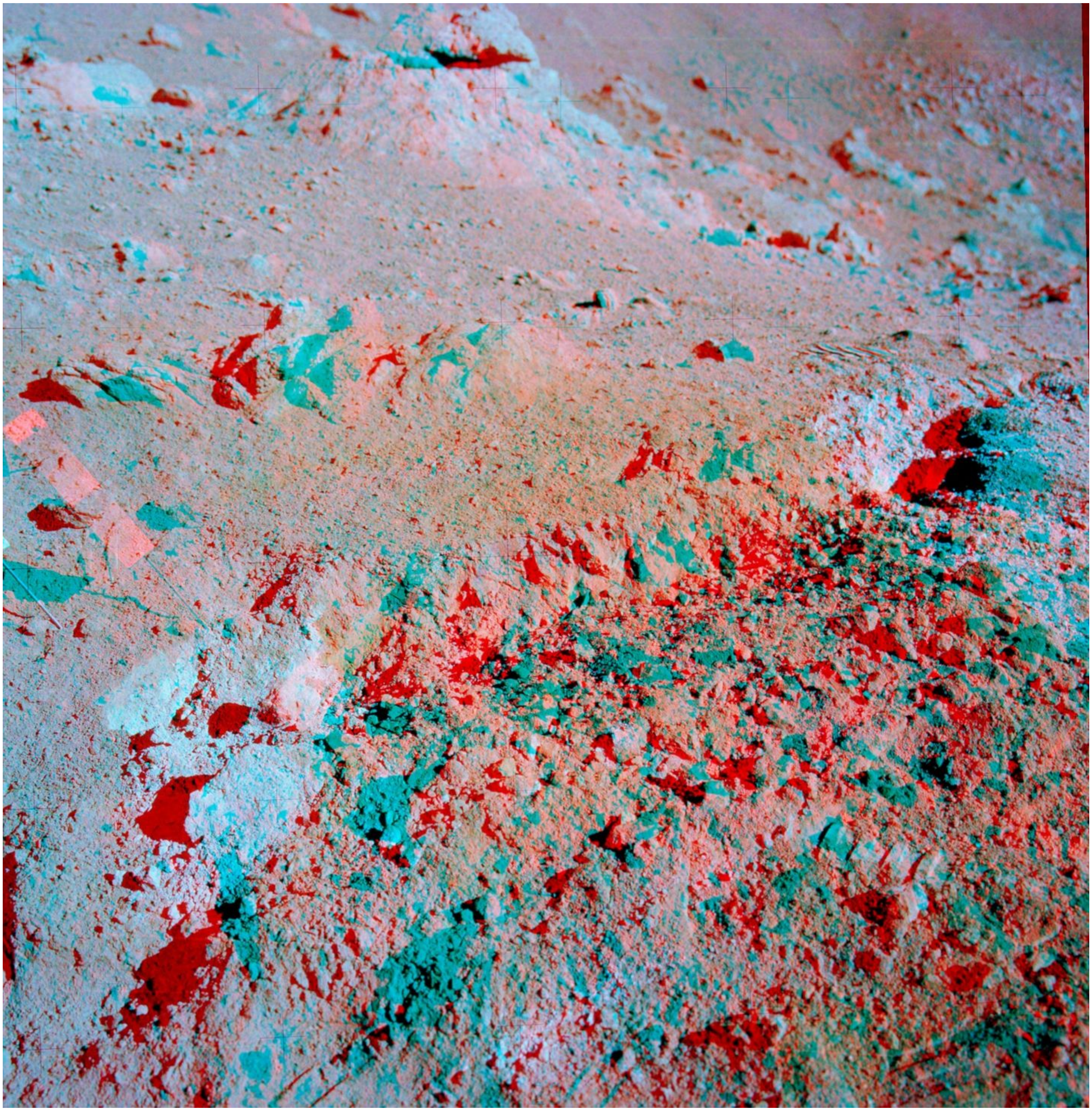


Fig. 23. The orange soil discovered by Jack Schmitt at Shorty Crater, **Station 4**. The brightness of the orange color is masked in this anaglyph production because of the red anaglyph lens although it is still apparent. A plain, non-3D view demonstrating the bright orange color is given in **Fig. 24**. (From NASA photos AS17-137-20985, and -86).

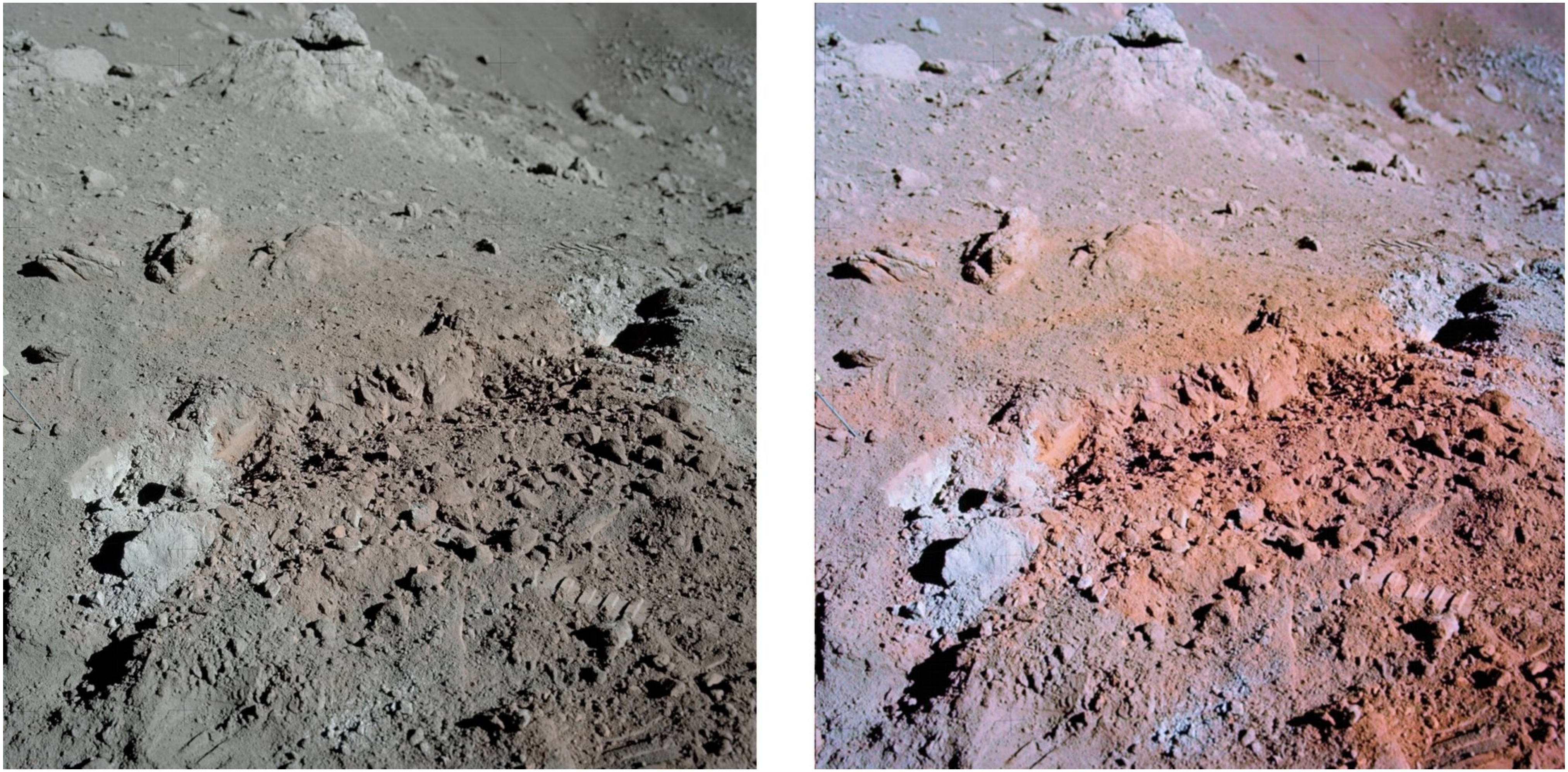


Fig. 24. (*left*). NASA photo AS17-137-20986 as incorrectly printed in many publications of the orange soil photos (view this figure without anaglyph glasses). **(*right*).** A color-corrected and enhanced version by the author and approved by Astronaut Jack Schmitt. It is the closest representation of the color he observed by a direct view with the gold visor of his helmet in the up position. The orange material is also seen in the crater walls of Shorty as indicated at far right. The astronauts also observed orange coloration around a number of other craters from orbit. The soil is the most colorful material returned from the Moon. It is comprised of volcanic glass from fire fountains spewed up from a depth of ~500 km beneath the surface. Its presence and associated volatile elements, including traces of water, have profound implications for hypotheses on the Moon's origin.

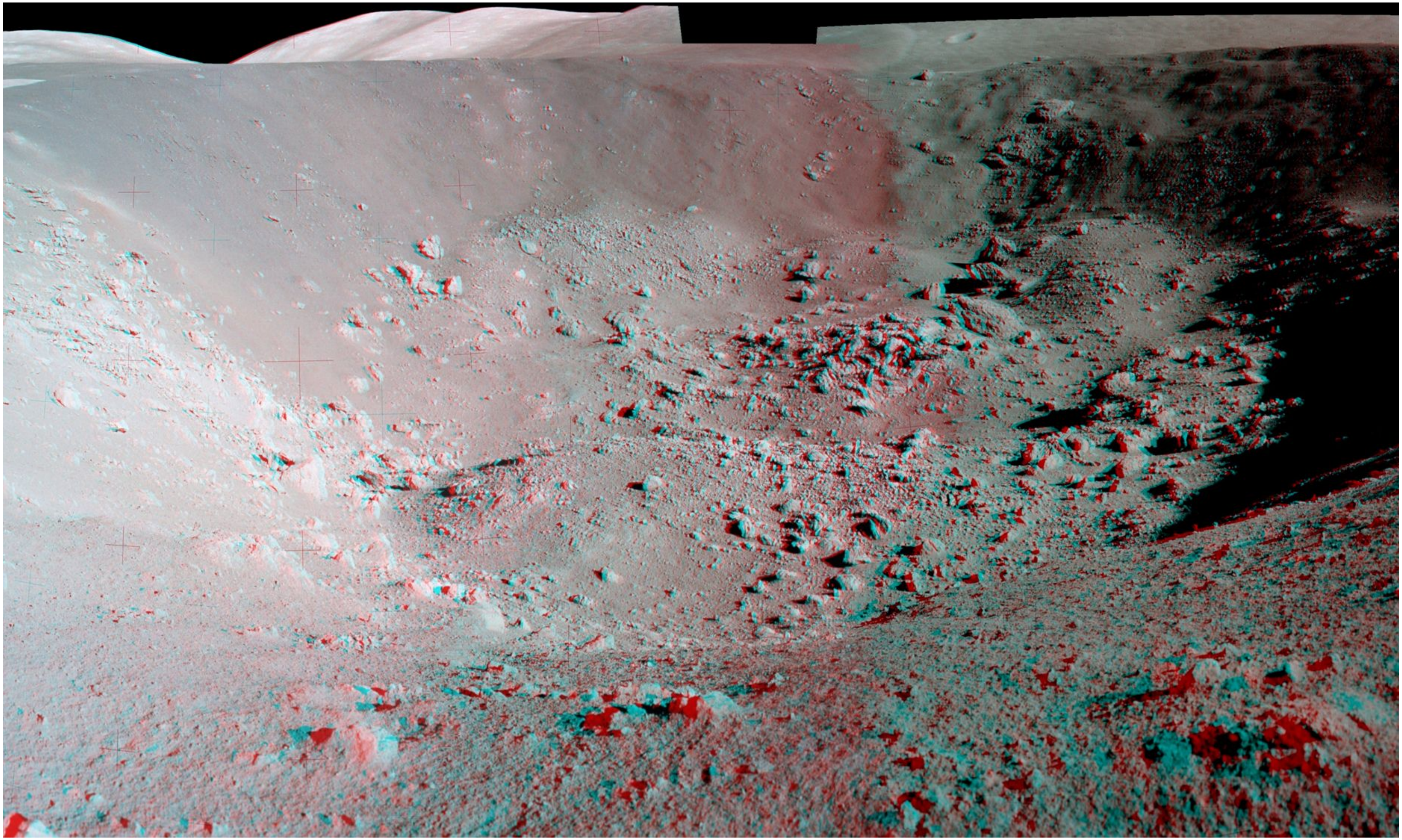


Fig. 25. A look down into Shorty Crater from part of the counterclockwise **Station 4** pan by Gene Cernan. The large rocky mound, **LRV** and orange soil trenches are on the rim off picture at left. (From NASA photos AS17-137-20996, -97; -94, -95; and -92, -93).

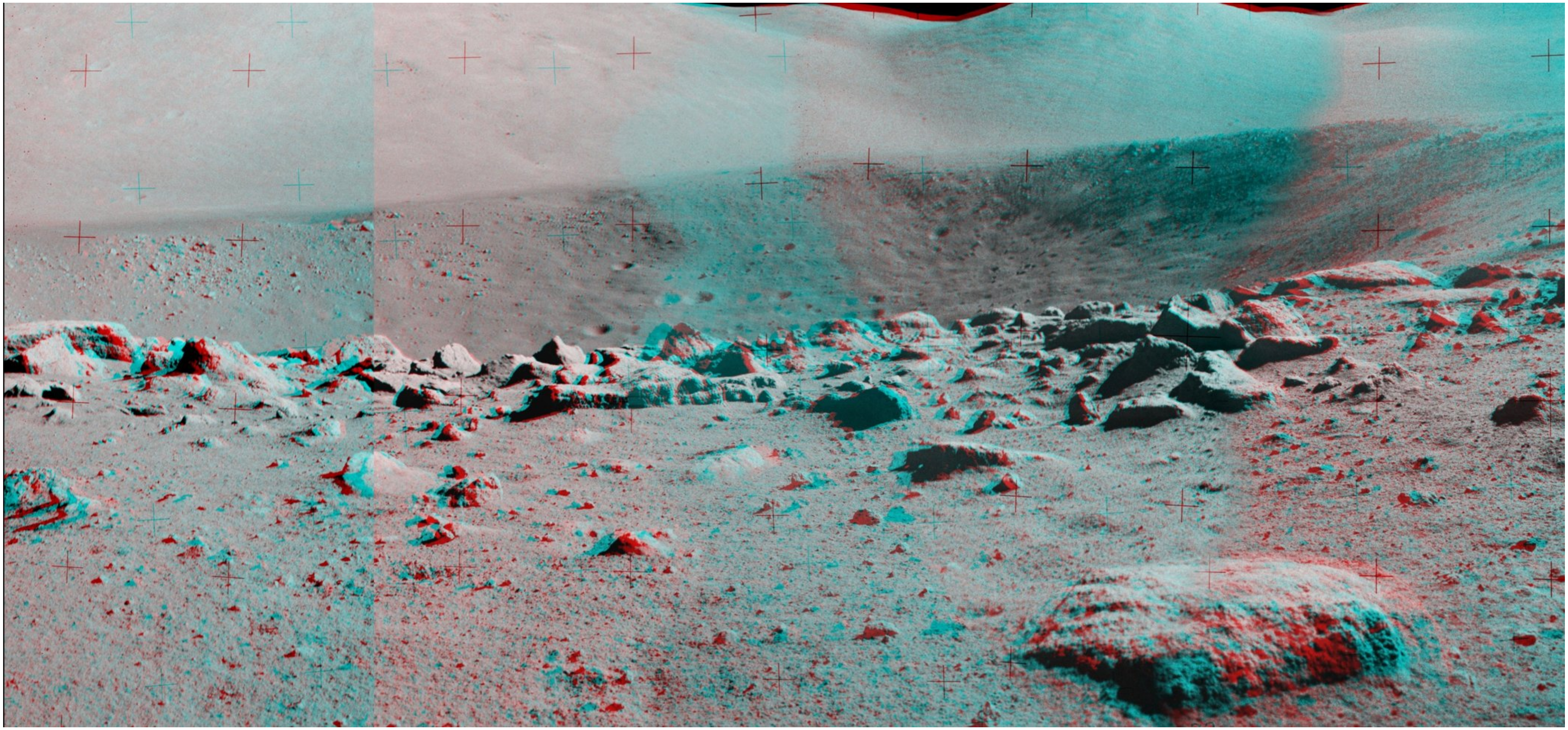


Fig. 26. Part of Jack Schmitt's **Station 5** pan showing most of the 600 m diameter Camelot Crater. Both astronauts wanted to walk as far down into the crater as would have been prudent taking samples from inside the crater rather than just in the boulder field on the rim. However, time constraints prevented this excursion. (From NASA photos AS17-133-20344 through -49, inclusive).

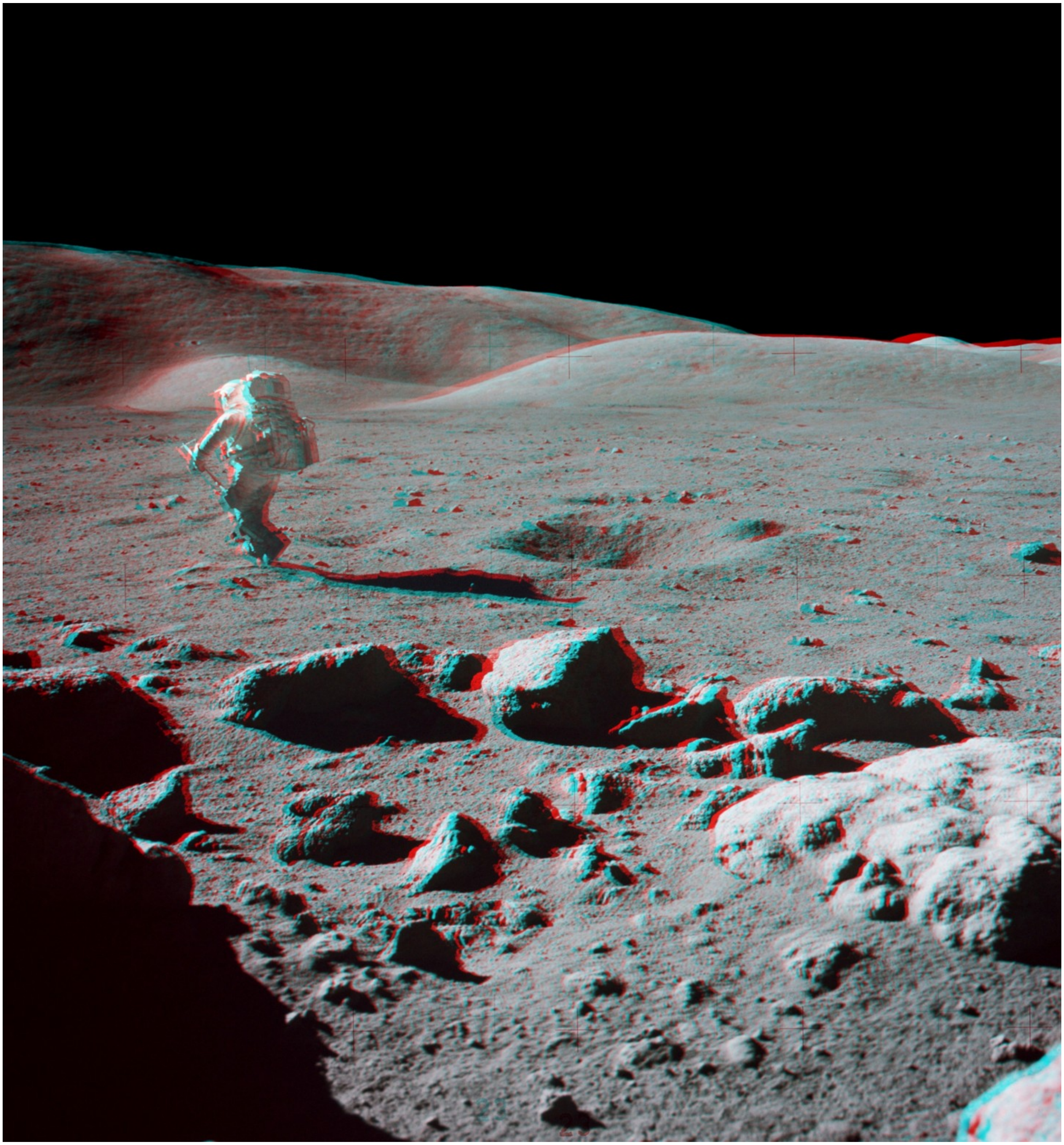


Fig. 27. Gene Cernan's full frame **Station 5** stereo of the boulder field at Camelot Crater with Jack Schmitt running back to the **LRV**. Details of the anaglyph construction were explained in the **Prologue**. (From NASA photos AS17-145-22165, and -64).

