B. SUPPLEMENTARY GEOLOGY TABLES AND THE `POSEIDON` SURFACE ALBEDO DATABASE

Table A1. Supplementary Geology Glossary

Word (1)	Definition (2)	Exoplanet Context (3)
Mineral	Inorganic element or compound with a orderly internal structure and characteristic chemical composition. See succint introduction on minerals, Vaughan (2014).	An exoplanet's observed disc-integrated dayside being composed of pure minerals is unlikely, though the surface can have rocks with large mineral inclusions (e.g., phenocrysts). Depending on the rock, distinct spectral signatures of specific minerals (like quartz in granite) can be readily detected.
Rock	An aggregate of one or more minerals. Rocks are determined by their mineralogy and bulk chemical composition, where resultant spectra is determined by mineralogy (i.e., two rocks of the same chemical composition can have different spectra due to different mineralogy (Paragas et al. 2025)). See succinct introduction on rocks, Zalasiewicz (2016) (Z16).	If the observed dayside of a rocky planet is completely cooled and solid, we are likely to observe spectral signatures of specific rocks (or, a conglomeration of rocks). The resulting color and spectral features of a rock is largely given by its mineral composition, though typically minerals do not spectroscopically mix in a linear fashion (Hu et al. 2012; Ehlmann & Mustard 2012).
Igneous Rocks	Rocks formed from the cooling of lava (extrusive/volcanic) or magma (intrusive/plutonic). They are the most common rock found on the surface of rocky planets in the Solar System, and are the first to form as a rocky planet cools from its initial formation state (magma ocean) and resurface a planet's surface from subsequent partial melts of mantle material.^{Z16}	With the exception of Earth, igenous rocks are the most common surface rock for Solar System rocky planets. The surfaces of currently observable rocky exoplanet daysides will be hot enough that we expect them to be molten or cooled molten, they therefore compose a majority of our database and the variety of processes that form them are detailed below in this table.
Sedimentary Rocks	Rocks formed from accumulation of pre-existing rocks over time. They are the most common rocks on Earth's surface, due to its unique processes like plate tectonics (that pushes portions of the crust high enough into the atmosphere to erode), atmospheric processes (winds), surface water (oceans and rivers), and glacial processes. Some common sediments that form from igenous rocks include clays, muds, sand (mostly composed of quartz), and gravel; salts and calcium carbonates are also considered sedimentary and precipitate directly out of ocean water. Common rocks that form from the lithication of sediments are mudrocks (e.g., shale), sandstone, and limestone. Surface water and limestones have an inverse relationship with atmospheric carbon dioxide in the Solar System: Earth's carbon dioxide is stored in limestone while Venus, which has no limestone, has a carbon dioxide dominated atmosphere (Hunten 1993). Sedimentary rocks can indicate the presence of past (sedimentary rocks have been found in proposed river basins on Mars (Lewis & Aharonson 2014)) or present liquid water, or just any process (like atmospheric erosion) that can create and accumulate sediment over time (i.e., dunes formed by winds on Mars, or see potential Venus sedimentary processes (Carter et al. 2023)).^{Z16}	Sedimentary rocks require atmospheres and/or liquid water to form. Sedimentary rocks can form in hot and dense atmospheric environments (similar to Venus) that could be present in currently observable exoplanets. They could also possibly be present on airless rocky exoplanets that once housed a substantial atmospheres and/or surface water. The database presented in this work includes a few clays and salts.

Table A1 *continued*

Table A1 *(continued)*

Word (1)	Definition (2)	Exoplanet Context (3)
Metamorphic Rocks	Rocks formed from transformation of other rocks due to high heat and/or pressure, or hydrothermally. In Earth's traditional rock cycle, sedimentary rocks formed from igenous rocks get buried over time (i.e., in mountain belts) where, due to higher pressures and temperatures (regional metamorphism) mica minerals form from mudstones (that then can metamorphize a variety of rocks, like slate, schist, and gneiss, where gneiss is nearly identical in composition to the igenous rock granite), sandstone forms quartzite, and limestone forms marble, before finally melting into a magma to form new igenous rocks. High-pressure, low-temperature metamorphism that occurs at subduction zones in the ocean (hydrothermal) can form the mineral serpentine. Contact metamorphism occurs when rock is heated and crystallized due to heating from nearby magma. Impact metamorphism is where large impacts form glasses and high-pressure minerals. Metamorphic rocks are present on the surface of Earth due geologic uplift (via plate tectonics) and subsequent erosion of overlying layers.[Z16] Metamorphic rocks could be the natural form of rocks of a surface with an overlaying thick and high temperature atmosphere, as in the case of Venus (though, chemical alteration via sulfuric acid might dominate Venus's metamorphic processes) (Barsukov et al. 1982; Semprich et al. 2025). Hydrothermal and impact metamorphic rocks have been found on Mars (Hazen et al. 2023).	For rocky, airless exoplanets with magma oceans at their substellar point, the solidified rock around the magma ocean might be primarily in the form of metamorphic rocks from contact metamorphism with the neighboring magma ocean. On close-in rocky exoplanets, a form of high-temperature, low-pressure metamorphism might occur on the dayside due to incident irradiation (Chao et al. 2021). Exoplanets with Venusian like atmospheres might have chemical alteration of the surface. Evidence of past bombardment can form specific rocks via impact metamorphism. Past surface water can also be probed via the presence of hydrothermal metamorphic minerals (like serpentine). While these are an incredibly important class of rock, the database presented in this work does not include any explicit metamorphic rocks, but does include some rocks with serpentine.
Intrusive vs Extrusive	Many igneous rocks have different names for intrusive vs extrusive variants of rocks with identical chemical compositions (and therefore, similar absorption features in their spectra). The main difference between the two variants are their textures, where intrusive rocks are typically coarse grained due to slow-cooling (which usually occurs underground, which allows large crystals to grow) while extrusive rocks are typically fine-grained due to rapid cooling (usually due to lava interfacing with an atmosphere or surface water, causing it to rapidly cool).[Z16]	The difference in texture can result in differences in observed albedos and spectra (Paragas et al. 2025; Hammond et al. 2025). Where relevant, we will indicate when two geological categories in our database are an intrusive/extrusive pair (examples being: granite/rhyolite, diorite/andesite, gabbro/basalt), though we note that care must be taken when applying Earth-like definitions of intrusive vs extrusive to exoplanet applications.
TAS Diagram	The Total Alkali-Silica (TAS) diagram categorizes extrusive igenous rocks based on alkali metal oxide (Na_2O+K_2O) and SiO_2 content to distinguish whether they formed from alkaline-rich/poor or silica-rich/poor magma. For a textbook review of magma petrology, see Winter (2014) (W14) or Philpotts & Ague (2022).	While not directly applicable to exoplanets, many rocks are explicitly classified on this diagram. When relevant, we will indicate when a geological category in our database is a specific rock category on the TAS Diagram.
Alkaline Content in Magma	On Earth, alkali-rich magma is thought to form deep in the mantle, and found at areas of continental rifts and hotspots, while alkali-poor magma is thought to form from shallow melting of the mantle and is found at mid-ocean ridges where it cools to form the most common igneous rock on Earth (subcategorized as tholeiitic (iron enriched) and calc-alkaline (no iron enrichment)).[W14]	Alkali oxides, by themselves, do not have strong mid-infrared features, and therefore are not readily probed with JWST. However, feldspars (which contain alkalis + silica) which compose many igenous rocks can be probed by their mid-infared features.
Silica Content in Magma	The silica content of magma is mostly determined by the age of magma and its degree of cooling (as magma cools, dense crystallized refractory material sinks and the remaining magma is enriched with silica). It is also used to determine whether or not a magma is mantle-derived (basaltic) or a crustal (granitic) melt. The silica content of magma strongly determines the viscosity (higher silica content results in a higher viscosity/more thick magma), and therefore determines how volcanoes erupt.[W14] Silica content can be used to further categorize rocks into ultramafic, mafic, intermediate, and felsic categories (see Table A3).	Silica content is the most accessible characteristic of rocky exoplanet surfaces that can derived from spectroscopy with JWST due to strong mid-inrared Si-O absorption band and the Christiansen Feature. In our database, we choose to focus on silica content for this reason. Since silica content gives a wealth of degenerate information about the surface, such as initial formation abundances and degree of partial melting, care must be taken in interpreting it.

Table A1 *continued*

Table A1 *(continued)*

Word (1)	Definition (2)	Exoplanet Context (3)
Mantle Material	The mantle for evolved planets (with a fully cooled crust, and a fractionated core) is the middle region of a terrestrial body (in contrast, for lava worlds without a cooled crustal region the observable surface is often referred to as the mantle). Surface geology is intrinsically linked to a planet's mantle chemistry, wherein partial melts of mantle material cools and is reprocessed over time to form the surface of a planet. Typical mantle mineraology and composition can be modeled from stellar compositions (see §5.1). On Earth, 90% of the upper mantle is composed of olivine, orthopyroxene, and clinopyroxene minerals that form mostly peridotite (and some pyroxenite) rocks.^{Z16}	Earth-like upper mantle rocks (composed of olivines and pyroxenes) are predicted to be the dominant mantle material for exoplanets from models using the `Hypatia Catalog` (Putirka & Rarick 2019; Wang et al. 2022). However, more exotic mantle chemistry has been observed from white-dwarf pollution measurements where quartz and periclase saturation can instead occur (Putirka & Xu 2021). While the detection of surface composition can hint at a parent mantle composition, white dwarf pollution measurements are the only method by which to directly measure the mantle compositions of exoplanets (Xu & Bonsor 2021).
Partial Melts	As a terrestrial body cools from its initially molten state, refractory material with high melting points (i.e., olivines, pyroxenes) begin to solidify and remove themselves from the melt mixture, changing the bulk composition of the remaining melt. If the solidified material is removed from the system (i.e. sequestered deeper in the body via differentiation), the resulting melt will cool into a rock with a different composition from the original melt. The reverse process is also true, where as solidified mantle rocks are heated, volatile material begins to melt. Both processes above play a large role in determining the surface composition^{Z16}	Partial melts of solid mantle material in Earth (i.e., ultramafic peridotites) produce more silica-rich magmas that cool to form mafic basalts. This pattern extends to all Solar System rocky planets, and is predicted to extend to most exoplanets. In general, more silica-rich material is more volatile and is first to melt (last to solidify), which is important to take into account when predicting the surface composition of planets with more exotic mantle compositions.
Melt fraction	The percentage of a rock that has melted from an original rock composition, where the resulting partial melt is typically more Si-rich than the original rock composition.	For lava worlds, the composition of the observable lava on the dayside will have a composition that is a melt fraction of the mantle. The quenched glasses from Fortin et al. (2022) represent the resulting melt chemistry of a mantle that has been melted a certain percentage and then rapidly quenched (to retain the internal structure of the magma). Magma composition, like solidified rocks, can be probed spectroscopically.
Oxygen Fugacity	fO_2 quantifies the amount of available oxygen to take part in oxidizing (loss of electrons/gaining oxygen) or reducing (gain of electrons/losing oxygen) chemical reactions in the interior of a planet. For internal geology, fO_2 is proportional to Fe^{+3} (ferric) / Fe^{+2} (ferrous) abundances. Low fO_2 favors metallic iron (Fe) and wüstite (FeO), while high fugacity favors hematite (Fe_2O_3) (Cottrell et al. 2025). Oxygen fugacity controls the amount of interior metallic iron (and therefore the size of the iron core) (Unterborn & Panero 2017), the ease by which rock melts to produce magma (with higher fugacities resulting in a lower melting point) (Lin et al. 2021), and which molecular species are out-gassed (Gaillard et al. 2021) (i.e., H_2 vs. H_2O, CO vs CO_2, H_2S vs SO_2). In the Solar System, Earth's mantle is the most oxixided while Mars and the Moon are more reduced (where, Deng et al. (2020) argue that deeper magma oceans on larger planets naturally result in a more oxidized surface). While the above concerns mantle oxygen fugacity, the atmosphere of a planet can also reduce or oxidize crustal material (see Oxidized vs Reduced Surface in Table A3).	While the oxygen fugacity of an exoplanet's mantle cannot be directly known, many studies have explored how detecting specific atmospheric compositions can be tied to a mantle's oxygen fugacity (e.g., Drant et al. 2025; Perez et al. 2025). White dwarf pollution studies have shown that many exoplanets probably form with Earth-like oxygen fugacities (Doyle et al. 2019). While the amount of reactive oxygen in the mantle is directly tied to its formation conditions, the actual mantle oxygen fugacity can change depending on a planet's mineralogy (which depends on the initial Mg/Si from formation), wherein suppressed formation of a mineral like pyroxene can inherently increase mantle oxygen fugacity (Guimond et al. 2023) and change which molecular species are outgassed.