Fig. 28. Near the end of **EVA-2**, Jack Schmitt stopped at this ca. 3 m diameter, shallow crater near the **ALSEP**. It contained a glassy area in the bottom (whitish rock patch at bottom center and right of center) from which he wanted to take a glass sample. He had planned to get such a sample before the mission because colleagues had suggested that an impact glass sample might preserve any extant magnetic field as the melt cooled through the Curie Point. A glassy rock would mean that its orientation would have remained unchanged since formation because not enough time would have elapsed for micrometeoritic impact to abrade away the glass, thus disturbing the rock orientation. Hence, it should be possible to determine the magnetic field intensity and its orientation at the time of impact. No such glassy samples were returned from the other Apollo missions, so Jack's documented sample from this site represents an important piece of information. A search of the Apollo science documentation indicates that after the mission, the "before" and "after" *in situ* stereo photos that Jack took were not utilized for sample position and orientation, and paleomagnetic studies on this sample were never undertaken. The following photos and anaglyphs present the sample's orientation for the first time. (NASA photo AS17-145-22185).

Fig. 29. (*upper*): One of a "before" cross-sun pair taken by Jack Schmitt of the sample area. The elongated sample is shown centered within the white circle. (*lower*): An enlarged view of the location showing the sample in the center of the white circle. (NASA photo 145-22188)

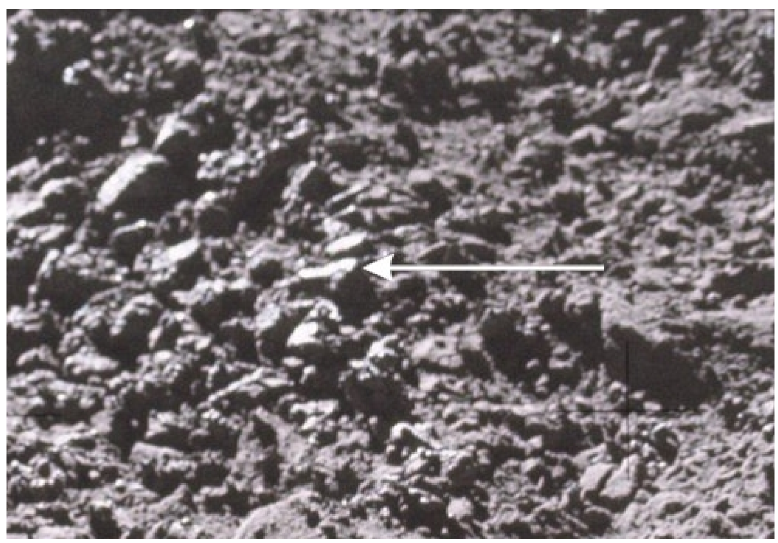


Fig. 30. (*upper*): The "before" up-sun view with the white arrow pointing to the location of the rock sample. There was no "after" photo taken in the up-sun direction. (*lower*): An enlargement of the sample and its location. (NASA photo 145-22187).

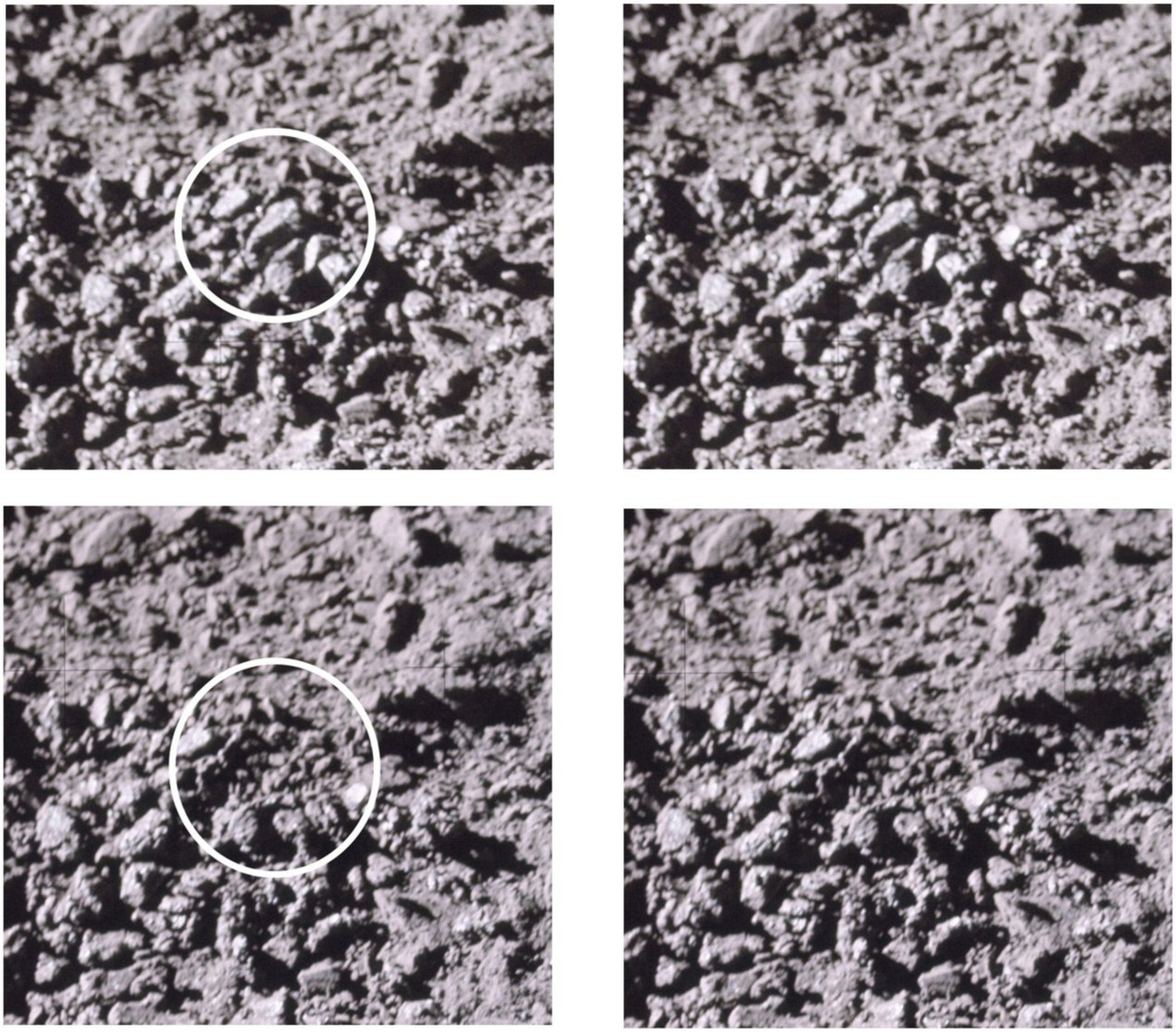


Fig. 31. (*upper register*): The "before" cross-sun enlargement with and without the white circle identifying the rock sample. (*bottom register*): The "after" cross-sun enlargement with and without the white circle showing the absence of the removed rock sample. A study of **Figs. 29-31** should enable the reader to view the anaglyph stereos on the following three pages and be able to quickly discern the sample and its location *in situ*. (From NASA photos 145-22188 and -22191).

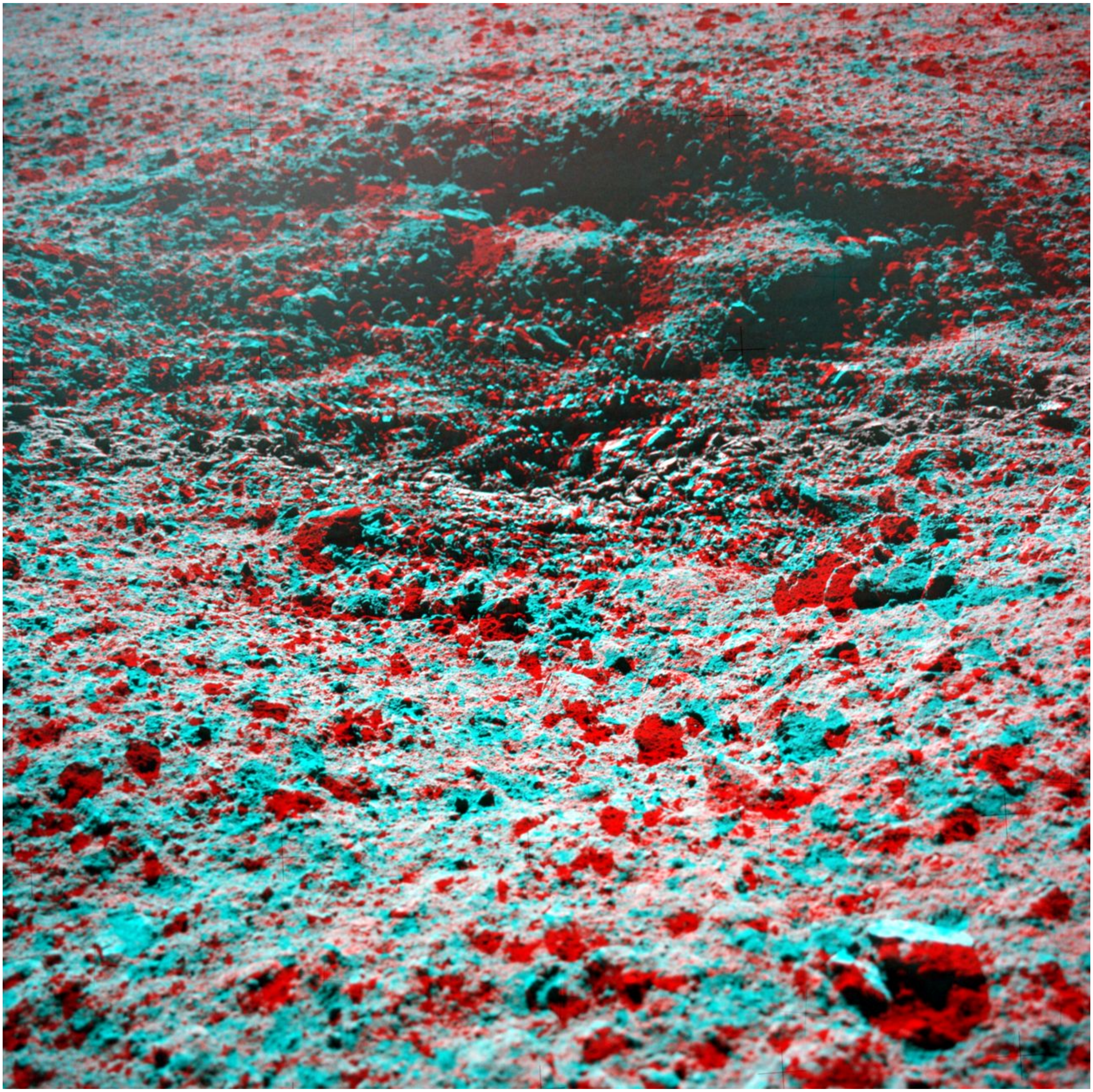


Fig. 32. The up-sun 3D view made from Jack Schmitt's stereo photos. The glass area of the crater is just above the middle of the photo. The **sample** is about 5.0 inches (13 cm) long (as later measured in the lab) and lies a little less than 1/3 of the way to the right of the center of the photo with the shadow end facing the viewer. Cf. **Fig. 30, Fig. 33** and **Fig. 34**. (From NASA photos AS17-145-22187 and -22186).

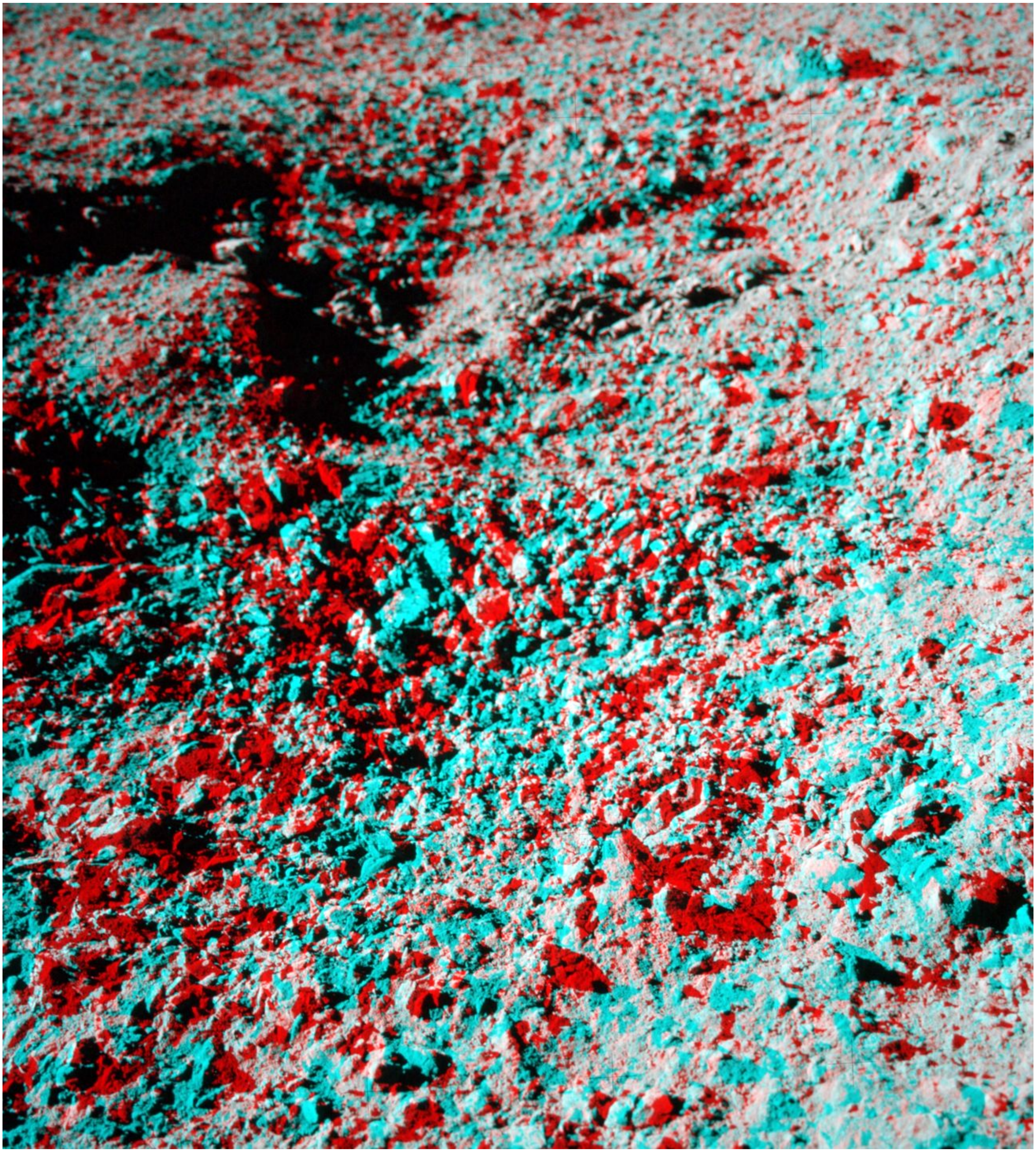


Fig. 33. The cross-sun "before" 3D view of the sample *in situ*. Cf. Fig. 29 and Fig. 34. (From NASA photos AS17-145-22189 and -22188).

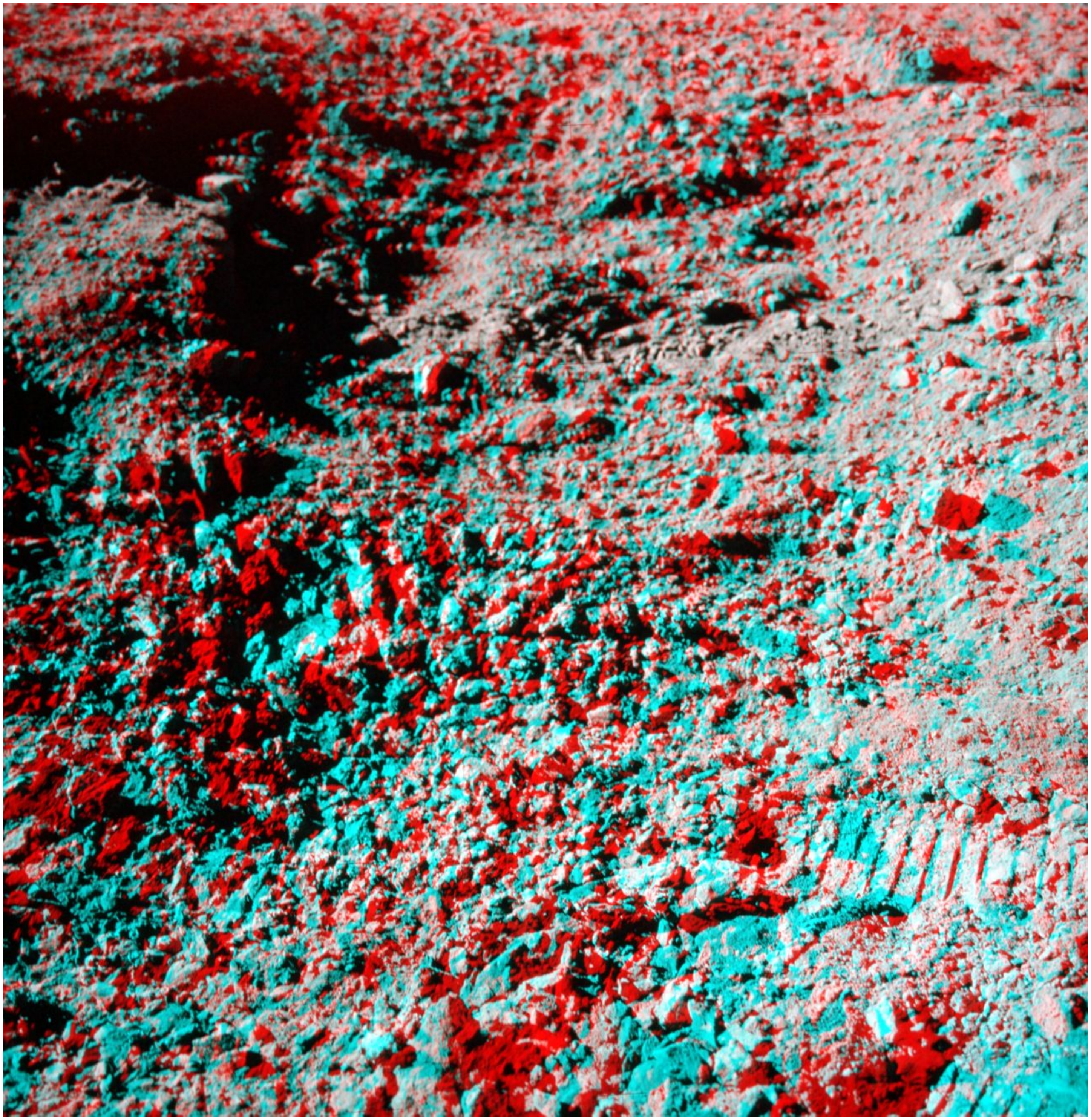


Fig. 34. The cross-sun "after" 3D view of the sample location. Cf. [Fig. 31] and [Fig. 33]. The sample was within about 2 feet of Jack's right boot print at the bottom right so within easy reach of the sample tongs without disturbing the surroundings. (From NASA photos AS17-145-22191 and -22190).