Table A1 *continued*

Table A1 *(continued)*

Word (1)	Definition (2)	Exoplanet Context (3)
Crustal Material	For terrestrial planets with a solid and cooled surface, the crust represents the top-most layer of the planet. The resulting bulk composition of the crust changes is a strong function of time from a planet's initial formation and is a complex result of cooling processes (like differentiation), resurfacing processes (like plate tectonics, volcanism, and large impacts), and alteration processes (like aqueous alteration and atmospheric oxidation). Here, we include the the crustal definitions of Condie (2022) (C22) that outline the types of crusts in the Solar System.	For exoplanets with cooled crusts, their dayside surface composition will be a strong probe of past and current geologic processes.
Primitive Crust	The crust that forms first from planetary accretion, which is common on smaller asteroids and comets, but rarely survives on larger bodies (due to their large heating during formation, which forms a magma ocean). An example of a primitive crust is on Vesta.[C22]	This crust rarely survives on larger bodies, and therefore is not expected to be observed on exoplanets.
Primary Crust	The crust that forms on a planet due to the differentiation and solidification of an initial magma ocean. While rare in the Solar System, there are examples of isolated regions on terrestrial bodies with primary crust: e.g., the lunar highlands, which formed from rocks (i.e., anorthosite) composed of plagioclase feldspars (a mineral group with the endmember minerals albite and anorthite) that crystallized in the magma ocean and floated to the top.[C22]	For young exoplanets, or ones without active geology, their crust might be primary. As an initially molten surface cools, dense condensed material that crystallizes out is sequestered deeper in the mantle (olivines, pyroxenes) while less-dense condensed material (like anorthosite) floats to the top. A similar analysis done by modeling the resulting top-level crust from cooling a compositionally specific magma ocean can be done to determine whether or not an observed crust is primary or not.
Secondary Crust	Produced from partial melts of solid mantle material (which are typically ultramafic rocks) that usually cools into mafic basalts. This form of crust is the most common on rocky planets in the Solar System, and replaces the primary crust over time due to mantle overturn and volcanism. On Earth, fresh secondary crust is formed at mid-ocean ridges.[C22]	Most exoplanets will probably have some form of secondary crust that has been formed from the cooled material produced via the partial melting of their solid mantle. Additional processes, like impacts, intense stellar irradiation, and past/present atmosphere might further alter the secondary crust. Exoplanets without active geology will have a more altered secondary crust.
Tertiary Crust	Requires the gradual modification of the secondary crust through a process like plate tectonics. The only known example is the continental crust of Earth.[C22]	Earth's thick and old tertiary crust is formed from plate tectonics, which are solely unique to Earth and require large amounts of surface water to occur (water lowers the melting point of mantle material, lowers viscosity, and reduces friction between plates (Tikoo & Elkins-Tanton 2017)).[Z16] While it is unknown whether or not observable exoplanets will have plate tectonics, it is possible that the idea of what constitutes a tertiary crust will expand with the as-of-yet unknown geologic processes that dominate in highly-irradiated, tidally locked rocky exoplanets.

Table A1 *continued*

Table A1 *(continued)*

Word (1)	Definition (2)	Exoplanet Context (3)
Surface Composition	The resulting surface composition of a terrestrial body, and therefore what can be detected directly with spectroscopy, is determined by a complex interplay of a planet's initial formation composition, the cooling of the planet over time (which determines the level of differentiation and resurfacing processes that occur), the heating of the planet (which in the case of tidally-locked worlds with dayside temperatures above the melting point of the exoplanet's crustal rock composition, can result in dayside magma oceans), whether or not the planet is still geologically active (i.e., Mars due its small size is now geologically dead), and subsequent alteration of the surface from a past or present atmosphere, liquid water, or impacts.	While these processes are difficult to disentangle from the detection of geology on a exoplanet, inferences can be made about what lead to a specific observed surface composition (see §5.1 and Table A3). For example, the detection of a granitic surface could indicate the presence of current or past Earth-like plate tectonics, the cooling of a planet that formed with a silica-rich mantle (an 'exotic' mantle), or the resurfaced metamorphic transformation of rock into a mineralogical form similar to granite (e.g., gneiss). The database presented in this work focuses on lab data of rocks with specific mineralogies and chemical compositions, where if the spectral signature of one is detected, how that rock (or something similar to it) is the primary spectral signature of an exoplanet's surface can be deducted within the context of modern-day geology. Other works have explored the detection of an exoplanet's chemical composition in lieu of a specific rock (SiO_2 wt% content via detection of the Christiansen Feature (Paragas et al. 2025; First et al. 2025)), and methods by which to learn more about the surface composition from observed atmospheric compositions (Herbort & Sereinig 2025).
Resurfacing	The resurfacing of a planet via melted mantle material, and therefore the formation of secondary crust (which produces basalts in all the Solar System rocky planets) can occur in many different ways; on Mercury, the youngest surface material formed from lava flows generated by large bombardments, on Venus there is evidence of cyclic planet-wide resurfacing and active volcanism, on Earth there are plate tectonics and volcanism, on the Moon the dark basaltic regions were created by lava filling the lowlands, on Mars the northern lowlands are theorized to be fresh lava from a large impact while the southern highlands represent early explosive volcanism, and on Io there is sulfur-rich volcanism induced by tidal forcing from Jupiter.[Z16]	It is unknown which resurfacing processes are expected to dominate on large-size (super-Earths) and tidally-locked rocky exoplanets, though if the pattern in the Solar System is to be followed, it is inevitable that some amount of the surface area of any planet will be resurfaced with freshly cooled partial melts from the mantle (Meier et al. 2026).
Volcanism	The process by which interior material is brought to a planetary surface. Provides a mechanism by which mantle-like material ends up on the surface without processes like seafloor spreading or large impacts, and can also provide out-gassing of specific atmospheric species.	Volcanism has been predicted to be the source of atmospheric SO_2 on some exoplanets (Bello-Arufe et al. 2025), where the amount of gas melted mantle material can hold is a strong function of its composition (Brugman et al. 2021). It is argued that in planets with high internal heat (i.e., due to tidal forcing) pipe volcanism akin to Io to dominate resurfacing (Reinhold & Schaefer 2024), while models of tidally locked planets predict nightside volcanism to dominate (Meier et al. 2026).

Table A1 *continued*

Table A1 *(continued)*

Word (1)	Definition (2)	Exoplanet Context (3)
Plate Tectonics	The process by which crustal material is reprocessed through subduction. In the Solar System this process only occurs on Earth and enables formation of rocks like granites. There are a myriad of other tectonic regimes (where Earth has a mobile lid that causes plate tectonics, and Venus has a proposed episodic lid that causes cyclical planet-wide resurfacing), which are described in Lyu et al. (2025). The lack of plate tectonics is the stagnant lid regime, which can still have very active geology occurring (Noack et al. 2017).	As mentioned above in Tertiary Crust, plate tectonics are solely unique to Earth due to surface water, and therefore unlikely to be on hot observable exoplanet surfaces. Other forms of tectonism can still occur though, through processes like episodic tectonics on Venus. It is possible that partially molten lava exoplanets can have regions of solidified crust floating on top of the magma, which can undergo plate tectonic-like processes like subduction (Chao et al. 2021), or they have single-lid tectonics that recycle solid crust at the terminators (Meier et al. 2026).

Note—Broad geology definitions and their potential application to exoplanet studies. This table, which is in no way extensive, was generated to help guide future considerations for exogeology studies, foster collaboration between geologists and exoplanet scientists, and contextualize the categorization the surface albedos featured in the `POSEIDON` surface albedo database. $^{\mathrm{W14}}$ indicates that information preceding the superscript was summarized from Winter (2014). $^{\mathrm{Z16}}$ indicates that information preceding the superscript was summarized from Zalasiewicz (2016). $^{\mathrm{C22}}$ indicates a crustal definition from Condie (2022).

Table A2. Supplementary Geology Categories and Solar System Context

Category (1)	Definition (2)	Solar System Context (3)
Minerals	See Table A1	Minerals compose rocks and can be found in their pure form in rocks composed entirely of one mineral (e.g., anorthite and anorthosite, quartz and quartzite), or as large inclusions in rocks. On Earth's surface, minerals formed at high temperatures in the mantle (i.e., olivines, pyroxenes, feldspars) are broken down easily by atmospheric and surface water processes to form the basis of sedimentary rocks while stable minerals, like quartz, aren't.[Z16]
↪ Ferropericlase	$(Mg,Fe)O$ (also known as magnesiowüstite), mineral category that encompasses periclase MgO and wüstite FeO	Makes up a portion of the lower mantle of Earth (alongside other lower mantle minerals like perovskite, $CaTiO_3$). While stable at high pressures in the mantle, it is not stable in the low pressures found on the surface.[Z16] Due to this, no MgO or FeO albedo data is explicitly included in our database, but we include its definition here due to it being a potentially large mineralogical component of exotic upper mantle compositions (Putirka & Rarick 2019; Putirka & Xu 2021).
↪ Olivine	$(Mg,Fe)_2SiO_4$, mineral category that encompasses the endmembers forsterite Mg_2SiO_4 to fayalite Fe_2SiO_4	Olivine is one of the first minerals in a melt to crystallize out of a magma as a planet initially cools from formation, where due to its high density it often sinks. It can be present in its pure form as large crystals (phenocrysts) in rocks. On Earth's surface it often weathers quickly.[Z16] Alongside pyroxene, it represents the most abundant mineral in the upper mantle of Solar System rocky planets (Guimond et al. 2024). Olivine itself is also a large component of the material used to build planetesimals, and therefore has been found ubiquitously in the Solar System (Leone & Tanaka 2023).
↪ Pyroxene	$XY(Si,Al)_2O_6$, mineral category that encompasses enstatite $MgSiO_3$, orthopyroxenes $(Mg,Fe)_2Si_2O_6$, clinopyroxenes $Ca(Mg,Fe)Si_2O_6$, and augite	One of the most common minerals that crystallize first out of a magma. Alongside olivine, represents the most abundant mineral in the upper mantle of Solar System rocky planets (Guimond et al. 2024).[Z16]
↪ Silica	SiO_2, mineral group composed of multiple crystalline polymorphs (e.g., quartz, tridymite, cristobalite, coesite, opal)	Quartz is the most common polymorph of silica on Earth and comprises about a tenth of Earth's crust, though all polymorphs of silica can be found on Earth in small amounts (Richard Drees et al. 1989). Quartz is stable in the conditions of Earth's surface and therefore is the main component sand. Glass is amorphous silica. [Z16] Other polymorphs of silica can be found on the surfaces of planets; tridymite and cristobalite has been found on Mars and Moon (Seddio et al. 2015; Morris et al. 2016; Yen et al. 2021), and coesite has been found in impact craters. While not a main mineralogical component of the upper mantle in Solar System planets, it has been found to be a potentially large component of exotic upper mantle compositions (Putirka & Xu 2021).
↪ Feldspars	Aluminium-silicate mineral category that is composed of alkali feldspars (orthoclase, $KaAlSi_3O_8$ to albite, $NaAlSi_3O_8$) and plagioclase feldspars (albite. $NaAlSi_3O_8$ to anorthite, $CaAl_2Si_2O_8$)	Feldspar minerals are the most abundant rock-forming mineral in Earth's crust, where the weathering of them forms clays. In primordial Earth and the Moon, plagioclase feldspars condensed out of calcium and aluminum enriched magma (which was depleted of iron and some silica due to olivine condensation) where, due to their low density, the crystallized material floated to the top and became a main component of the primary crust.[Z16]
↪ Pyrite	FeS_2, also known as Fool's Gold	Forms from iron and sulfur reacting together in an oxygen poor environment. It is the most abundant sulfide mineral on Earth. On Earth, it primarily forms in oxygen-poor underwater sediments via anaerobic microbes that strip oxygen from sulfate ($SO_4{}^{-2}$) ions to produce disulfide (S_2^{-2}) that reacts with reduced ferrous iron (Fe^{+2}) to form pyrite. Pyrite rapidly decomposes when exposed to the oxidizing environment of Earth's atmosphere.[Z16] Pyrite has been found on Mars (Vaniman et al. 2014), hinting that Mars once housed reducing environments.

Table A2 *continued*

Table A2 *(continued)*

Category (1)	Definition (2)	Solar System Context (3)
↪ Hematite	Fe_2O_3	Forms from iron bonding with oxygen, usually from the weathering of iron-rich materials in oxidizing conditions, or, formed from precipitation in aqueous environments. It ss often found in the soil composition on Earth. When mixed with soils and clays, it can cause a red color; Mars has a thin layer of hematite on its surface causing its famous reddish color.^{Z16} Hematite has been attributed to being a potential cause of the Fe^3 signal from Venus (Fegley et al. 1995), and has been recently discovered in the highlands of the Moon, despite it lack of a substantial atmosphere (Li et al. 2020).
Ultramafic Rocks	Category of rocks with chemical compositions that are the most magnesium-rich, silica-poor ($SiO_2 \leq 45$ wt%)	On Earth, ultramafic rocks were the first to condense out of the primordial magma ocean, forming the upper mantle. These rocks partially melt to form silica-rich magmas that then cool to form mafic rocks.^{Z16}
↪ Peridotite	Rocks made from olivine and pyroxene minerals; by definition, is > 40% olivine	Peridotites are the main constituent of Earth's upper mantle, wherein their partial melts subsequently cool to form basalts. Models have also shown that peridotites are thought to be the main constituent of exoplanet upper mantles (Putirka & Xu 2021). Peridotites crystallize from magma early on, and can often found as fragments in mafic rocks as 'xenoliths' that form when magma breaks off mantle rocks during its ascent to the surface. On Earth, large dislocated slabs of the lithosphere can be brought to observable crustal layers via tectonics and contain the full strata of basalts, gabbro, peridotite, and spinel (in that order of depth).^{Z16} The relative abundance of olivine vs pyroxene in peridotite depends on the level of partial melting a rock has experienced, with example rocks in our database being dunite (> 90% olivine), harzburgite (< 5% clinopyroxene), and lherzolite (intermediate composition of clino- and ortho-pyroxene).^{W14}
↪ Pyroxenite	Rocks made from olivines and pyroxenes; by definition, is > 60% pyroxene	While the olivines and pyroxenes minerals in Earth's upper mantle mostly produce peridotite, they produce a small percentage of pyroxenite as well. While it does not dominate any upper mantle in the Solar System, exotic mantle mineralogical compositions could produce abundant pyroxenites in the upper mantle (Putirka & Xu 2021).
Mafic Rocks	Broad category of rocks with chemical compositions that are relatively magnesium (Mg) rich ($SiO_2 < 63$ wt%)	On Earth, mafic rocks form from the cooling of partial melts of ultramafic mantle material, where it forms fresh crustal material at mid-ocean ridges. A majority of Solar System rocky body surfaces are composed of mafic rocks.^{Z16}