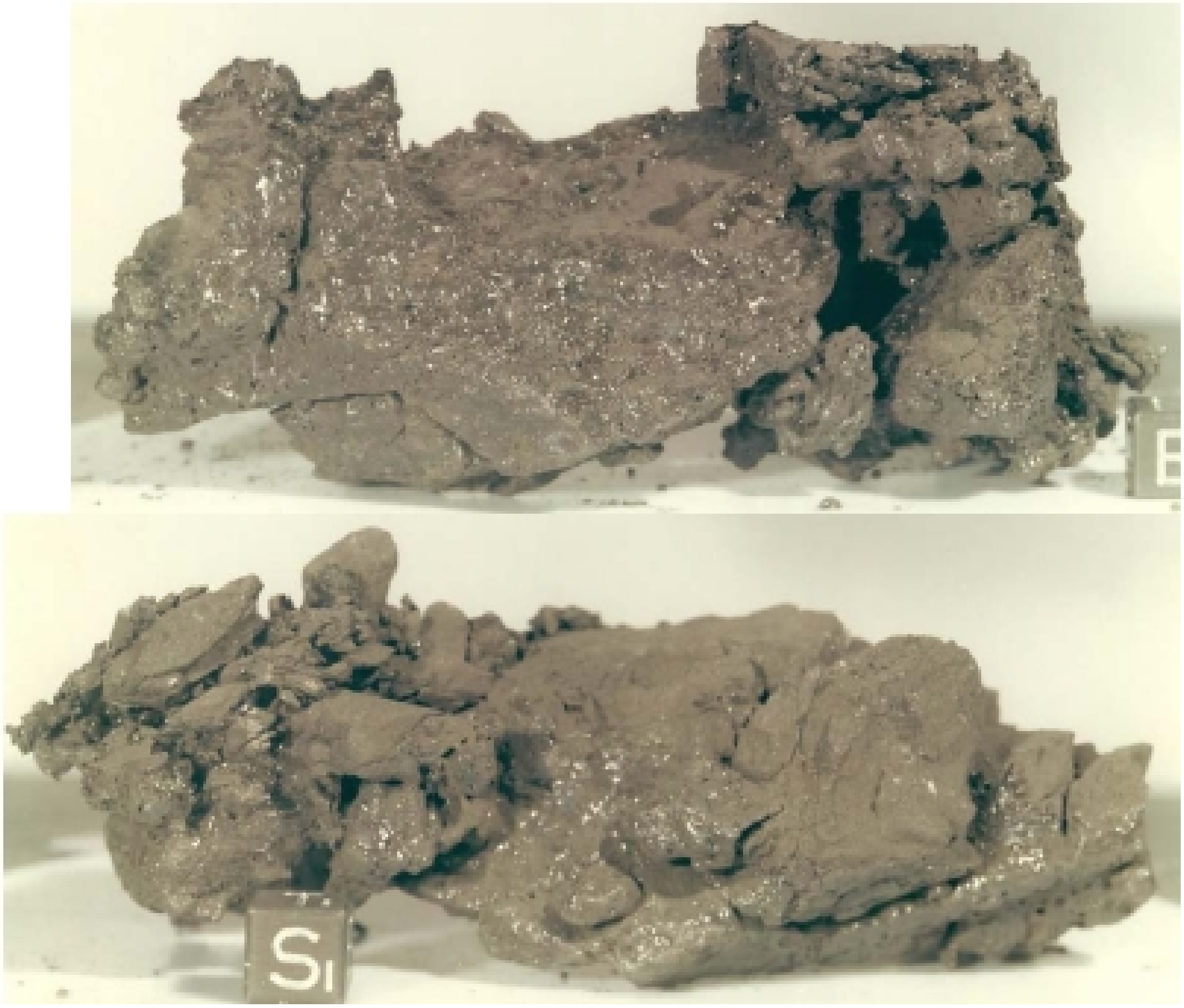


Fig. 35. Two views of the glass-welded breccia, given the lab designation of 70019, which Jack Schmitt picked up from a glassy patch near the bottom of a shallow, 3 m diameter crater between the ALSEP and the LM (**Fig. 28**). The cube has 1 cm sides. The sample itself weighs 159.9 gm. Lab photos and data on all archived returned lunar samples are available online in C. Meyer, *The Lunar Sample Compendium*, http://curator.jsc.nasa.gov/lunar/lsc/). Computation of the sun's azimuth and elevation from the time of the photos combined with a line through the shadows of a dozen samples in the crater gave the azimuthal orientation of the 70019 rock as 215.33° ± 3.86°. Four of those measurements were from the up-sun photos in which shadow lengths were more difficult to determine. A line through the rock sample itself was also difficult to determine because of its near end-on, foreshortened aspect. Those measurements grouped together to give values much lower than the eight measurements from the cross-sun photos. If those four are omitted, then the orientation increases to 217.5° ± 2.55°. Studies of the paleomagnetic properties of 70019, as well as a few possibilities from at least two other missions, are under consideration. (NASA/JSC photo, http://curator.jsc.nasa.gov/lunar/lsc/70019.pdf).

Fig. 36. (*upper*) Jack's up-sun locator photo taken within the shallow 70019 crater showing the position of the LM. Several i.d. markers are also shown in an attempt to locate the 70019 crater marked by the white * using the LRO photo of [Fig. 37](#). **A,B** denote two craters on the other side of the parallel LRV tracks. **C** denotes a crater in the near field between the distances of **A**,**B**. **D** is a boulder beyond **C**. The LRV tracks are to the right of **A**,**B**. The direct line-of-sight from Jack's camera is centered on his window in the LM as indicated by the reseau cross in the enlargement at right of the black square area above. See also [Fig. 28](#) for the larger, unlabeled version of this photo. (NASA photo AS17-145-22185 and enlargement).

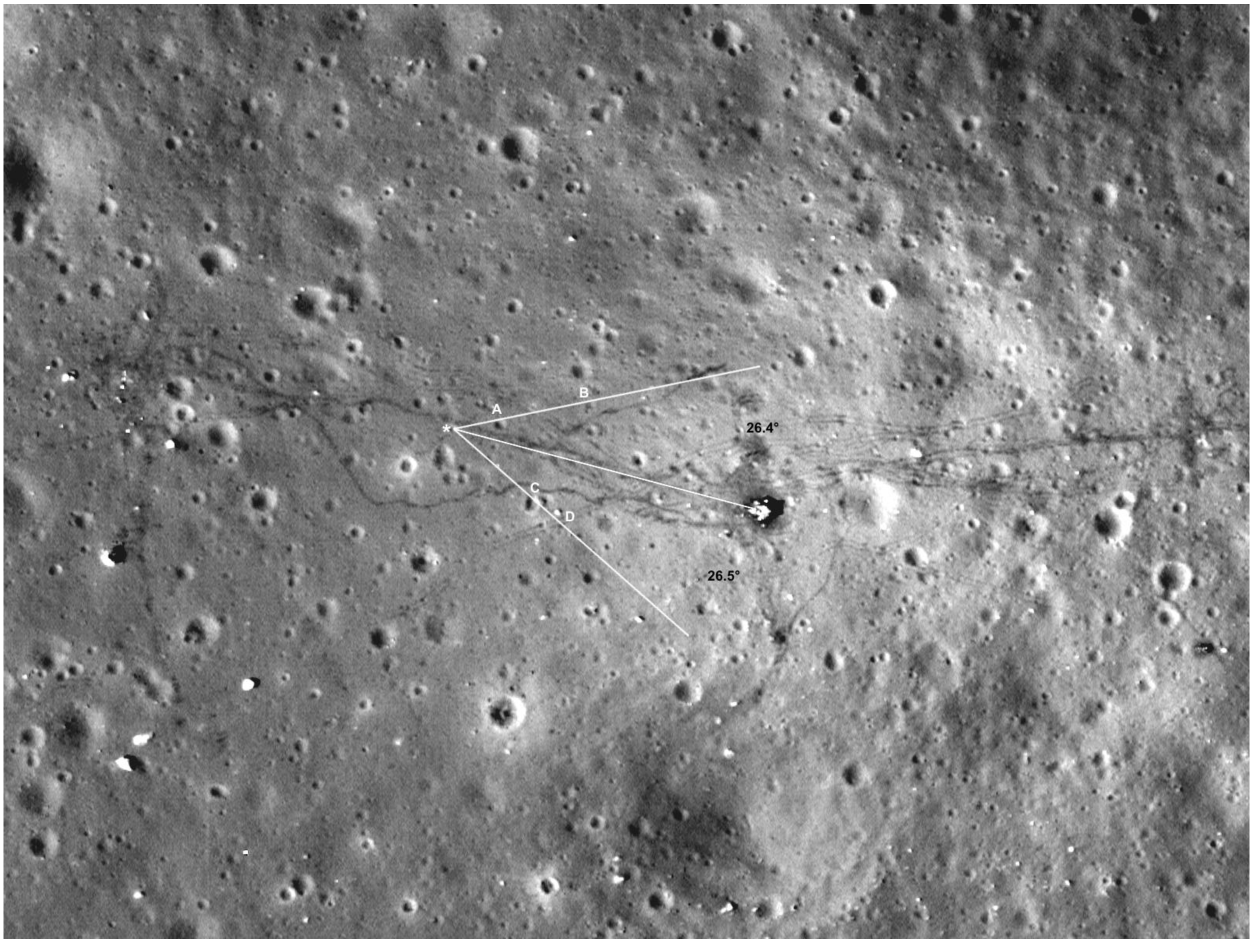
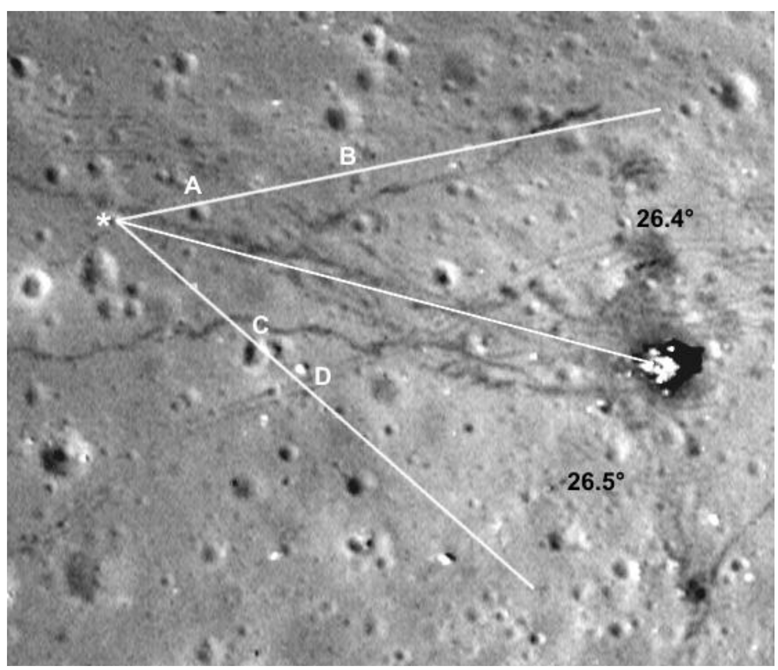
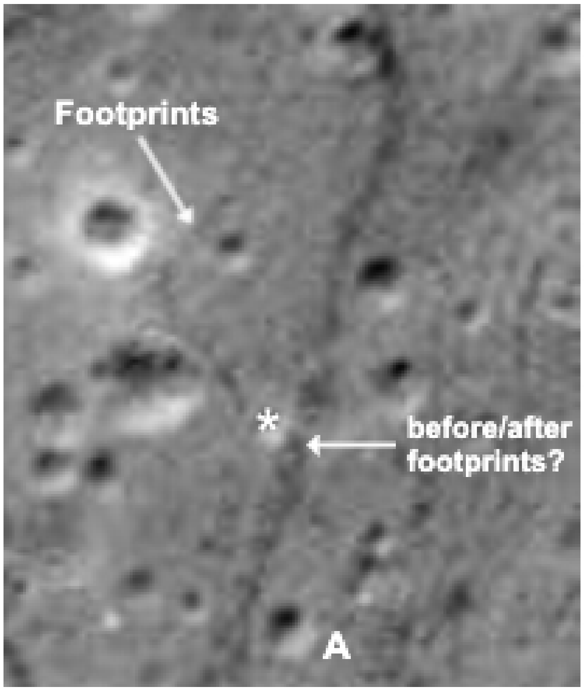


Fig. 37. (*upper*) LRO photo M168000580, the highest resolution NAC photo of the Apollo 17 landing site taken on 08/14/2011 from an altitude of 22 km. (*right*) Enlargement of the central area of the photo showing the tentative location of the 70019 crater (*), and the i.d. markers depicted in **Fig. 36**. The reseau crosses have an angular separation of 10.3°. The direct line of sight intersects Jack's LM window. Thus, the left and right edges of the photo have angular separations from the window of 26.4° (top) and 26.5° (bottom). The corresponding lines are marked in both photos. The reader can compare the marker locations **A,B** and **C,D** with the photo in **Fig. 36**. The location of the 3 m diameter 70019 crater was suggested to the author by Jack Schmitt. The determination may be clearer from Jack's footprints in **Fig. 38**. (NASA/ASU/GSFC photo and enlargement).





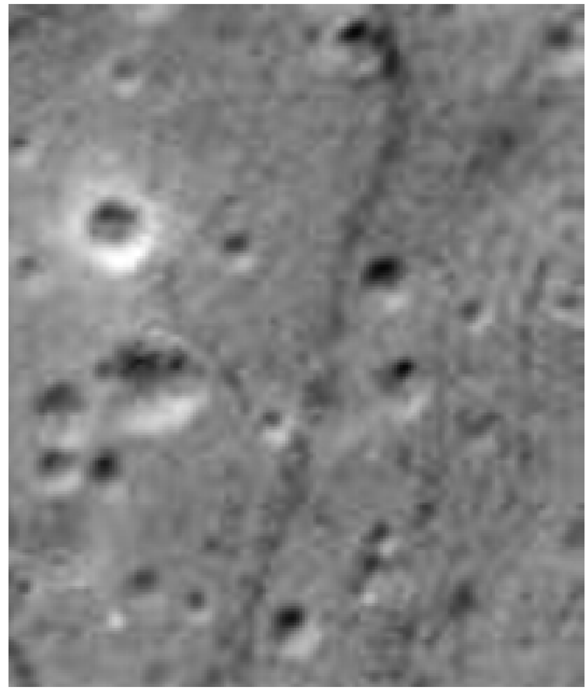


Fig. 38. Enlargement of the area showing the tentative location of the 70019 crater (*). The enlargement has been rotated so that West is at the top. The grouping of 4 craters at center left which resembles a cat's paw can be used as a locator in **Fig. 37**. **A** is the same crater marked in **Fig. 37**. Of particular interest is the line of footprints proceeding down the photo and swinging around the cat's paw towards the crater marked with the asterisk (*). The path resembles a sine wave. The footprints join a pair of LRV tracks, one of which is on the very lip of the cat's paw crater. The other heavier track stops at the 70019 crater edge as seen in the unlabeled view at right. The lighter part of that same track continues on past the 70019 crater. Jack had taken Gene's camera and a set of sample tongs near the end of EVA-2 when they were returning from Camelot crater (at 147:06:41, see **ALSJ**, italic annotation) and walked towards the 70019 crater, which he had probably noted earlier when he walked back to the LM from setting up the ALSEP during EVA-1. The single line labeled "Footprints" marks that track. The LRV tracks that skirt around the cat's paw crater were probably made when Gene drove the LRV alone on an outbound trek to the ALSEP area during EVA-1. Jack's "sine" wave tracks above mark his return for the sample. In the crater, he faced the LM to take the locator photo in **Fig. 36** and also the "before" up-sun photo pair (**Figs. 30**, **32**) of the sample he was about to pick up. He then walked out of the crater to the right, turned around and made two more photos, the "before" cross-sun stereo pair (**Fig. 33**), before getting the sample. He then proceeded back into the crater, turned to face the LM as indicated by his boot prints in **Fig. 34**. This positioned his right side towards the sample making it easier for him to lean over in the manner shown in **Fig. 12** at the SEP. He used his sample tongs to pick up the rock and then carefully turned to his left to walk back out of the crater. He then double-bagged the sample because it was fragile, and turned around to take two more photos of where the rock had been, the stereo "after" cross-sun pair. All of these later motions with the before and after photos and double-bagging the sample must have disturbed the finer soil much more than a single line of walking. These actions may therefore be the explanation of the "nodule" or dark shadow next to the crater marked by the arrow in the left view above. The darkish band through here and wavy lines at right mark the course of other foot traffic and of the LRV in several excursions (Cf. **Fig. 37**). Finally, the resolution of the photo is effectively 0.5 m/px, which implies the 3 m crater is 6 pixels wide, consistent with enlarging the photo until the pixels become visible enough to count. (photo enlargement from NASA/ASU/GSFC LRO photo M168000580).