Table A2 *continued*

Table A2 *(continued)*

Category (1)	Definition (2)	Solar System Context (3)
↪ **Basalts** (TAS)	Rocks formed from partial melts of ultramafic material, which contain relatively low SiO_2 (46-52 wt%) and low Na_2O+K_2O (<5 wt%) when compared to other TAS rocks. Basalts have a mineralogical composition comprised mostly of feldspars and pyroxenes, and its intrusive variant is gabbro	Basalts are the most common igenous rock on the surface of Earth and are the main component of Earth's oceanic crust, where fresh crust is created continuously at mid-ocean ridges. They are the most ubiquitous surface component of other Solar System terrestrial planets and moons (Mercury, Venus, southern highlands of Mars, dark lowland regions of the Moon, volanic eruptions of Io) despite different internal structures and large-scale geologic processes in these objects. Most non-exotic silicate mantles are predicted produce basaltic magmas; where, in general, partial melts of ultramafic mantle material will cool and produce a basalt (First et al. 2025).^{Z16} The two main sub-categories are alkali basalts, which have higher Na_2O+K_2O content, and tholeiitic basalts, which are more SiO_2 saturated. Tholeiitic basalts are the most common form of basalt on Earth, being the form of basalts that emerge at mid-ocean ridges (they are also the most common form of basalt on the Moon) and represent more shallow mantle melting, while alkali basalts form in regions of low tectonic activity and represent more deeper mantle melting (like volcanic islands and continental rifts).^{W14} Basalts are usually dark-colored due to augite or pyroxene minerals, but can be lighter due to feldspar minerals. It has been shown that basalt's mid-infrared absorption feature cannot be modeled by mixing individual mineral absorption features, highlighting the necessity of lab data (Hu et al. 2012; Ehlmann & Mustard 2012).
↪ Trachybasalt (TAS)	Similar SiO_2 content to basalts, but with a higher content of Na_2O+K_2O (5-7.3 wt%)	It is found in Earth on some ocean islands, continental rift volcanoes,^{W14} and has been found in the Gale Crater on Mars (Edwards et al. 2017).
↪ Basaltic Andesite (TAS)	Slightly higher SiO_2 content to basalts (52-57 wt%), but with a similar Na_2O+K_2O content	Found in volcanic arcs (a belt of volcanoes above a subducting plate) on Earth, and have also been found on Mars (Ruff & Christensen 2007; Mullen & McCallum 2013).
↪ Tephrite (TAS)	Distinguished from basalt by a lower SiO_2 content (41-49 wt%) and higher Na_2O+K_2O content (3-9.4 wt%)	Found in specific regions of Earth and Mars where local magma was enriched in alkaline material.^{W14}
↪ Phonolite (TAS)	Higher SiO_2 content than basalts (52.5-61 wt%), and is the TAS category with the highest amount of Na_2O+K_2O content (> 12 wt%)	Rare on Earth, where their formation requires a very low degree of partial melting such that alkali-rich rocks melt but silicon-rich rocks don't.^{W14}
↪ Gabbro	Is the intrusive variant of basalt, which is more coarse grained	When compared to basalts, which cool rapidly at the surface of fresh oceanic crust due to the magma's interaction with water, grabbro forms in the denser sub-surface portion of oceanic crust on Earth where it can cool slowly (and therefore form larger grains).^{Z16}
↪ Anorthosite	Rock composed of plagioclase feldspar minerals	Anorthsite is a large component of the Moon's surface (bright areas). When plagioclase feldspars condense into anorthosite, they are less dense than the surrounding magma and float to the top, creating a bright, primary crust.^{Z16}
Intermediate Rocks		
↪ Andesite (TAS)	Distinguished from basalt by higher SiO_2 content (57-73 wt%) with an identical Na_2O+K_2O content; its intrusive variant is diorite	Basalts and andesites are often found together, though basalts are more indicative of oceanic crust and ocean floor spreading, while andesite is commonly found in subduction zones (particularly in island arcs) and has been considered a hallmark of Earth's plate tectonics (Tatsumi et al. 2015). Andesitic magma forms from the same mechanism that produces granitic and rhyolitic magma (see Figure 4), but rapidly cools on the surface (and therefore is not coarsly textured). Andesite has also been found in the crust of Mars, and theorized to be present on Venus (Pavri et al. 1992; McSween et al. 2009).

Table A2 *continued*

Table A2 *(continued)*

Category (1)	Definition (2)	Solar System Context (3)
↪ Trachyte (TAS)	Higher SiO_2 content than basalts (57-69 wt%) with a large amount of Na_2O+K_2O content (> 7 wt%)	Found in specific regions of Earth where alkaline magma has cooled enough (where refractory materials condense and remove themselves from the melt) that the remaining magma has a composition similar to alkali feldspars. Rarely, on Earth, do more alkali-rich magmas form (that generate phonolite).^{W14} It has been found in the Gale Crater on Mars (Sautter et al. 2016).
Felsic Rocks	Broad category composing of relatively silicon (Si) rich ($SiO_2 \geq 63$ wt%) material	On Earth, felsic rocks form from partially melted mafic parent material, typically at subduction zones, where the partial melts are enriched in silica. Earth has the highest percentage of felsic material on the surface when compared to other Solar System planets, due to processes like plate tectonics gradually producing large amounts of continental crust (from repeated processing of oceanic crust) over geologic timescales.^{Z16}
↪ **Granite**	Rocks formed from the partial melts of mafic material, which contain very high SiO2 (≥ 70 wt%) and low MgO (≤ 1 wt%), with a mineralogical composition comprised mostly of quartz and feldspars; extrusive variant is rhyolite	Granite is the main component of Earth's continental crust, where its parent, silica-rich magma is typically formed on Earth by the partial melting of mafic (basaltic) oceanic crust at subduction zones. The silica-rich magma then ascends and cools slowly, forming a coarse grained rock that makes up the continental crust.^{Z16} In the Solar System, a widespread presence of granite is unique to Earth due to plate tectonics, though minimal amounts have been found on Mars (Bonin 2012).
↪ Rhyolite (TAS)	Highest amount of SiO_2 content (> 69%) with large range of Na_2O+K_2O content (0-13 wt%); intrusive variant is granite	Found wherever silicon-rich lava rapidly cools, and is a common component of volcanic ash (where the silica-rich, viscous nature of rhyolitic magma often results in explosive volcanic eruptions with pyroclastic rocks, on Earth). Forms via the same mechanism as granite, except the parent rhyolitic lava cools rapidly on the surface (forming a fine-grained rock, in lieu of slowly cooled, coarse-grained granite). Obsidian is a rhyolitic glass, pumice is often rhyloitic, and rhyolitic tuffs are a common structure on Earth's surface.^{Z16} Rhylotic-like lava has been theorized on Mars due to the discovery of tridymite (Morris et al. 2016; Yen et al. 2021).
Others		
↪ Clays	Category of sedimentary, soil materials (fine-grained) that forms from clay minerals (hydrous aluminum phyllosilicates)	Clays form in the presence of water. While they are very abundant on Earth^{Z16}, they are relatively rare on other bodies (though clays have been found on Mars (Du et al. 2023) and Ceres (Rivkin et al. 2006)), indicating past or current surface water.
↪ Salts	Category of minerals formed from the combination of a positive and negative ion, that commonly precipitate from surface water	The most common salts in Earth's ocean are NaCl (table salt) and $MgSO_4$ (epsom salt) (Loganathan et al. 2017). Solid NaCl has been found in salt deposits on Earth and Mars (indicative of dried-up salt beds) (Bramble & Hand 2024), the sub-surface of Europa (Trumbo et al. 2019), and potential salt glacier have been propose to exist in regions of Mercury (Rodriguez et al. 2023). $MgSO_4$ similarly has been found on Earth and Mars (Vaniman et al. 2004).

NOTE—Geological categories used to sort the `POSEIDON` surface albedo database in Table A4. As in Table A1, this table is not extensive and was generated to help guide future considerations for exogelogy studies and foster collaboration between geologists and exoplanet scientists. Basalt and Granite in boldface due to their extensive use in this paper. (1) Category name. The five large categories are Minerals, Mafic Rocks, Intermediate Rocks, Felsic Rocks, and Others. We take our ultramafic, mafic, and felsic definitions from Paragas et al. (2025). Instead of having a distinct intermediate category, as in Paragas et al. (2025), we only label rock categories as intermediate if their TAS-defined SiO_2 range falls between our mafic and felsic distinguishing SiO_2 percentage (63%). If a sub-category has (TAS) beside it, it means that it is a specific rock category in the Total Alkali-Silica (TAS) classification diagram where the ranges of SiO_2 and alkali metal oxide content for each category are taken from Le Maitre et al. (2005). We note that that the database presented in this work does include representive lab data for the following TAS fields: foidite, picrobasalt, basanite, phonotephryte, tephryphonolite, basaltic trachyandesite, trachyandensite, trachydacite, and dacite. (2) Definition of the category. (3) Solar-System Context of the category. ^{W14} indicates that information preceding the superscript was summarized from Winter (2014). ^{Z16} indicates that information preceding the superscript was summarized from Zalasiewicz (2016).

Table A3. Detectable Exoplanet Surfaces and Considerations for Interpretations

Surface Type (1)	Table A2 Categories (2)	Potential Considerations for Interpretation if Detected (3)
Ultramafic Surface	Ferropericlase, Olivine, Pyroxene, Peridotite, Pyroxenite	According to Solar System theory, once a planet has formed its initial surface will be molten and, as it cools, the first material to condense out are dense ultramafic materials that sink forming the upper mantle. In the modern-day Solar System, ultramafic mantle material is partially melted to form mafic (basaltic) material on all rocky planets, though solid ultramafic rocks can be brought to the surface as large inclusions in other rocks (xenoliths) or via dislocated lithospheric slabs (see Peridotite in Table A2). Hu et al. (2012) argue that an ultramafic surface can be an indication of primary crust with mantle overturn, or a secondary crust formed from hot lavas. Mantle overturn is the process wherein largescale convection causes the mantle to essentially 'flip' so that dense material rises to top and light mantle material sinks, which could have occurred in the past on Mars, the Earth, the Moon (Elkins-Tanton et al. 2005; Bédard 2018; Liang et al. 2024). The hot lavas mentioned in Hu et al. (2012) are formed by some process like tidal heating, that completely melts ultramafic material (as opposed to partially melting it) in the subsurface and transports the melt to the surface to cool), which is analogous to the ultramafic lavas of Io (Breuer et al. 2022). An ultramafic surface could also be the remnant of a planet's initial formation chemical composition (very high Mg/Si ratio), the result of stripping away of the crust (and revealing the mantle), or dayside reprocessing from intense incident irradiation.
Mafic Surface	**Basalt**, Trachybasalt, Basaltic Andesite, Tephrite, Phonolite, Gabbro, Anorthosite, Andesite (Intermediate), Trachyte (Intermediate), Basalts in Table A5	From exoplanet mantle modeling and Solar System observations, basalts (and therefore, mafic rocks) are generally thought to be the most common surface component on rocky planets. This is because the secondary crusts of most planets will be basaltic as a natural consequence of what crystallizes (controlled by phase equilibria) from partial melts of ultramafic mantle material (which, from the modeling of rocky exoplanet compositions derived from host star compositions (e.g., Putirka & Rarick 2019), is expected to be the dominate mode of exoplanet materials). Additionally, most Solar System resurfacing processes (see 'Resurfacing' in Table A1) and models for tidally-locked exoplanets (e.g., terminator recycling in Meier et al. 2026) result in mafic surfaces. However, if a planet orbits a Mg-poor star (and therefore can have a more exotic mantle composition, as probed in the Putirka & Xu (2021) white-dwarf pollution study), a mantle could be more mafic (instead of ultramafic), and a mafic surface could indicate processes similar to the ones listed for 'Ultramafic Surfaces'. In Hu et al. (2012), it is argued that a feldspathic surface (i.e., anorthosite) is indicative of a primary crust without mantle overturn (where as the magma ocean cools rocks, like anorthosite, float to the top) while a basaltic surface is indicative of the formation of a a secondary crust. If a mafic rock-type (like basalt) is detected alongside a more felsic rock-type (such as andesite or granite), it can indicate that there are processes such as the remelting of basalts (which occurs due to plate tectonics in subduction zones on Earth) or extensive fractional crystallization (a process which forms felsic material from a mafic parental melt on Earth, Mars, and the Moon) (Udry et al. 2018). Modelers can test for specific Earth-like geologic processes by comparing their data to the basalt library of First et al. (2025).