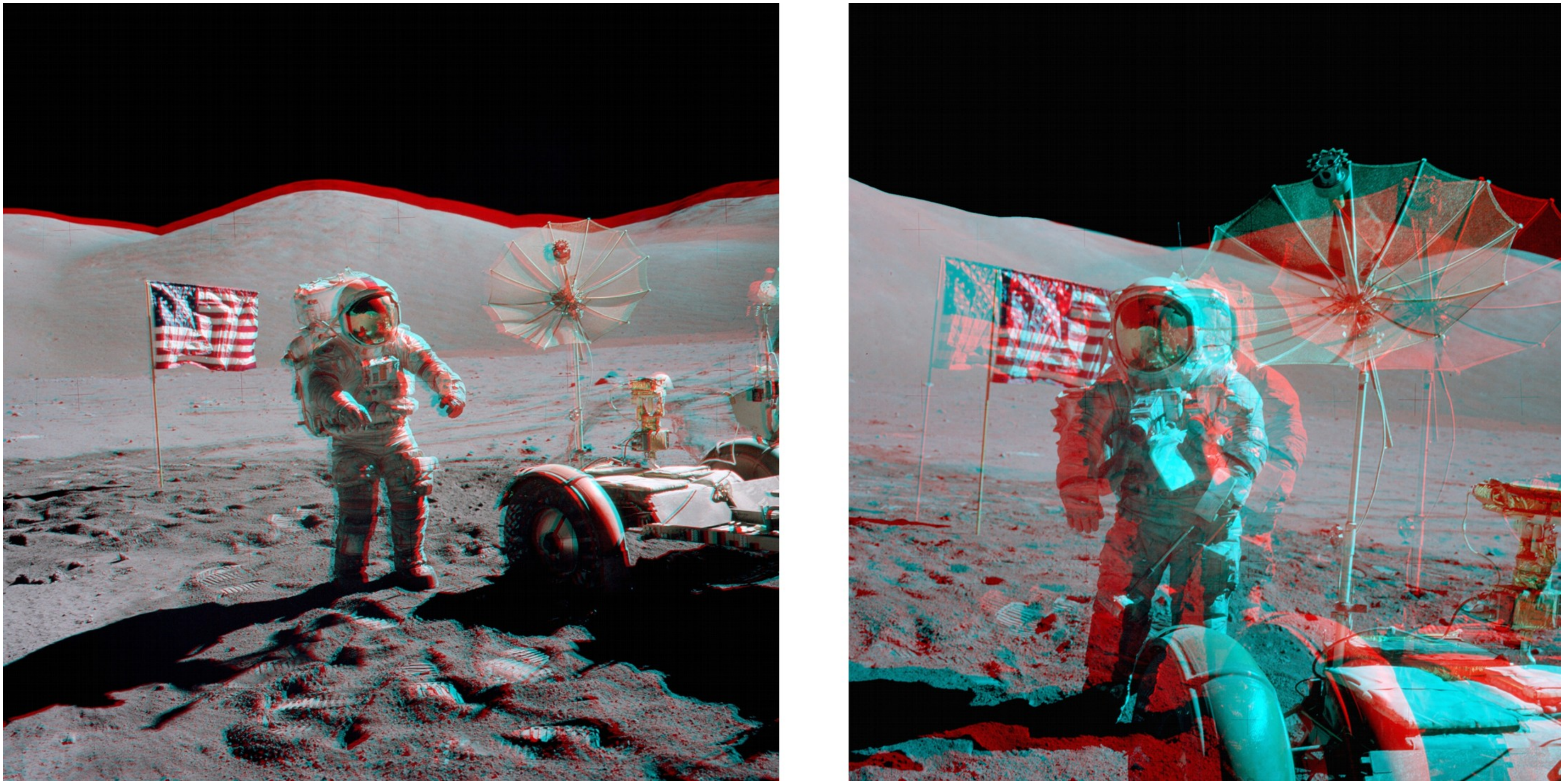


Fig. 39. At the start of **EVA3**, the astronauts photographed each other near the **LM** before heading towards the large boulder at Station 6, which had earlier been seen in Apollo 15 orbital photos of the valley. At left is Jack Schmitt's portrait of Gene Cernan. Note that Cernan's Hasselblad camera is not attached to his chest because Schmitt is using it (it has the color film). At right is Gene Cernan's portrait of Jack Schmitt. Schmitt's camera is attached because it contains the b&w film. (From NASA photos AS17-140-21388, and -89 (*left*); and AS17-140-21385, and -86 (*right*)).

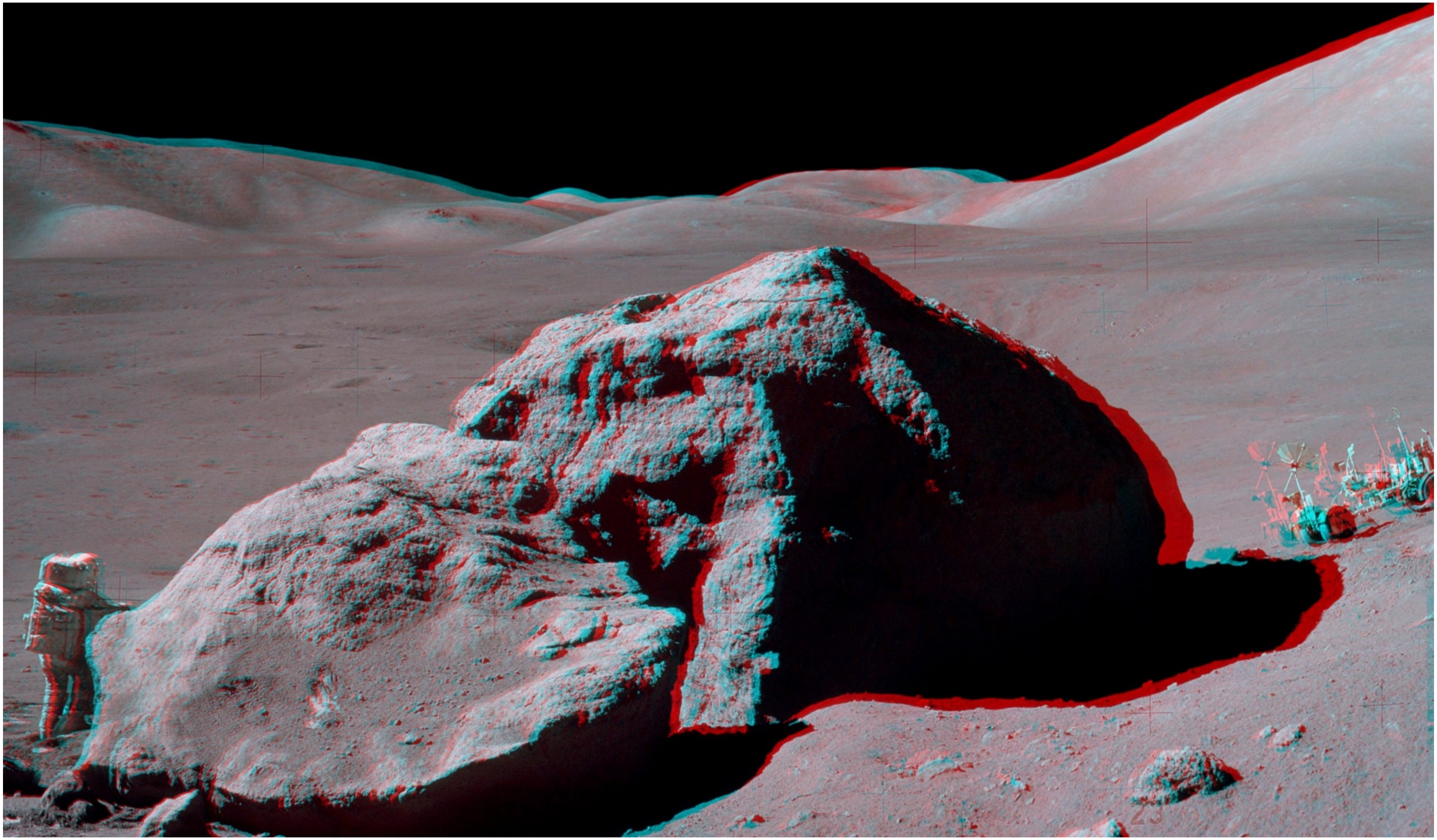


Fig. 40. Part of Gene Cernan's **Station 6** pan showing Jack Schmitt walking along the southern side of the boulder. Schmitt referred to it as the "Split Boulder" during the mission because it had broken into five pieces after rolling down the North Massif. However, Al Bean later dubbed it "Tracy's Rock" after Cernan's daughter because of the painting he made of it, adding Tracy's name in the dirt beside the scrape marks on the shelf. The rover is parked on a 10° slope. (From NASA photos AS17-140-21497, -95; and -96, -94).

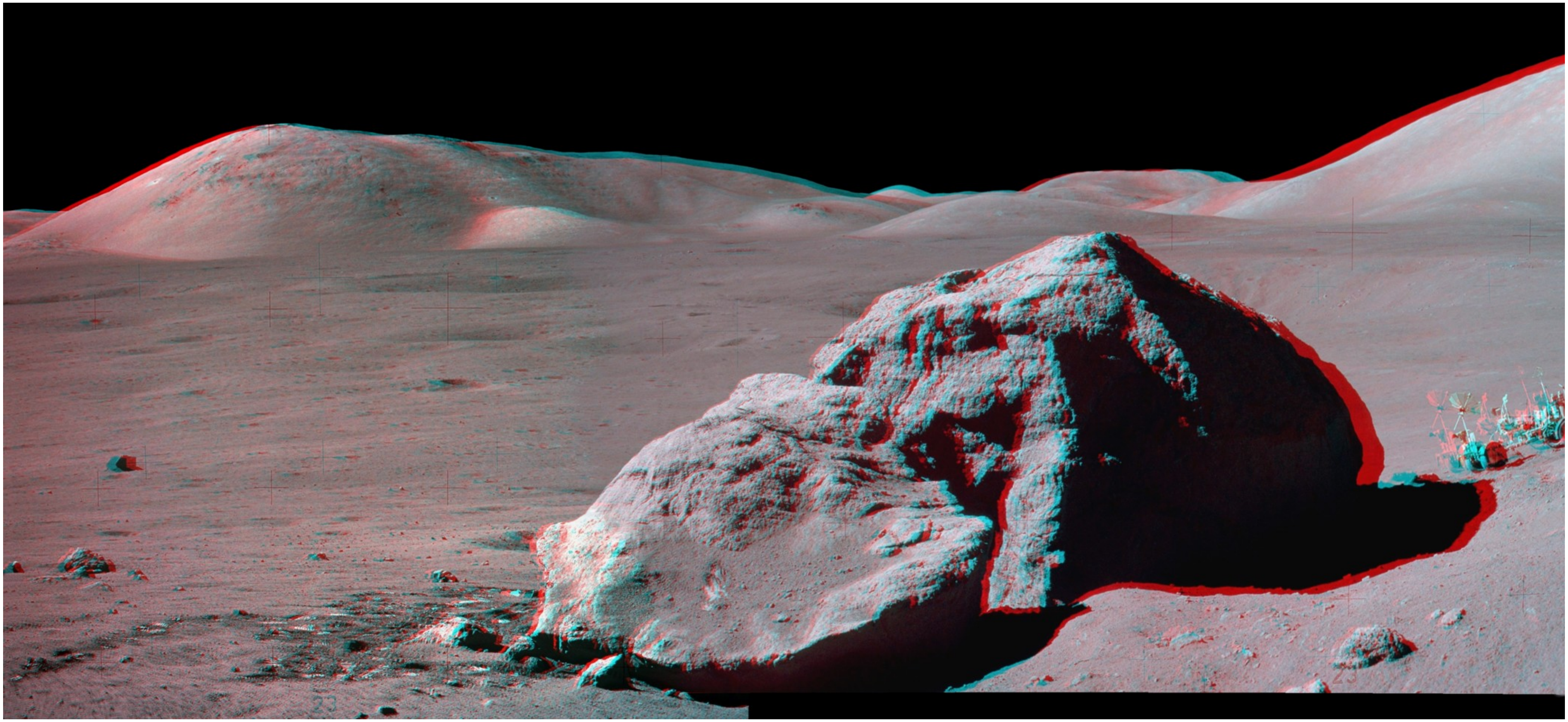


Fig. 41. A wider view from Gene Cernan's pan of the **Station 6** boulder showing the central part of the valley. The East Massif peak at left is located 20 km away. Bear Mountain at the top of the boulder is about 8 km away. The left and right sides of Henry Crater can be seen near the top of the boulder. The **LM** is located ~3.0 km away in the small, horizontal bright streak intersecting the top of the boulder on the right just above Henry Crater. (From NASA photos AS17-140-21500, -499; -497, -95; and -96, -94).

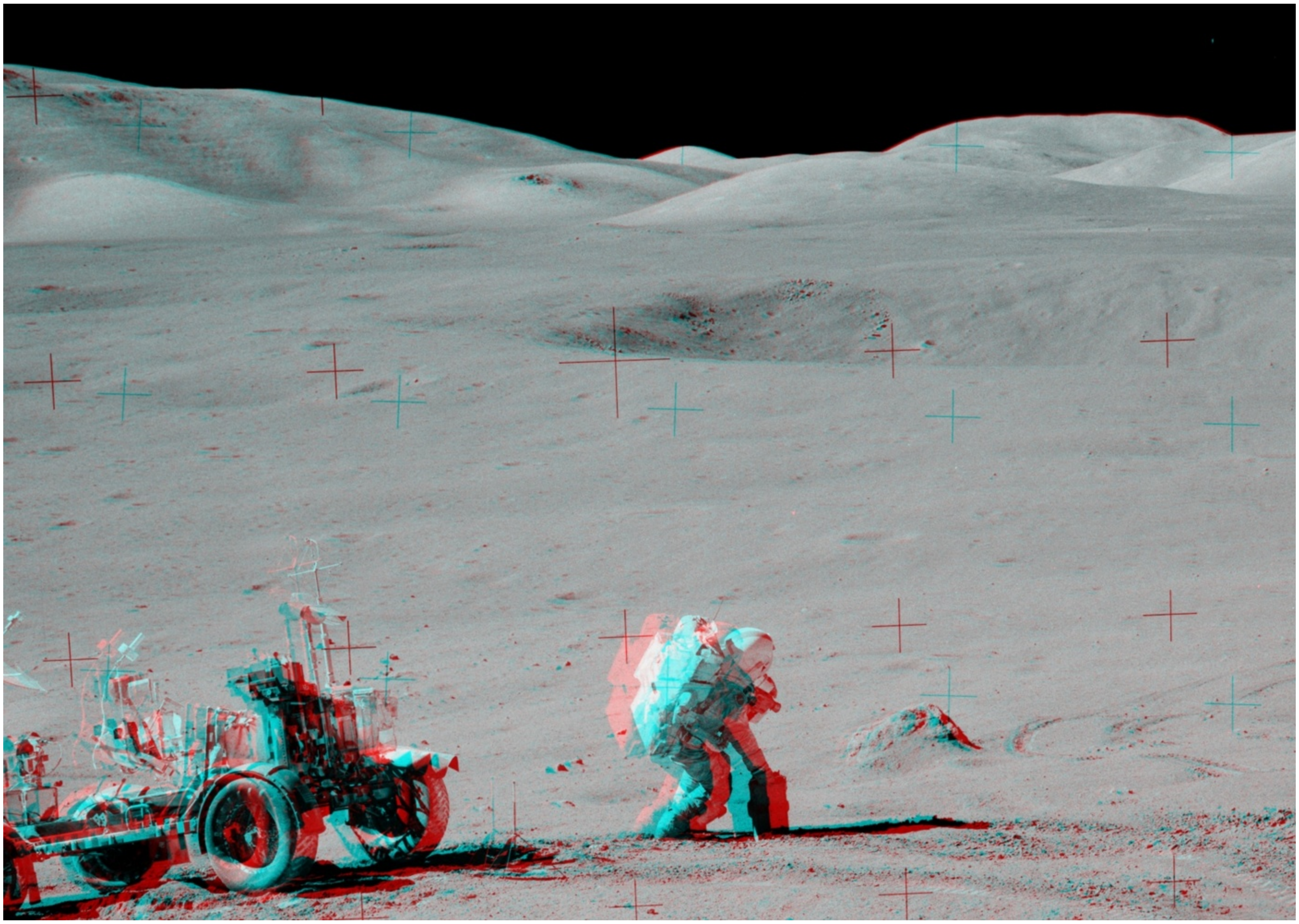


Fig. 42. Gene Cernan is placing the traverse gravimeter on the ground for a reading of local gravity at **Station 6**. The **LM** can be seen in the upper right portion of the frame as the small cube in the whitish, horizontal streak just above the Henry Crater's south rim (rim opposite viewer). Enlargement of the page size will facilitate finding the LM. (From NASA photos AS17-141-21599, and -60).

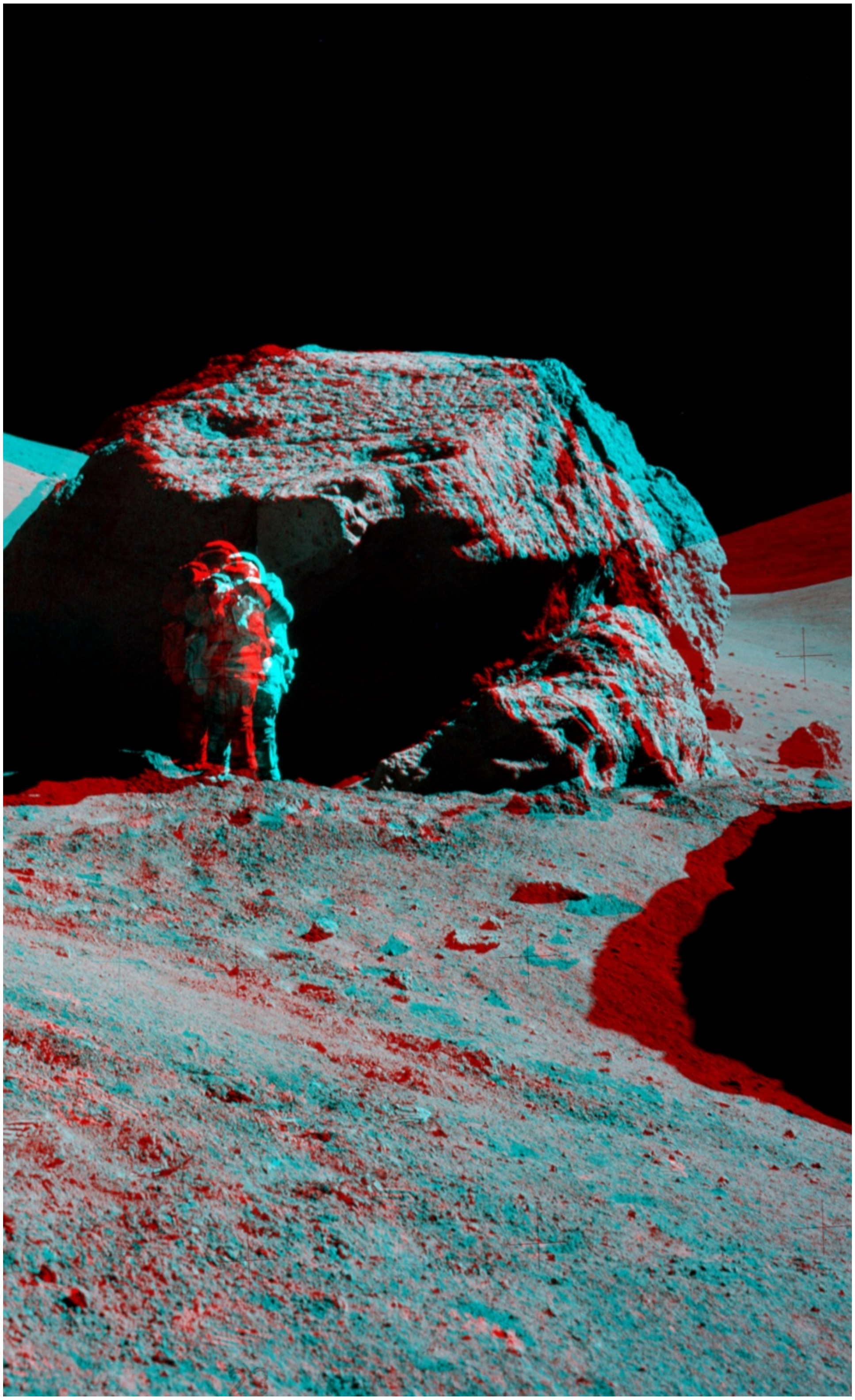


Fig. 43. Gene Cernan is standing near the rover at the west end of the **Station 6** boulder taking a picture of Jack Schmitt as Schmitt takes a picture with the 500 m telephoto Hasselblad camera of the boulders on the side of the South Massif across the valley. (From NASA photos AS17-146-22294, and -93).