Table A3 *continued*

Table A3 *(continued)*

Surface Type (1)	Table A2 Categories (2)	Potential Considerations for Interpretation if Detected (3)
Felsic Surface	Silica, Feldspar, Andesite (Intermediate), Trachyte (Intermediate), **Granite**, Rhyolite	In the Solar System, felsic rocks only compose a large surface component percentage of the Earth, making up the core of continental crust. The buildup of felsic continental crust (over geologic timescales) on Earth has been attributed to the partial melting of mafic, oceanic crust at subduction zones that generate silica-rich magmas (e.g., Gazel et al. 2015). Hu et al. (2012) argue that granitic surfaces are indicators of a tertiary crust when assuming an Earth-like mantle. However, felsic surfaces are not always an indicator of past or present plate tectonics since exoplanets can form initially silicte-rich, non Solar System-like mantles (Putirka & Xu 2021). If a planet's mantle is mafic or felsic, partial melting of the mantle will produce silica-rich magma without plate tectonics. Additionally, metamorphic processes (i.e., rocks subject to high temperatures and high pressures) can form rocks with granite-like compositions (i.e. gneiss) that then can be uncovered on the surface via erosion or active bombardment.
Oxidized Surface	Hematite	If a planet has an oxidizing atmosphere, any iron on the surface will be oxidized. Hematite is just one common example of oxidized iron. In Hu et al. (2012), hematite is indicative of oxidative weathering. Curiously, hematite was recently discovered on the Moon, despite its reducing and thin atmosphere (Li et al. 2020), though this has been attributed to mass transport of oxygen ions from the Earth to the Moon (Zeng et al. 2025). An oxidized surface might also be related to the interior oxygen fugacity of the object (see Oxygen Fugacity in Table A1).
Reduced Surface	Pyrite	In the solar-system, pyrite is not common as a bulk surface component since it rapidly decomposes when exposed to an oxidizing atmosphere. Therefore, if was detected on an exoplanet it would potentially indicate a largely reducing environment that keeps pyrite stable. In Hu et al. (2012), it is argued that pyrite ('metal-rich') is indicative of a primary crust with its mantle ripped off, meaning the planet has lost a substantial amount of its crustal and mantle material either due to large impacts (which are predicted to be the cause of the high density population of super-Earths (Cambioni et al. 2025)), extreme crustal evaporation via incident irradiation (see example, K2-22 b (Tusay et al. 2025), or remnant planetary cores around white dwarfs (Veras & Wolszczan 2019)). A reducing surface might also be related to the interior oxygen fugacity of the object (see Oxygen Fugacity in Table A1).
Magma Surfaces	Glasses in Table A6	Some tidally locked, rocky exoplanets (like 55 Cancri e) are expected to be hot enough that their daysides host, either full or partial, magma oceans. The composition of these magma oceans can be determined spectrally from their instrinic emission (see Fortin et al. (2022, 2024)), thin vaporized rock atmospheres (Schaefer & Fegley 2009; Miguel et al. 2011; Ito et al. 2015; Kite et al. 2016; Teske et al. 2025), or thick outgassed atmospheres (Hu et al. 2024) (see Oxygen Fugacity in Table A1). Drawing geologic inferences from the top-level composition of a magma ocean require a framework that includes planetary properties (like gravity), temporal properties (age of planet), atmospheric properties, and water content (see useful review, Chao et al. 2021). Whether or not a magma ocean does exist on the dayside of a rocky planet, and the magmas ability to dissolve or outgas volatiles, is strong function of incident irradiation recieved, the crustal composition (as different rocks have different melting temperatures and volatile storage properties), and oxygen fugacity (Brugman et al. 2021; Gaillard et al. 2021; Lin et al. 2021; Meier et al. 2026). If solid crustal material exists surrounding a partial magma ocean, it might be subject to contact metamorphism from neighboring magma, or low-pressure high-temperature from incident irradiation (see Metamorphic Rocks in Table A1).

Table A3 *continued*

Table A3 *(continued)*

Surface Type (1)	Table A2 Categories (2)	Potential Considerations for Interpretation if Detected (3)
Aqueously Altered Surface	Clays, Salts, some Basalts in Table A5	While many known rocky exoplanets are expected to be too hot on their tidally-locked, observable daysides to harbour surface liquid water, water can alter the surface and leave remnants indicating its past existence. Clays only form on Earth from the interaction of phyllosilicates (like feldspars) and liquid water. Salts are often an indicator of past or present water in the Solar System (i.e., on Earth, Mars, Europa, etc), where they are left as a residue on the surface from evaporating water. Salts are not expected to be stable at high (>1700K) temperatures that can exist on the daysides of tidally locked rocky planets, though salt glaciers have been proposed to exist on shadowed regions of Mercury (Rodriguez et al. 2023). Specific minerals, like amphibole and serpentine, can be present in rocks and can indicate that the rock either formed from magma that had large amounts of dissolved water, or the rock interacted with external water, sometime in its past (First et al. 2025).

Note—Here, we further contextualize the geological categories in Table A2 into broad, detectable surface types for rocky exoplanets in the era of JWST, and provide potential pathways to interpret each one if detected. Similar to Tables A1 and A2, this table is not extensive and was generated to help guide future considerations for exogeology studies and foster collaboration between geologists and exoplanet scientists. Basalt and Granite in boldface due to their extensive use in this paper. (1) Surface type category, (2) which categories from Table A2 fall under each surface type, and (3) potential considerations for how to geologically interpret a surface if detected.