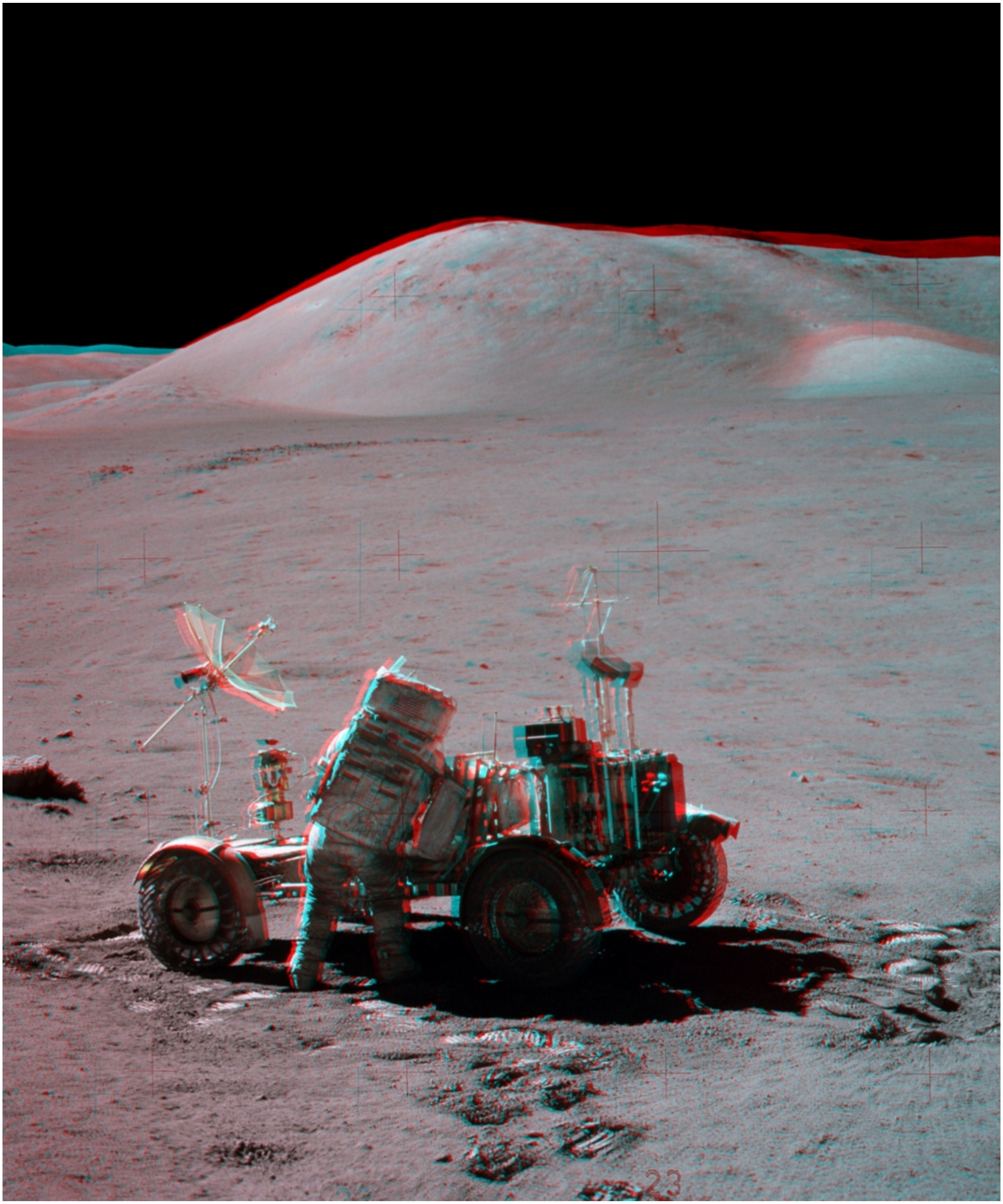


Fig. 44. Jack Schmitt at the **LRV** at **Station 7** taking the rock box (**SCB**) off his right shoulder to check the latches. (From NASA photos AS17-146-22345, and -46).

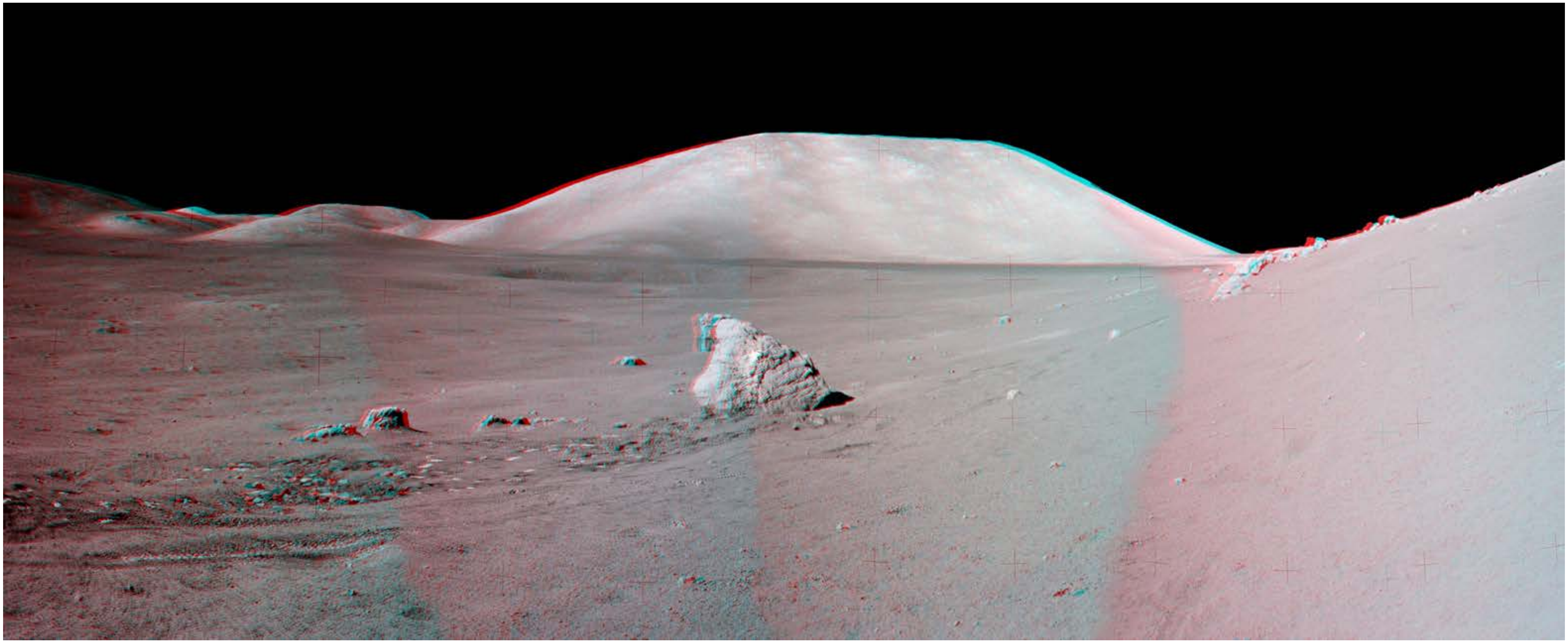


Fig. 45. Continuation of Gene Cernan's **Station 7** pan to the right of **Fig. 44**. The boulder at center was another sampling site as evident from the **LRV** tracks and footprints. The Station 6 **boulder** is in the middle group of the three groups of boulders on the slope at right about 475 m away. Henry Crater is above the Station 7 boulder. And the **LM** is located above left of Henry, just over 3 km away. (From NASA photos AS17-146-22348, -49, -50, -51, -52, -53, -54, and -55).

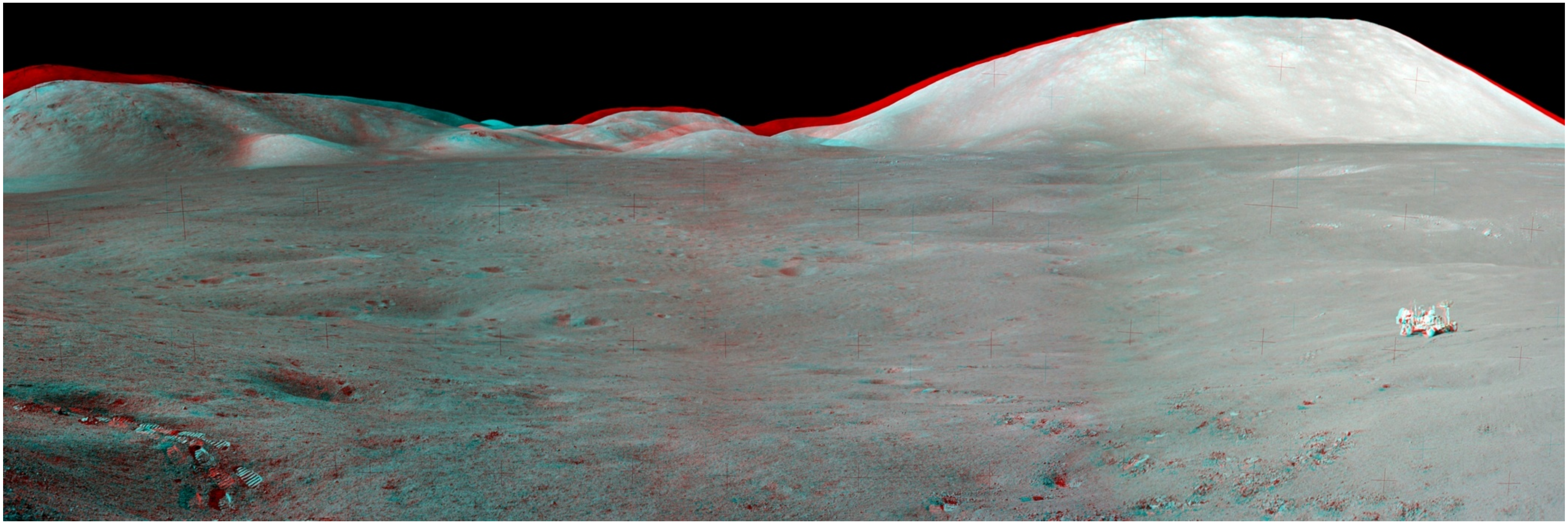


Fig. 46. View of Taurus-Littrow Valley from the easternmost point visited by the astronauts at **Station 8**. The straight line distance to Nansen, the westernmost **Station 2** at the far right just off the photo, is about 11 km. The **triad** crater group, Cochise (dark wall), Shakespeare (dark wall), and Henry (bright wall) are at upper middle and right. Jack Schmitt is at the rover. The **LM** can be seen, if the page is enlarged, above the right side of Shakespeare at just over 4 km away. (From NASA photos AS17-146-22378 through -87, inclusive).

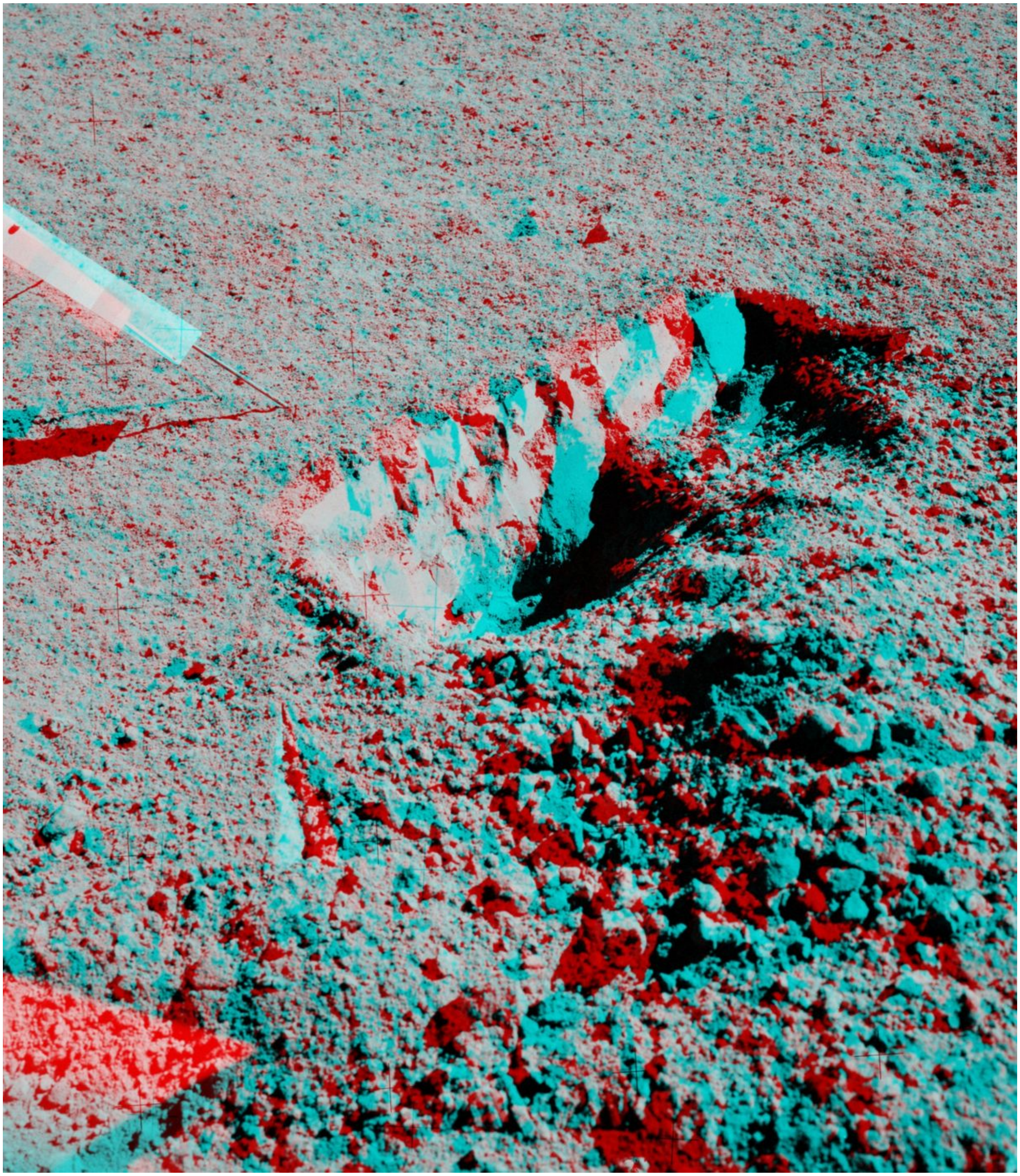


Fig. 47. A trench dug by Jack Schmitt at **Station 8** in order to obtain clod samples at various depths. The head of the scoop is at lower left. The soil is very cohesive as indicated by the fine, planar wall surfaces left by the action of the scoop in the trench. (From NASA photos AS17-142-21721, and -22).

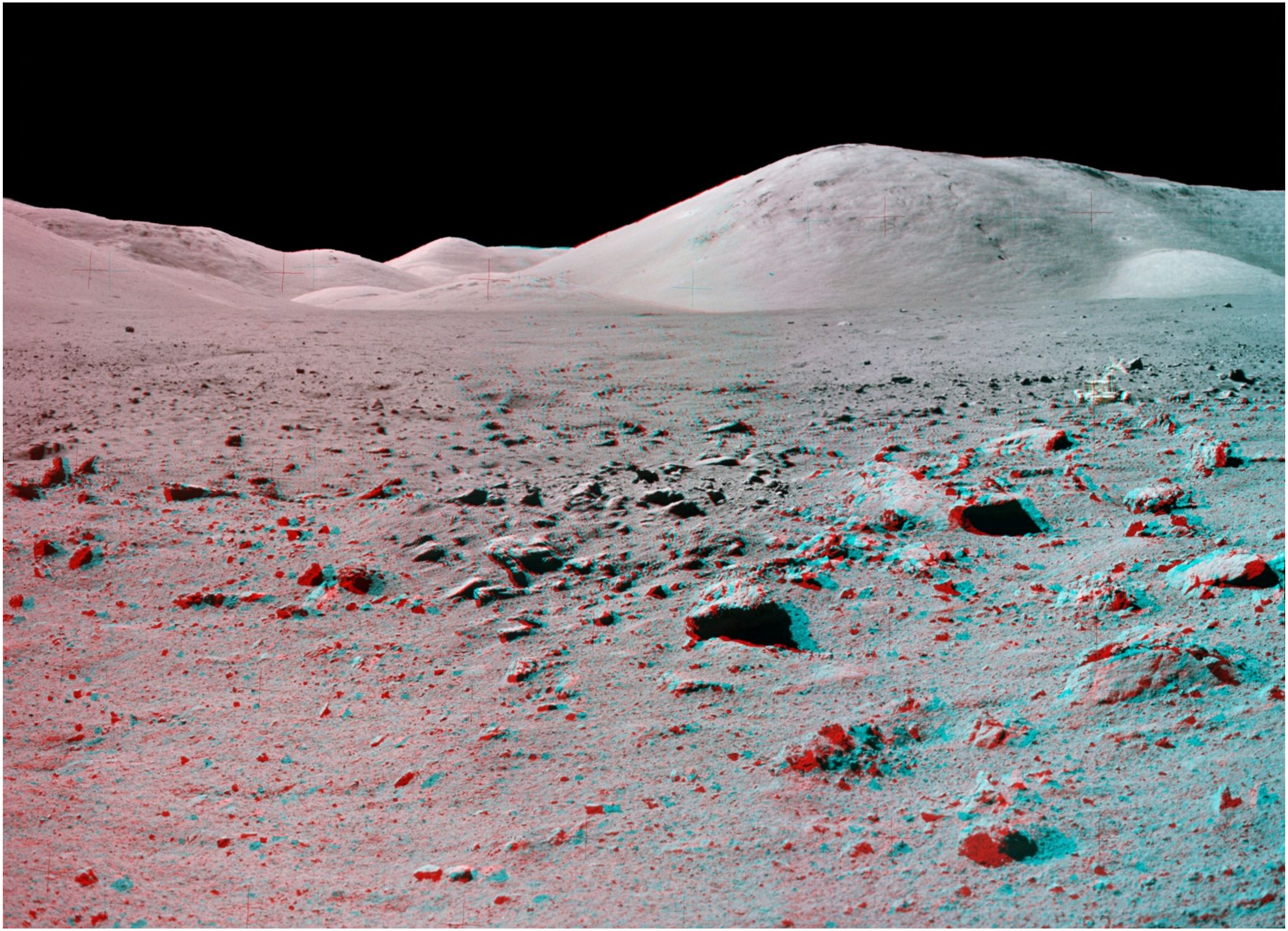


Fig. 48. The last stop before returning to the LM was at Van Serg Crater, Station 9. Note the roughness, the LRV at right, and boulders stopped in mid-roll for millions of years on the slopes of the East Massif. (From NASA photos AS17-146-22444, -45, -46, and -47).

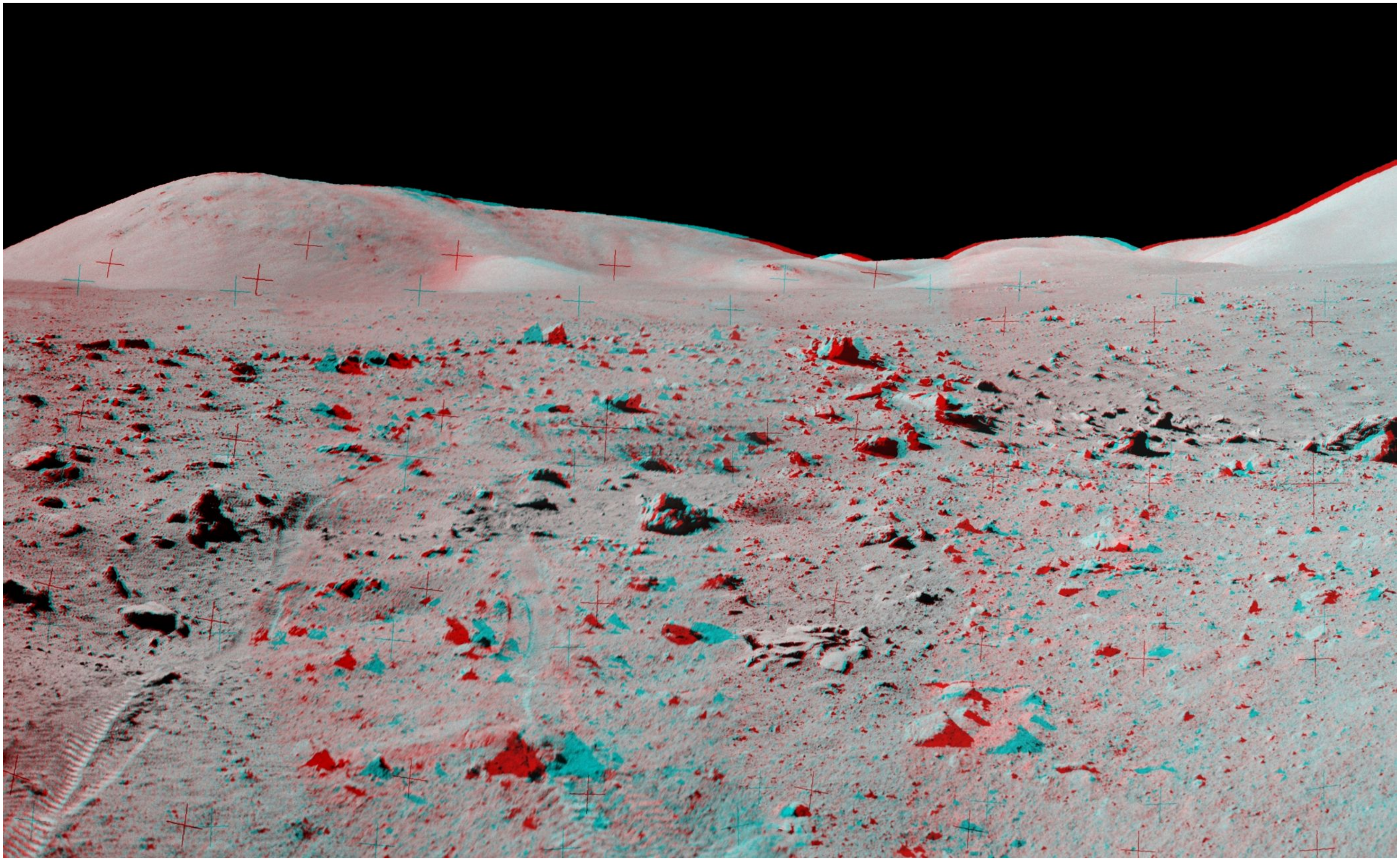


Fig. 49. Part of Jack Schmitt's pan made about 15 m southeast of the **LRV** at Van Serg, **Station 9**. Particularly noteworthy are the LRV tracks at left rolling down into and out of two successive, small craterlets. Driving the route indicated by these tracks into the distance must have provided a very bumpy ride! The jagged rocks in all of the Station 9 photos are friable breccias resulting from sintered fine grain material produced during the impact that formed Van Serg Crater. (From NASA photos AS17-143-21845, -46, -47, -48, -49).

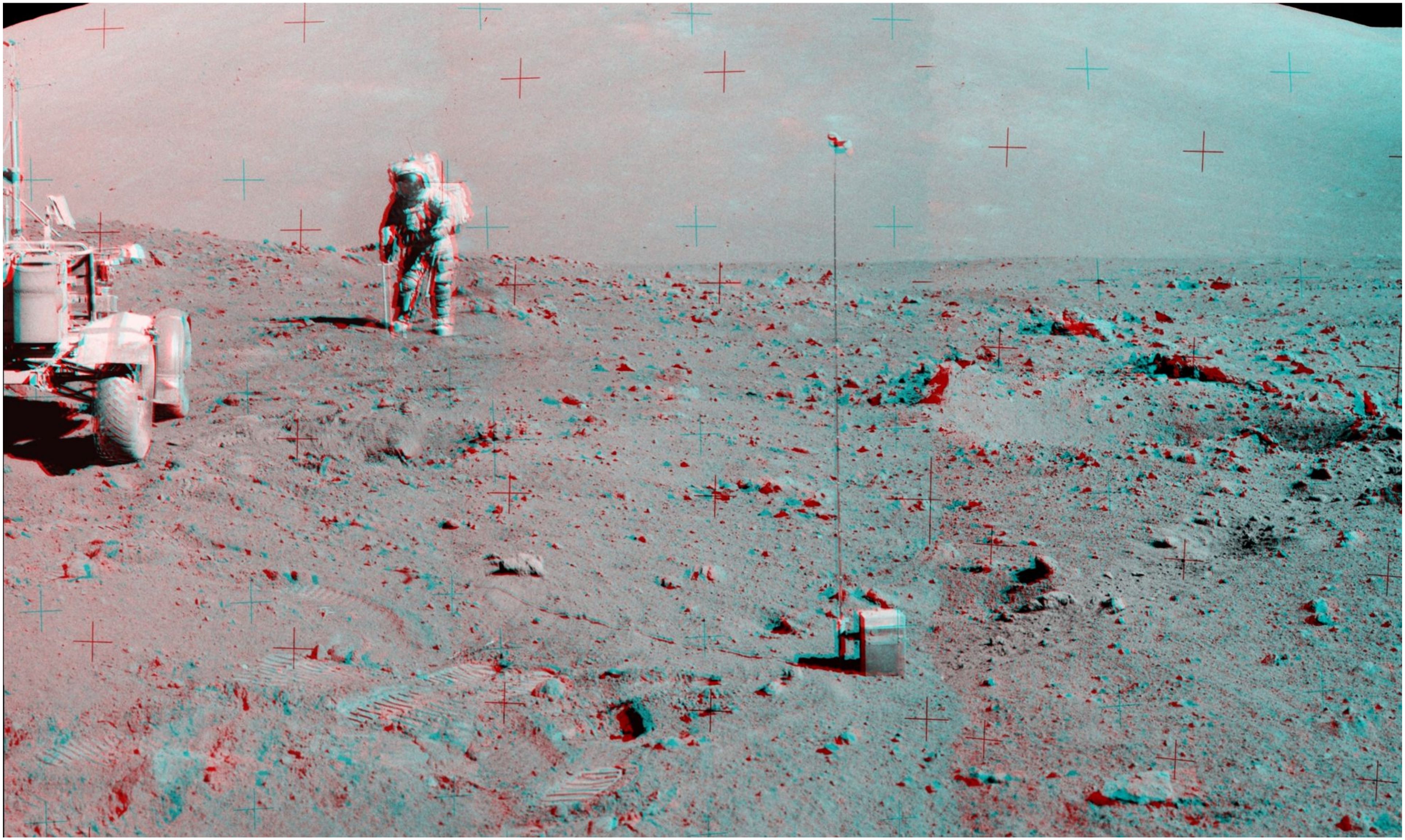


Fig. 50. Another part of Jack Schmitt's pan at **Station 9** southeast of the **LRV**, now visible at left. Gene Cernan is working with a double core tube. At right is seismic charge No. 5. A number of these charges were positioned around the valley to determine the regolith structure. They were detonated remotely from Houston after the astronauts left the Moon. (From NASA photos AS17-143-21836, -37, -38, and -39).

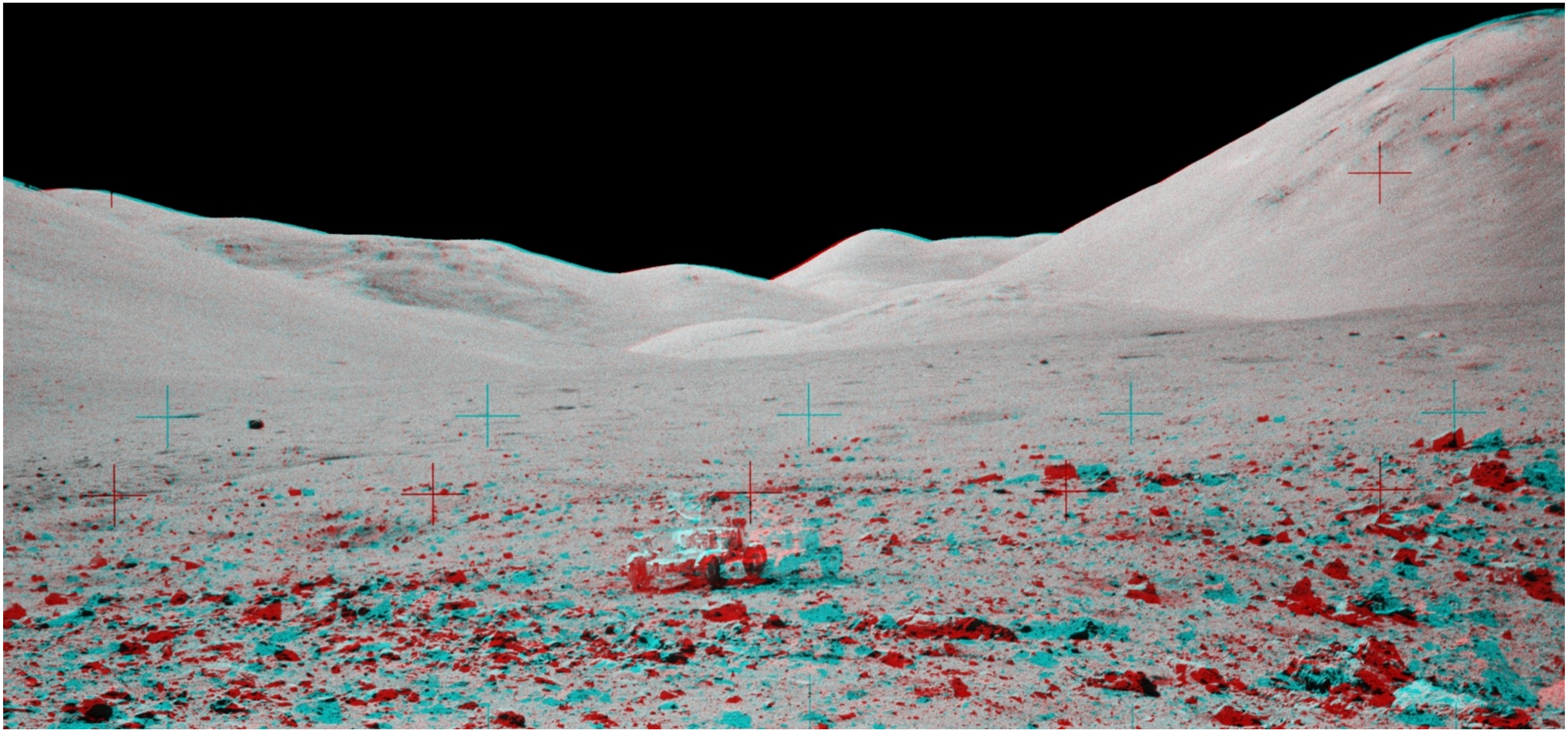


Fig. 51. Part of Jack Schmitt's pan at **Station 9** on the northwest side of the **LRV**. Van Serg Crater is behind Schmitt. The East Massif is at right. (From NASA photos AS17-142-21817, and 21824).

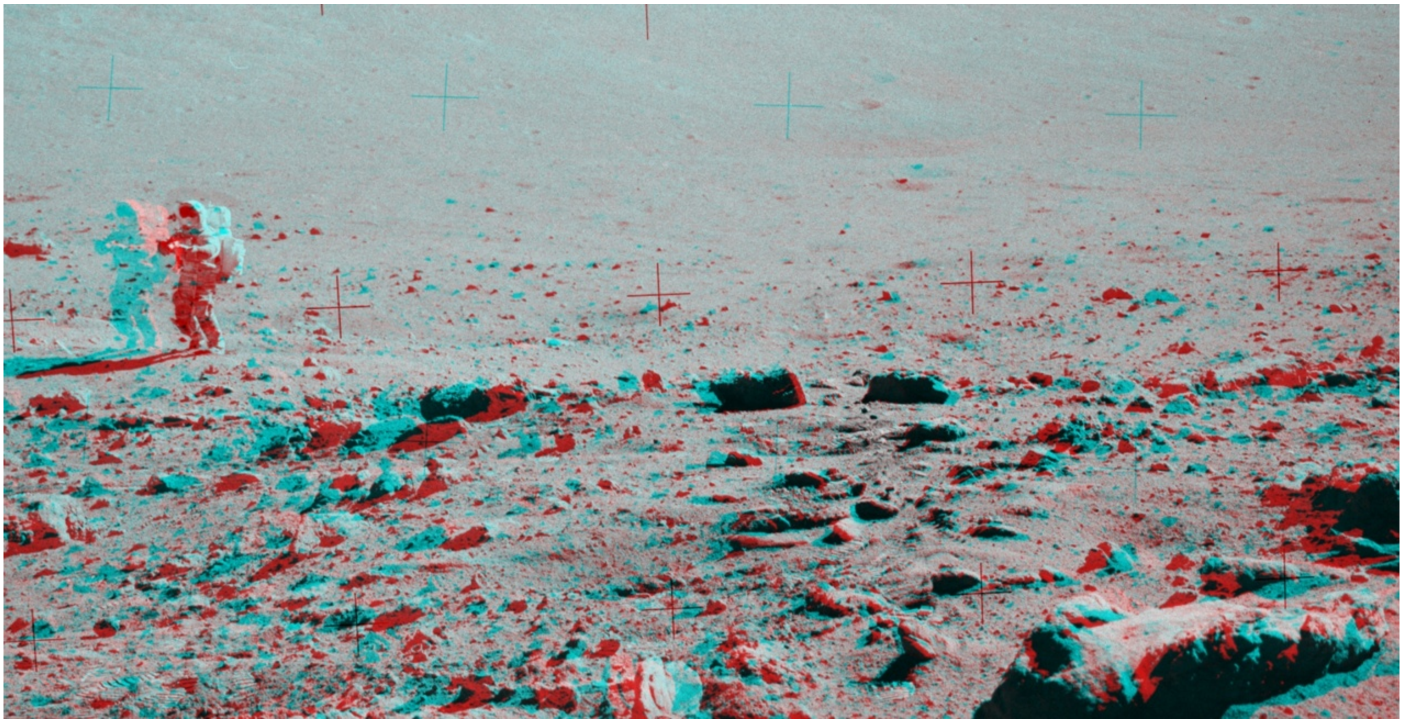


Fig. 52. Another part of Jack Schmitt's pan NW of the **LRV** counter-clockwise from **Fig. 51** showing Gene Cernan at the edge of Van Serg Crater making a pan of it. Note the typical posture resulting from lunar gravity and the heavy backpack. Cernan is leaning slightly forward with bent knees and is standing on tip toes. (From NASA photos AS17-142-21812, and -13).

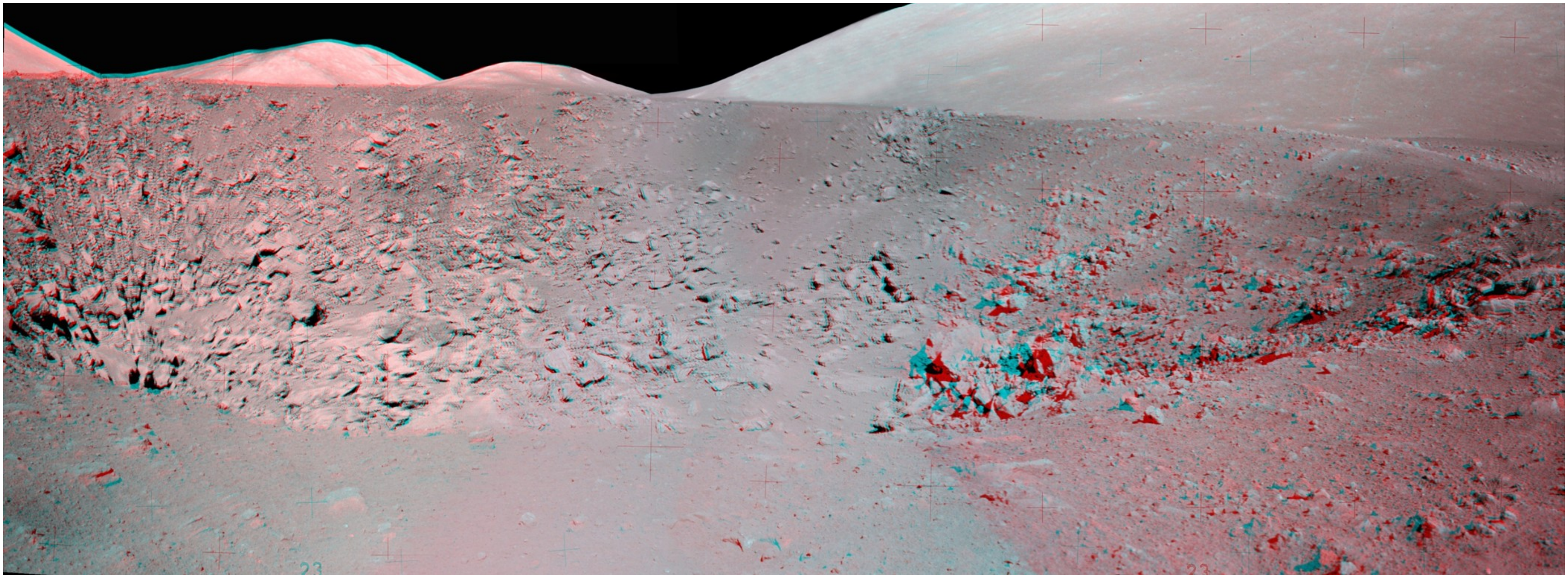


Fig. 53. Part of the pan Gene Cernan was making in **Fig. 52** of Van Serg Crater at **Station 9**. Part of the North Massif is at right and a small wedge of the South Massif is at left. What is now called (West) Family Mountain is the larger of the two mountains at the entrance to the valley and (Old) Family Mountain, the smaller, is to the right of it (see http://www.hq.nasa.gov/alsj/a17/a17.fam-mtn.html for this nomenclature) (From NASA photos AS17-146-22426, -27, -28, -29, and -31, -32).

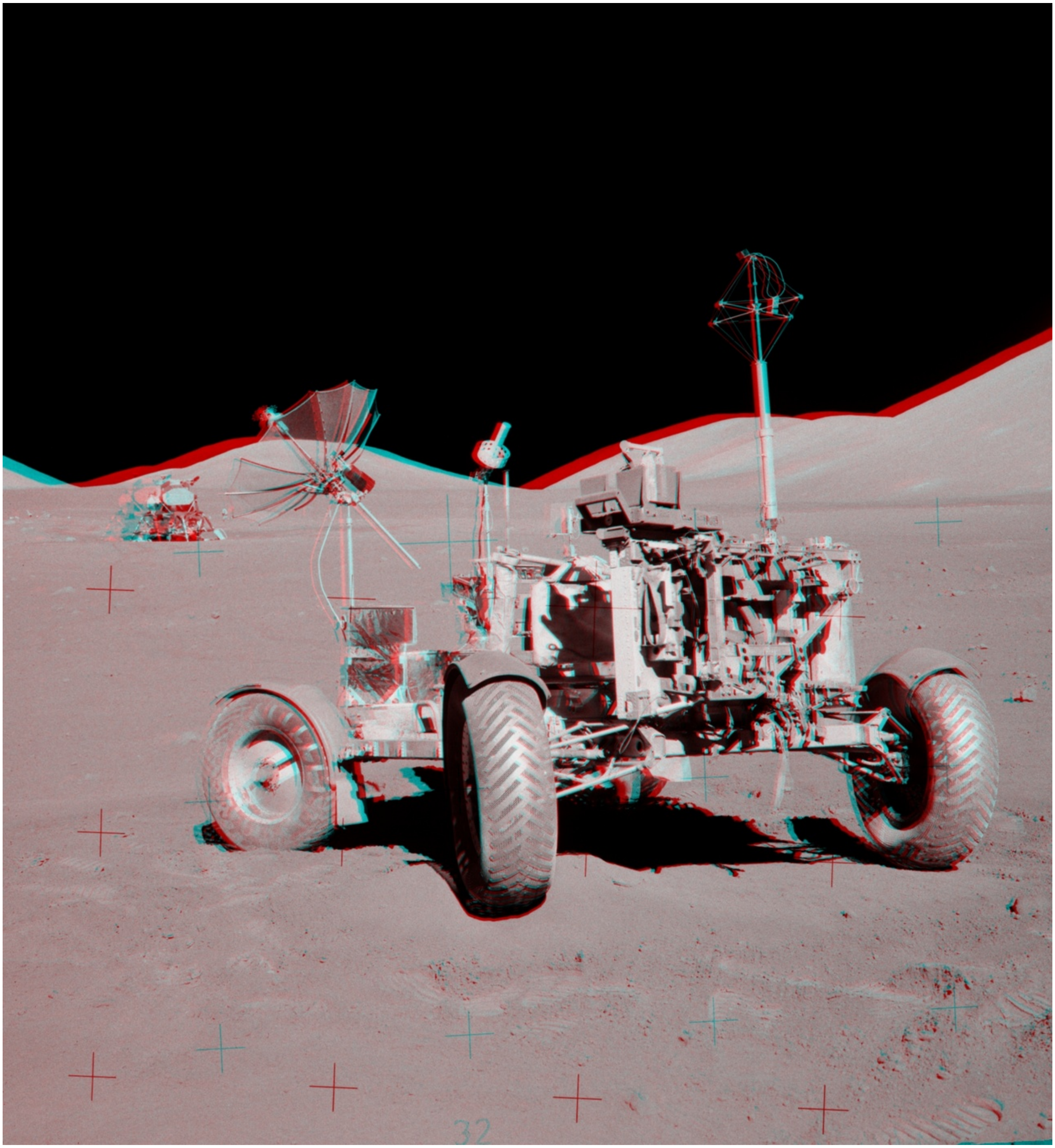


Fig. 54. At the end of **EVA3**, Gene Cernan drove the **LRV** about 100 m away from the **LM** so that Ed Fendell, the TV controller in Houston, would have a good position to follow the lift-off. This parking spot became known as the **VIP** site for all the LRV missions. Note that there is one seismic charge left on the transporter pallet at the rear of the rover. Cernan will remove and emplace it while walking on his way back to the LM. (From NASA photos AS17-143-21933, and -32).

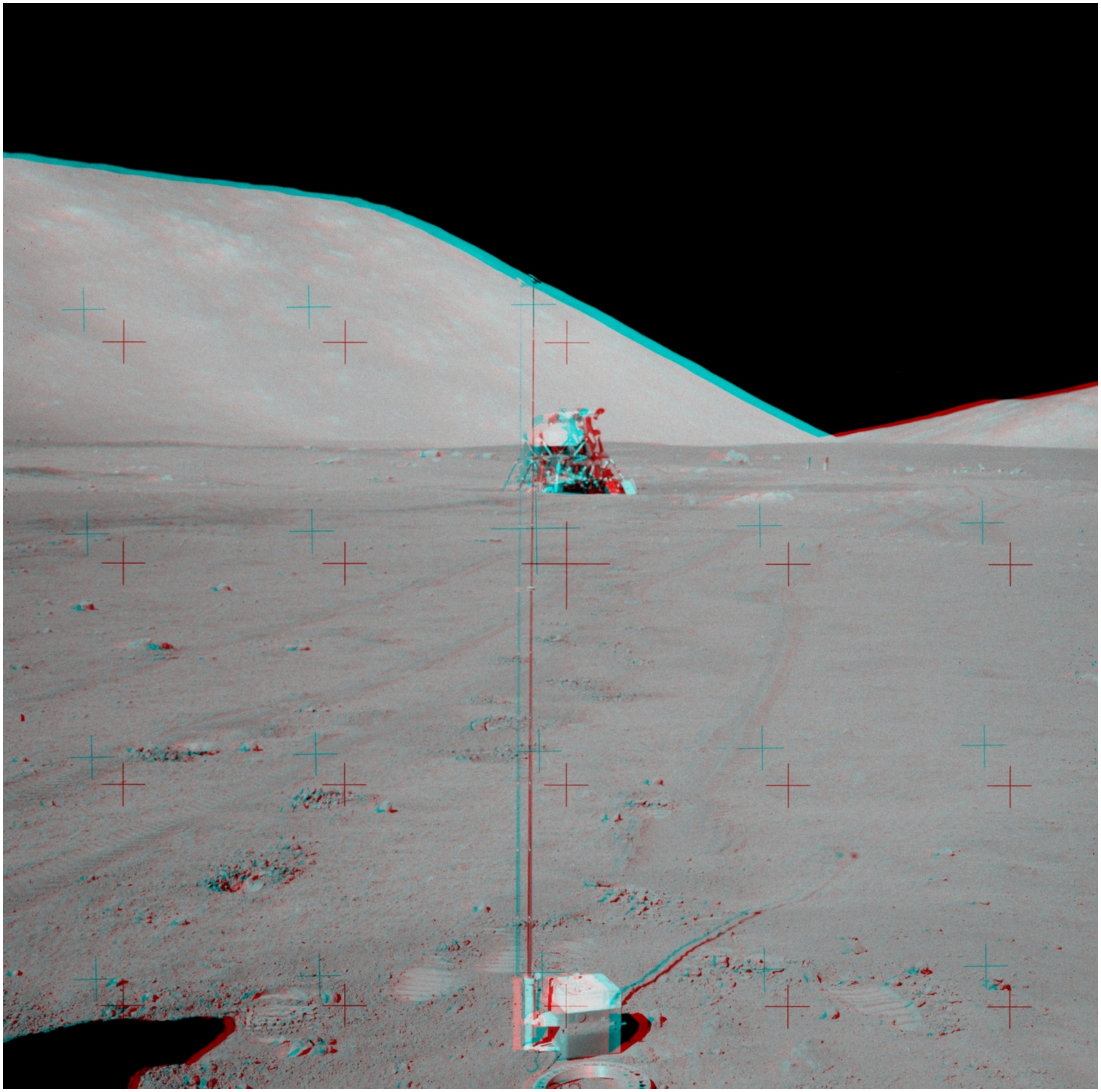


Fig. 55. Gene Cernan has positioned the last seismic charge for detonation after they leave the valley. Jack Schmitt is working at the **LM** preparing for departure. To the right is the American Flag, and about halfway between the LM and the Flag is Geophone Rock. (From NASA photos AS17-143-21936, and -37).

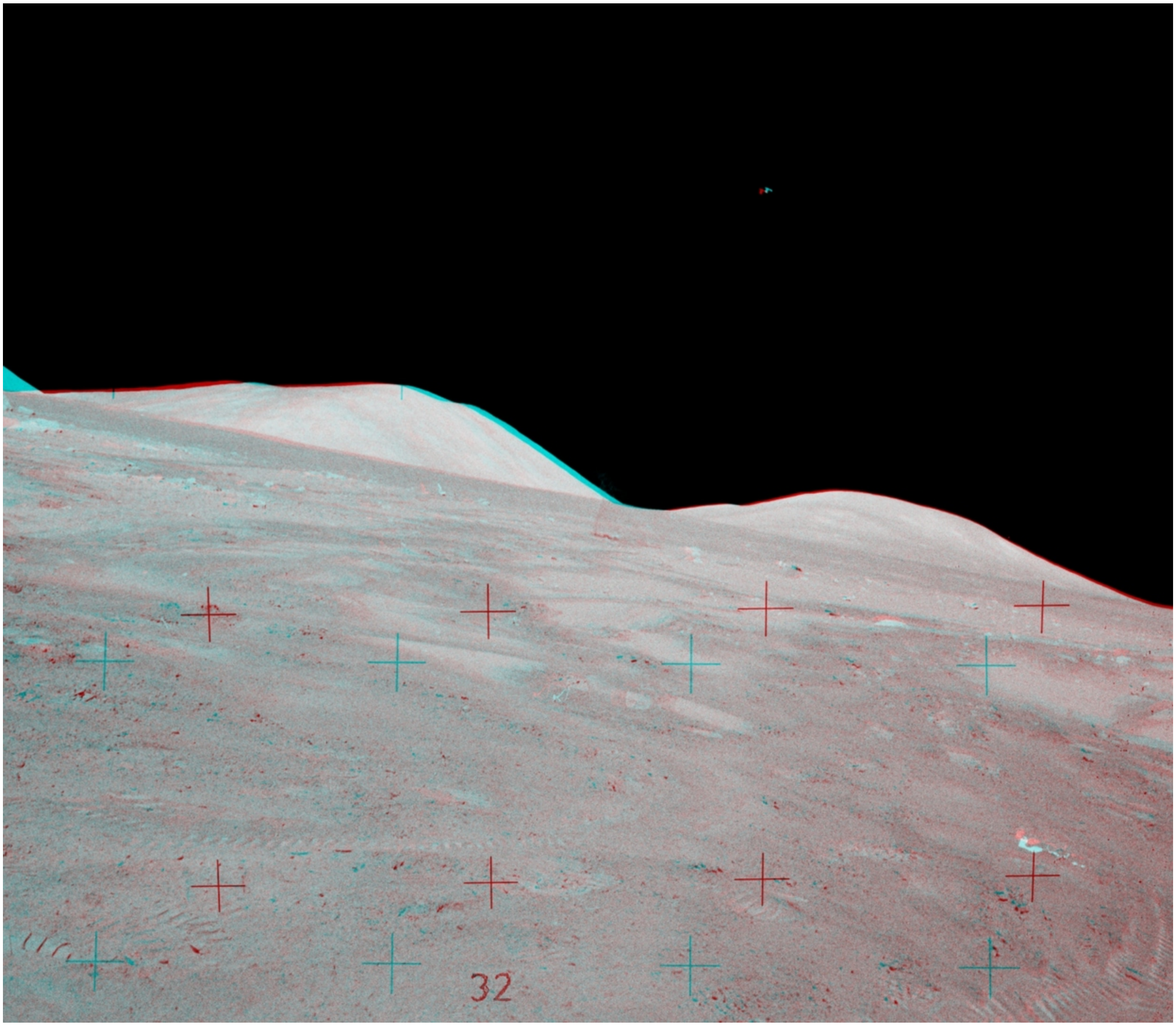


Fig. 56. Before they climb aboard ***Challenger***, Jack Schmitt asks to throw the geology hammer in an Olympic toss. Cernan tells Schmitt to go ahead, but not to hit the **LM** or the **ALSEP**. Cernan took four photos of the throw. Two of them have been made into the anaglyph shown here. An enlargement of the page shows that the hammer is end-on in this view. (From NASA photos AS17-143-21939, and -40).

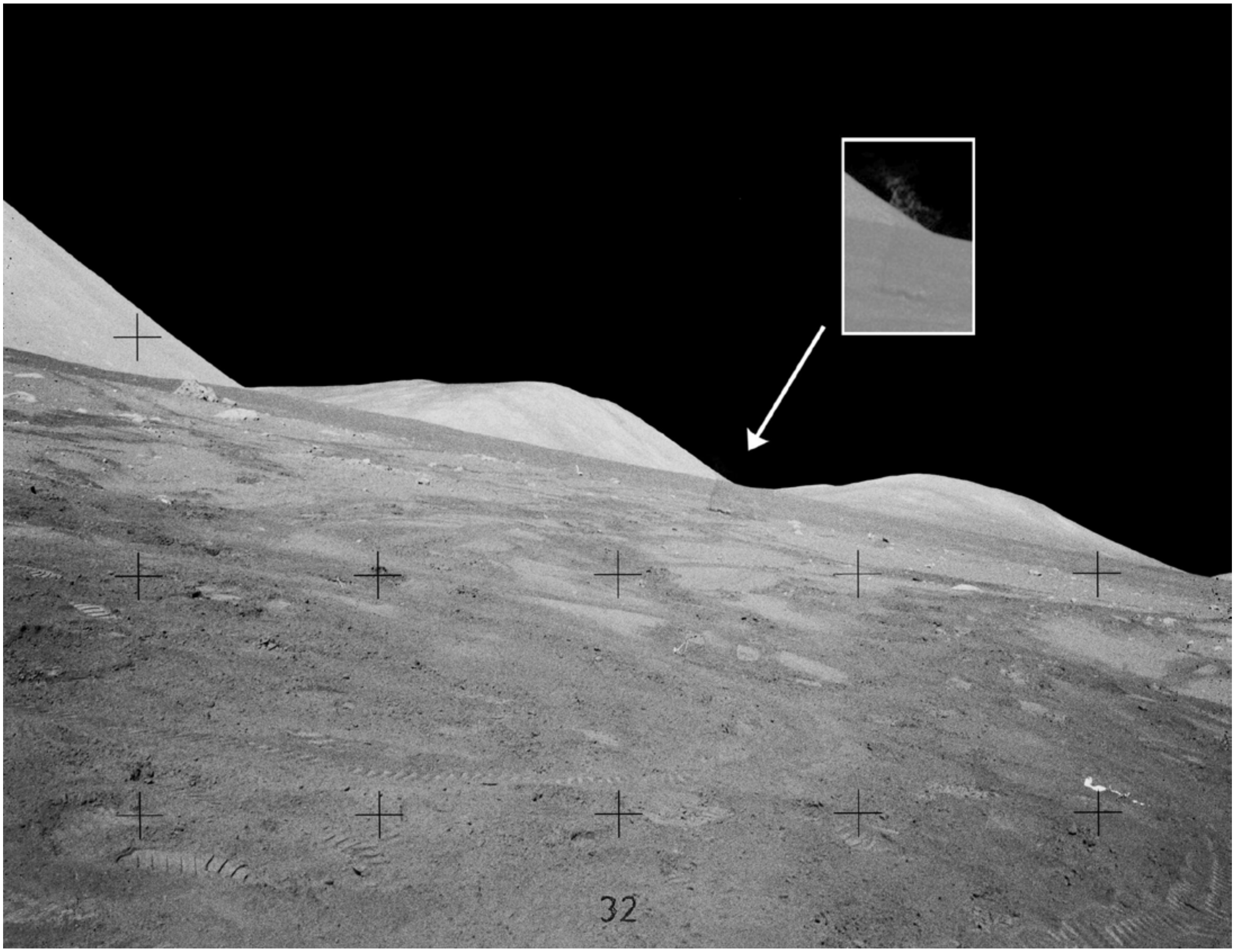


Fig. 57. This non-3D view of the impact of the hammer shows that it raised a plume of dust to which the white arrow points. The **ALSEP** central station antenna can be seen pointing to the Earth at the left below (West) Family Mountain. Geophone Rock is at the far left. The inset shows an enhancement of the plume so that its extent against the black sky can be more clearly seen. That indicates that the dust cloud was quite extensive for such a small object, and provides some insight on what the impact of even a small meteorite must have been like to watch. The impact occurred about 44 m away. Details of the throw and calculations of the distance are given by Jim Scotti at: http://www.hq.nasa.gov/alsj/a17/a17.hammer.html. (From NASA Photo AS17-143-21940).

Fig. 58. This view of Jack Schmitt looking at the American flag pointing towards the Earth was made by Gene Cernan during the start of **EVA 1**. However, it has become such an iconic scene that it seems fitting to close this book with it. The pose, although deliberate, was a lucky accident. Cernan, seen mirrored in Schmitt's gold visor, held the Hasselblad camera down and at arm's length while bending his knees hoping that the flagpole hanging bar would point the American flag homeward bound towards the Earth. A portion of the lunar surface can be seen behind Schmitt and in his visor. This mission concluded America's first great human exploration of our nearest neighbor in space more than 40 years ago on Dec. 19, 2015. (Adapted from NASA photo AS17-134-20383 together with AS17-134-20384).

Epilogue

By the ninth day of the Apollo 17 mission, the two Moonwalkers had returned from the surface some 40 hours earlier, cleaned the lunar soil off themselves as much as was possible, and jettisoned the LM which impacted on the top of the South Massif. In addition, the three crew members had also performed a full day's geology observations of the surface along their ground track. A major part of those observations was recording other locations where orange soil could be seen around craters like that at Station 4, **Shorty Crater**. Transearth injection (**TEI**), the engine burn which put the spacecraft on its homeward journey, occurred when the **CSM** was on the lunar farside out of communication with Houston. After the spacecraft signal was re-acquired as they came out of orbit, Gene Cernan reported an almost perfect 1/2 g engine burn.

While the spacecraft was still in that part of the transearth trajectory which had swung the astronauts outward away from the Moon above its eastern hemisphere, Jack Schmitt took three photos of the lunar globe through the 80 mm lens of the **CM** Hasselblad camera[1]. These photos show a view of the Moon impossible to see by Earth-bound observers, but which all the Apollo astronauts of the eight prior lunar missions had also seen— namely, a view with Mare Smythii and Mare Marginis near the center of the lunar disk and Mare Tranquillitatis on the western (left) limb (with north at the top). After Schmitt had made the first photo, he later spoke with CapCom Gordon Fullerton about whether the spacecraft had traveled far enough relative to the apparent lunar central meridian to be sufficient to form a stereo view of the globe if he were to take another photo. Here is the actual conversation from the air-to-ground transcript (the time marks refer to days, hrs, mins, secs since the mission launched from Earth):

09 21 25 07	**Schmitt:**	Hey, Gordy, I don't know whether your camera people have anything to do this evening, but I've got a little problem for them if they'd like to work on it.
	Fullerton:	Okay, go ahead.
	Schmitt:	Well, it seems to me we're not only moving away from the Moon, but we're moving across the face, and I took a picture about 5 minutes ago of the Moon, and it seems to me we could take another one at some X-number of minutes and have pretty good stereo if we matched the printing of the two pictures in terms of scale. And, I'm wondering what's a good time elapse here for a good stereo of the whole globe?
	Fullerton:	Okay, we understand the problem, but I'm not – Well, we'll try.

[1] The astronauts had three Hasselblad cameras which were left behind on the surface: two with 60 mm lenses, and one with a 500 mm lens. Aboard the CM ***America***, they had a Hasselblad camera with interchangeable 80 mm and 250 mm lenses. These all used 70 mm film. There was also a Nikon 35 mm camera with a 55 mm lens on the CM.

Schmitt: Well, I guess, if you could figure out what it would – how far we have to move across the face of the Moon and how long that would take to get about a – oh, shoot, a 30 to 1 base-height ratio would probably be enough – 20 to 1 would probably be better, obviously, but 30 to 1, you could still see the stereo. And you ought to be able to figure that problem out. How fast do – do the guys know how fast we're moving across the face of the Moon?

09 21 26 41 **Fullerton:** No, I'll put that one to FDO. Just looking at the big chart up here. I'm sure that the rate is slowing down rapidly, and – because you're – the farther you get away, of course, the straighter away from it you're going. Stand by, I'll see what we can do.

09 21 44 55 **Fullerton:** Jack, this is Houston with kind of a crude answer to your question.

Schmitt: Go ahead.

Fullerton: Okay, it turns out right now that you're not moving across the lunar surface very fast, and you – it's getting less and less – right now, I guess it's about a mile per minute. It would take a lot of minutes to get much of a stereo base since you're 10,000 miles out. But, remembering back to Ron's final picture there before you went to the UV attitude, after he asked the question about how high he had to be to fill up the 80-millimeter lens, I think he took one at that time. We're thinking of combining a picture now with that picture, and then enlarging the one to get it to the equivalent diameter. And, some rough calculations of your longitude at that time and then – now, show that you've changed about 21 degrees across the surface of the Moon between that picture and the present time, which comes out, if you take the average altitude between that time and now to – to about a 25-to-1 stereo base, as best I can figure.

Schmitt: Sounds good enough, Gordy. We've got it – I got that one at 5 minutes. I mean at 240 on the hour, so those are probably pretty close.

Fullerton: I would guess, you know, that the angle of looking at it – other factors have changed so much that it would be pretty hard to pull them together once you – even though you get the images reduced to the same size, but it might be interesting to try.

09 21 47 03 **Schmitt:** I agree.

In fact, the images that Schmitt took do make an excellent stereo view of the Moon— the view seen by the last Apollo astronauts to leave it (**Fig. 1**). Major features not easily seen or never seen from the Earth can be quickly picked out. For example, the large Tsiolkovsky Crater is on the lower right limb with the bright central peak. The name Mare Undarum to the southeast of Mare Crisium, the large ring at upper left, can more easily be understood as the Sea of Waves. The 4 or 5 white ringed structures crossing it when seen obliquely on the limb from the Earth would have appeared to early observers as waves. Mare Australe is the large dark, cratered oval area to the right of the central meridian in the south polar region. Above it, the squarish-shaped crater is Humboldt Crater. The fine structure along the eastern shore of Mare Crisium can now be seen more clearly. Many other notable details can be picked out, not the least of which is the globe shape of the Moon itself.

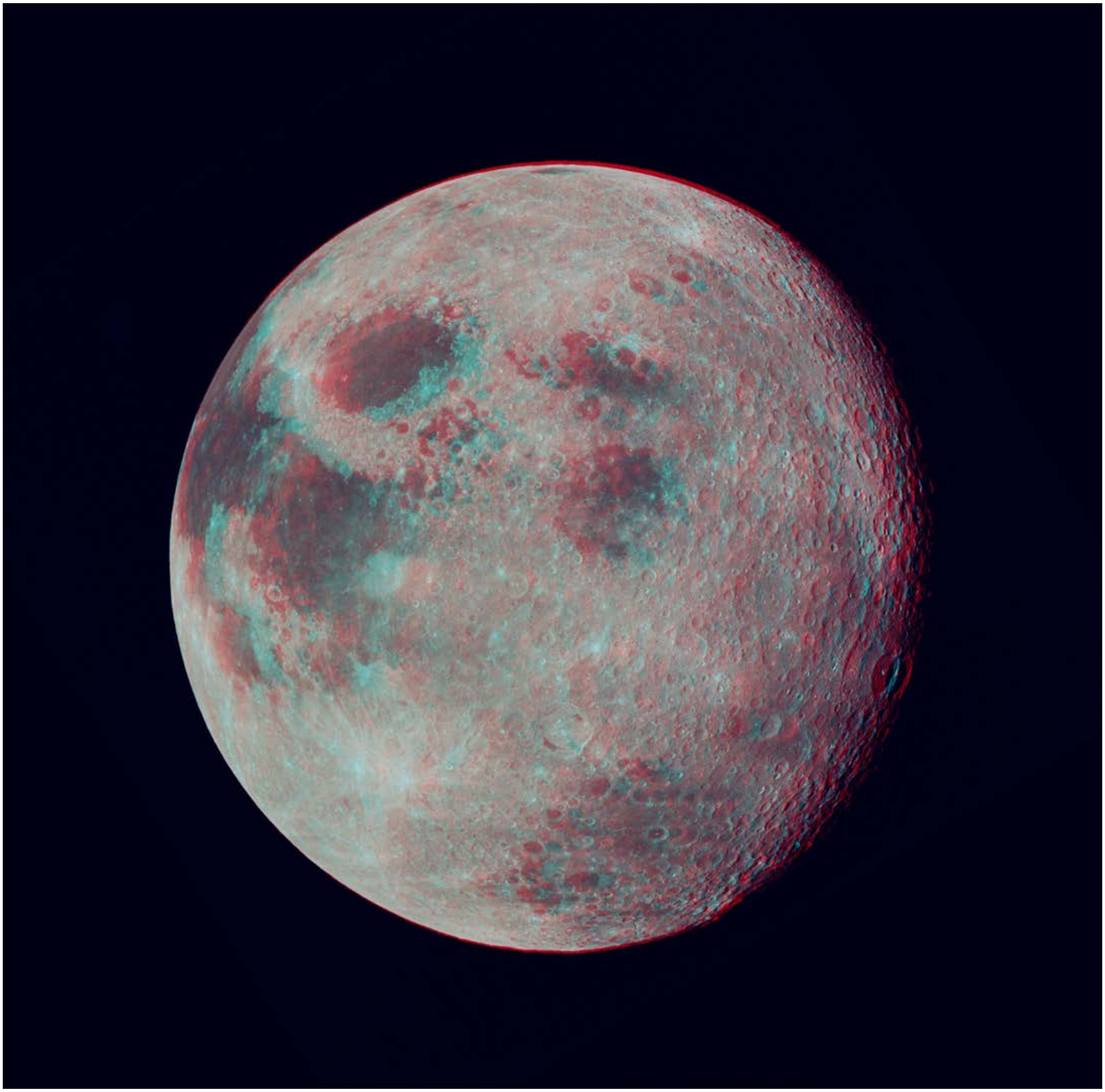


Fig. 1. The departing global view of the Moon seen by all American astronauts as they came out of lunar orbit on a homebound transearth trajectory. The slightly brownish tint of the globe agrees with similar color descriptions of other Apollo astronauts and with the 'true color' global images in Pl. 5 of the 2nd edition of the *Clementine Atlas of the Moon*. Mare Crisium is the large ring basin at upper left. Mare Tranquillitatis is to its southwest on the limb. Mare Australe is the dark oval basin (lower right) slightly smaller in size than the South Pole-Aitken Basin located further beyond the lower right limb. This anaglyph is the first published high resolution version of Schmitt's photos. (From NASA photos AS17-152-23308, and 23311).

In a similar manner, Schmitt took photos of the Earth about 5 hrs, 6 min into the mission, some 26 minutes after the Command and Service Module had linked with the Lunar Module as the crew were on their way to the Moon. The translunar trajectory had swung far enough to the south so that the continent of Antarctica was plainly visible. Similar photos from other missions do not show much of Antarctica, if at all. Schmitt maintained a running deep space commentary on the clouds and weather patterns like those seen in **Fig. 2** throughout the translunar coast (**TLC**), the first synoptic weather observations of the entire Earth ever reported. The National Oceanic and Atmospheric Association (**NOAA**) presented Schmitt with a special meteorological award for those historic global observations after the mission. It would not be until the **GOES** geostationary satellites were launched a few years after the Apollo 17 mission that full disk coverage of the Earth's weather patterns would become available on a synoptic basis. The non-stereo version of the image is one of the most frequent public requests for prints from the NASA archives.

The full Earth view visible in **Fig. 2**, of course, was not the view the astronauts had on the return journey. Rather, the Earth phase was a crescent at that time. **Fig. 58** in the Apollo 17 section showed the Earth as a waning gibbous disk (a little more than last quarter) during the astronauts' first day on the lunar surface. It would be ca. five more days before they would be homeward bound, and by then the Earth appeared as a thinner crescent. For an observer on the Earth, the Moon was full on Dec. 20, 1972. The Earth and Moon have opposite phases, so for an observer on the Moon facing the Earth, it would have been an invisible new Earth on Dec. 20th. The astronauts landed in the Pacific on Dec. 19th, so during their approach, they saw a very thin crescent Earth.

As the astronauts swung around the Moon into the final transearth coast as indicated by **Fig. 1**, the event marked the 69th anniversary of the Wright Brothers flight at Kitty Hawk, North Carolina on Dec. 17, 1903! Thus concluded a remarkable decade of innovative research into the development of spaceflight and the exploration of our nearest neighbor, just 40 years ago— both events true testaments to American exceptionalism.

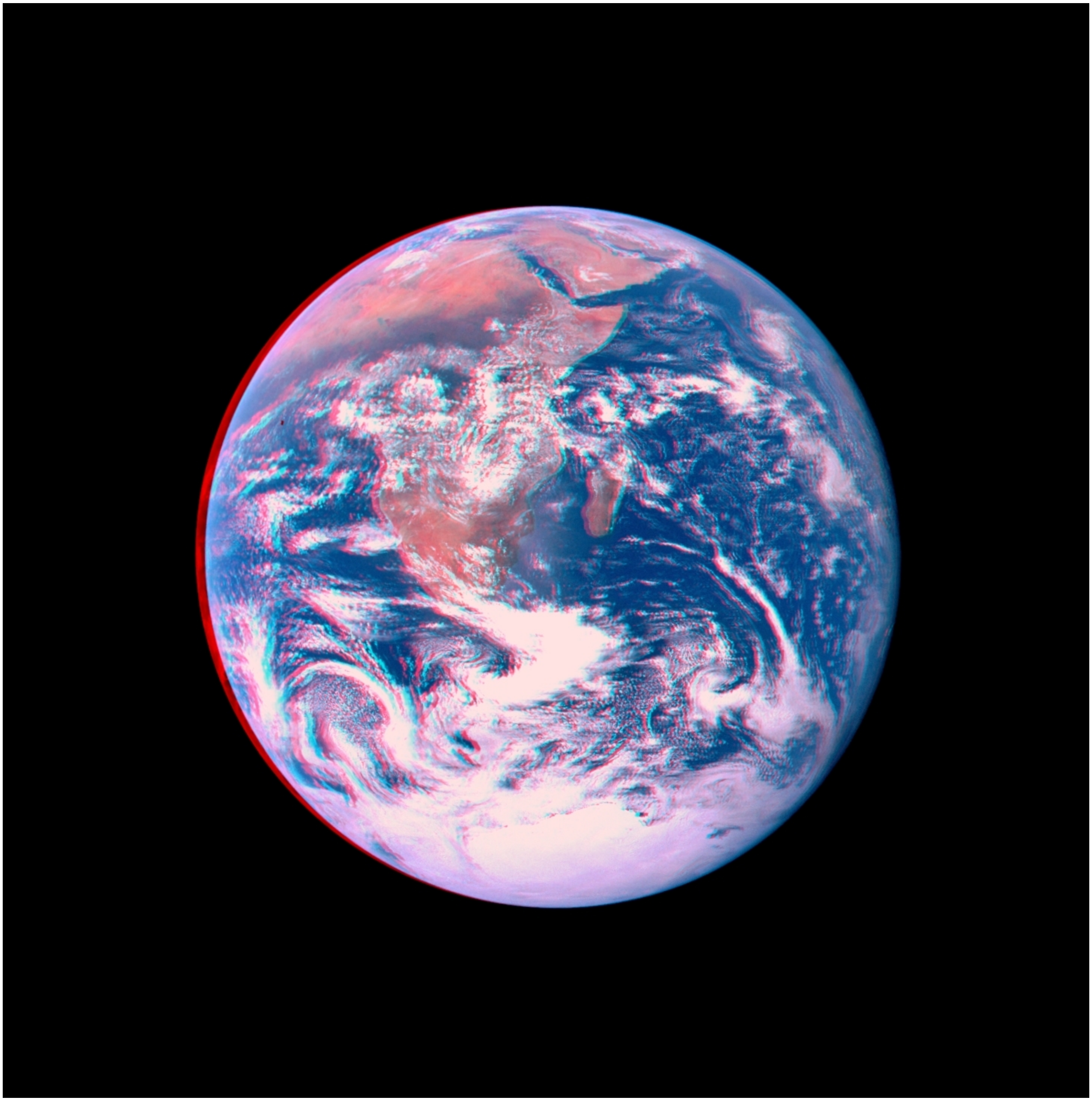
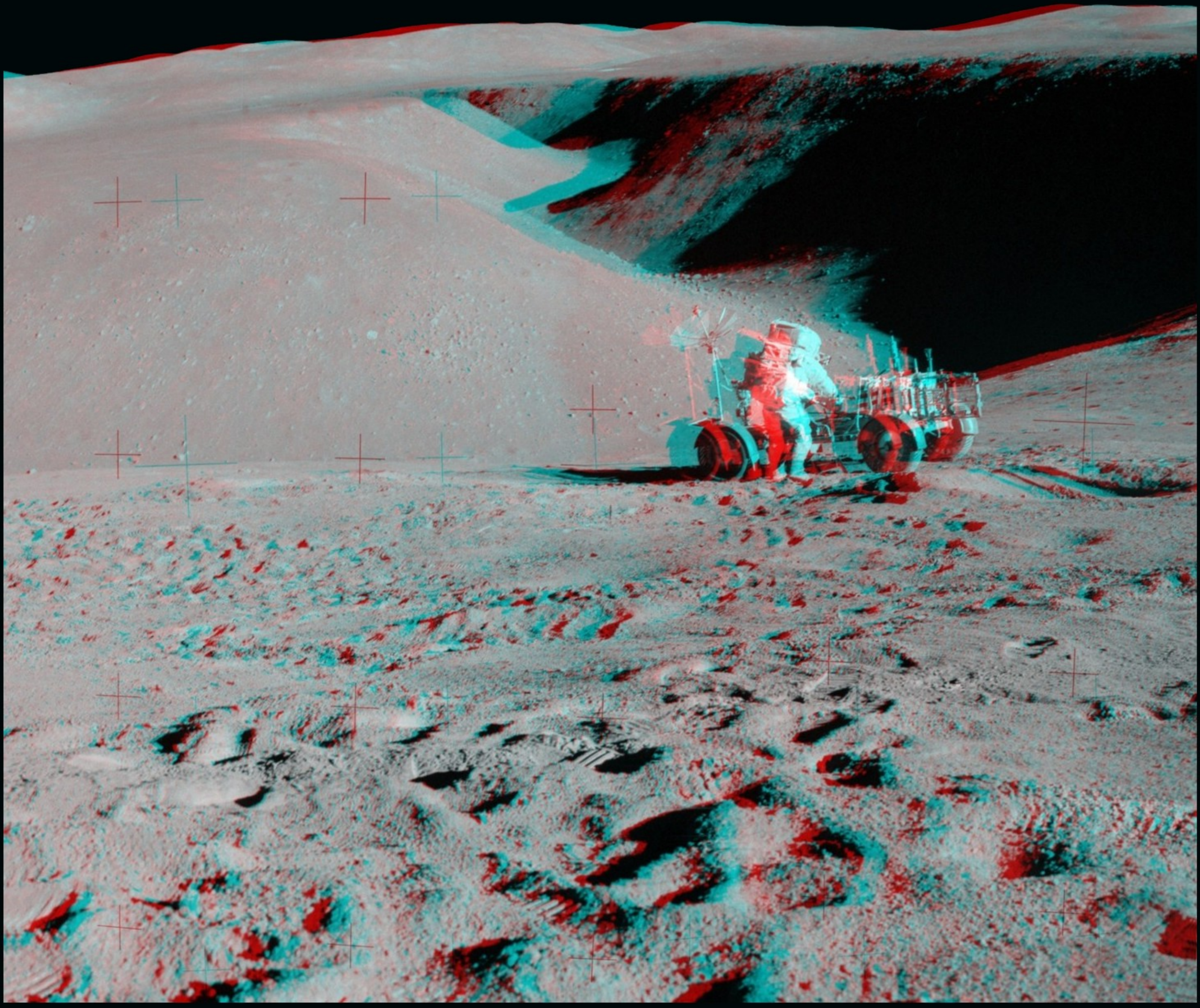


Fig. 2. The full Earth taken by Jack Schmitt shortly after the astronauts were in translunar coast (**TLC)**— a nostalgic reminder to the intrepid astronauts embarking on their long and perilous journey that “there is no place like home”. (From NASA photos AS-17-148-22726, and -22727).

Back Cover Caption:

A repeat of the Apollo 15 **Fig. 10** composite anaglyph of Dave Scott at the rover above Hadley Rille. Many space enthusiasts have opined that had this mission flown to the Moon first rather than Apollo 11, the American public would not have lost interest in lunar exploration so readily. That sentiment, however, ignores the reality of the necessity of building such a complex mission one step at a time on previous, simpler missions.



Apollo 15 Commander Dave Scott overlooking Hadley Rille