Table A4. `POSEIDON` Surface Albedo Database

Name (1)	Database (2)	Texture(s) (3)	Sub-Category (4)	SiO$_2$ % (5)	MgO % (6)	(Min, Max) µm (7)
Ultramafic & Mafic (SiO$_2$ $<$ 63 wt%)						
Fe-oxidized^{M}	H12	Powder	Hematite, Basalt	18.05^{S}	2.71^{S}	(0.30, 25.0)
Ice-rich Silicate^{M}	H12	Powder	Basalt	38.47^{S}	5.78^{S}	(0.30, 25.0)
Dunite xenolith	P25	Crushed, Powder	Olivine-rich peridotite	39.04	49.28	(0.40, 25.0)
Tephrite	H25	Powder	Tephrite	41-49^{T}	N/A	(0.30, 25.05)
Clay^{M}	H12	Powder	Clay	41.46^{S}	30.86^{S}	(0.30, 25.0)
Lunar anorthosite	H25	Coarse Powder	Anorthosite	44.08	0.09	(0.28, 49.86)
Basalt w/ Olivine Phenocyrsts	P25	Slab, Crushed, Powder	Basalt	44.50	15.78	(0.40, 25.0)
Lunar mare basalt	H25	Coarse Powder	Basalt	44.57	11.36	(0.31, 25.99)
Feldspathic	H12	Powder	Anorthosite	44.93	0.53	(0.30, 25.0)
Harzburgite	H25	Coarse Powder	Olivine-Pyroxene rich Peridotite	<45%^{S}	N/A	(0.30, 25.92)
Lherzolite	H25	Coarse Powder	Pyroxene-rich Peridotite	<45%^{S}	N/A	(0.30, 25.92)
Alkaline Basalt (large)	H25	Coarse powder	Basalt	45-48^{T}	N/A	(0.30, 25.05)
Alkaline Basalt (small)	H25	Powder	Basalt	45-48^{T}	N/A	(0.30, 25.05)
Basalt glass	H25	Powder	Basalt	45-48^{T}	N/A	(0.28, 25.05)
Basalt tuff	H25	Coarse Powder	Basalt (ejecta)	45-52^{T}	N/A	(0.30, 25.05)
Gabbro	H25	Crushed	Gabbro	45-52^{T}	N/A	(0.30, 49.86)
Norite	H25	Powder	Gabbro	45-52^{T}	N/A	(0.30, 25.05)
Mars Basaltic shergottite	H25	Powder	Basalt (meteoroid)	45-52^{T}	N/A	(0.30, 49.86)
Mars breccia	H25	Slab	Basalt (impact regolith)	45-52^{T}	N/A	(0.30, 25.05)
Trachybasalt	H25	Powder	Trachybasalt	45-52^{T}	N/A	(0.30, 25.05)
EG-19-63 Olivine clinopyroxenite	P25	Slab, Crushed, Powder	Pyroxenite	47.10	24.06	(0.40, 25.0)
EG-19-70 Olivine pyroxenite	P25	Slab, Crushed, Powder	Pyroxenite	47.58	19.62	(0.40, 25.0)
Tholeiitic Basalt	H25	Slab	Basalt	48-52^{T}	N/A	(0.30, 99.72)
Basaltic andesite	P25	Slab, Crushed, Powder	Basaltic Andesite	49.24	8.53	(0.40, 25.0)
Basaltic	H12	Powder	Basalt	50.11	4.06	(0.30, 25.0)
K1919 Basalt	P25	Slab, Crushed, Powder	Basalt	50.65	6.83	(0.40, 25.0)
Ultramafic^{M}	H12	Powder	Olivine, Pyroxene	50.72^{S}	49.28^{S}	(0.30, 25.0)
EG-16-68 Olivine gabbronorite	P25	Slab, Crushed, Powder	Olivine, Gabbro	51.05	11.65	(0.40, 25.0)
Phonolite	H25	Powder	Phonolite	52.5-61^{T}	N/A	(0.30, 25.05)
STM-101 Andesite	P25	Slab, Crushed, Powder	Andesite	52.82	4.42	(0.40, 25.0)
True Intermediates						
Diorite	H25	Powder	Andesite (intrusive var.)	57-73^{T}	N/A	(0.30, 25.05)
Andesite	H25	Slab	Andesite	57-73^{T}	N/A	(0.30, 25.92)
Trachyte	H25	Powder	Trachyte	57.8-69^{T}	N/A	(0.30, 25.05)
Felsic (SiO$_2$ $\geq$ 63 wt%)						
Dalmatian granite	P25	Slab, Crushed, Powder	Granite	67.51	0.71	(0.40, 25.0)
Granite	H25	Powder	Granite	>69^{T}	N/A	(0.30, 25.05)
Rhyolite	H25	Powder	Rhyolite	>69^{T}	N/A	(0.30, 25.05)
Orlando gold granite	P25	Slab, Crushed, Powder	Granite	73.51	0.1	(0.40, 25.0)
Granitoid^{M}	H12	Powder	Granite	76.66^{S}	1.23^{S}	(0.30, 25.0)
Other						
Metal-Rich	H12	Powder	Pyrite	0^{S}	0^{S}	(0.30, 25.0)
Pyrite	H25	Powder	Pyrite	0^{S}	0^{S}	(0.12, 20.02)
Hematite (Fe-oxidized)	P25	Crushed, Powder	Hematite	2.15	0.05	(0.40, 25.0)
Hematite	H25	Powder	Hematite	0^{S}	0^{S}	(0.12, 20.02)
Albite (dust)	H25	Powder	Feldspar	68.74^{S}	0^{S}	(0.13, 20.02)
Magnesium sulfate	H25	Powder	Salt	0^{S}	33.22^{S}	(0.30, 25.92)
Extras						
White	N/A	N/A	A = 1, all µm	N/A	N/A	(0.01, 100.0)
Black	N/A	N/A	A = 0, all µm	N/A	N/A	(0.01, 100.0)
Red	N/A	N/A	A = 1, 0.620-0.750 µm	N/A	N/A	(0.01, 100.0)
Orange	N/A	N/A	A = 1, 0.590-0.620 µm	N/A	N/A	(0.01, 100.0)
Yellow	N/A	N/A	A = 1, 0.570-0.590 µm	N/A	N/A	(0.01, 100.0)

Table A4 *continued*

Table A4 *(continued)*

Name (1)	Database (2)	Texture(s) (3)	Sub-Category (4)	SiO_2 % (5)	MgO % (6)	(Min, Max) µm (7)
Green	N/A	N/A	A = 1, 0.495-0.570 µm	N/A	N/A	(0.01, 100.0)
Blue	N/A	N/A	A = 1, 0.450-0.495 µm	N/A	N/A	(0.01, 100.0)
Purple	N/A	N/A	A = 1, 0.380-0.450 µm	N/A	N/A	(0.01, 100.0)

Note—The general `POSEIDON v1.4` database of surface albedos (see Tables A5, A6, A7 for more specialized collections). All surface albedos present are in their directional-hemispherical reflectance form and have data in wavelengths necessary to model both surface reflection (UV and visible wavelengths) and emission (infrared wavelengths). (1) Name of the surface albedo sample in the database. ^{M} indicates that a sample was modeled via mineralogical mixing, otherwise a real sample was measured. We have adopted broad ultramafic + mafic ($\leq$63% SiO_2), and felsic (>63% SiO_2) definitions, with the delineating percentage (63%) from Paragas et al. (2025), to further sort the table. (2) Original database the data is from; databases are Hu et al. (2012) (H12), Paragas et al. (2025) (P25) and Hammond et al. (2025) (H25). We note that H12 originally used Wyatt et al. (2001) for basalt, Cheek et al. (2009) for feldspatchic, and the `USGS Spectral Library` (Kokaly et al. 2017) for all other data; H25 utilized the `RELAB Spectral Database` (Milliken et al. 2021). (3) Texture(s) of the sample measured; following the definition of Paragas et al. (2025), slab is a solid sample, crushed corresponds to coarse crushed grains (500 µm to 1mm grains) and powder corresponds to fine grains (25-80 µm) [note we extend the Paragas et al. (2025) range from 63 to 80 µm to account for many Hammond et al. (2025) samples]. We have also included coarse powders (80-500 µm). (4) Sub-category as given in Table A2. (5, 6) SiO2 and MgO wt%, where when chemical compositional analysis was performed we report exact values, otherwise we use other methods to report a range: ^{S} indicates that stoichiometry was utilized to determine wt%, ^{T} indicates that the range of compositions was taken from the definition of the rock in the Total Alkali-Silica (TAS) Diagram (Le Maitre et al. 2005) (where identical ranges were used for intrusive and glassy variants). (7) Wavelength range of the data. Plots of albedo vs. wavelength can be seen in 'Albedo Database' in `POSEIDON`'s online documentation.

Table A5. Natural Basalt Library from First et al. (2025)

Name (1)	Texture (2)	Representative Geologic Process (3)	Note (4)	(Min, Max) µm (5)
CNE4	Slab	Supercontinent break-up	Titanite-rich (5%)	(1.34, 27.14)
CNE6	Slab	Supercontinent break-up	Pyroxene-rich (5%)	(1.34, 27.14)
CNE9	Slab	Supercontinent break-up	Titanite-rich (5%)	(1.34, 27.14)
GOR2	Slab	Deep-mantle plume, aqueously altered	Serpentine-rich (25%)	(1.34, 27.14)
LC02	Slab	Deep-mantle plume	Fresh, unaltered basalt	(1.34, 27.14)
LC09	Slab	Deep-mantle plume	Fresh, unaltered basalt	(1.34, 27.14)
LC10	Slab	Deep-mantle plume	Fresh, unaltered basalt	(1.34, 27.14)
SE04	Slab	Mid-Ocean Ridge, aqueously altered	Amphibole-rich (50%)	(1.34, 27.14)
SE20	Slab	Mid-Ocean Ridge, aqueously altered	Amphibole-rich (59%)	(1.34, 27.14)
TABT	Slab	Volcanic-arc basalt	Alumina-rich (∼20%)	(1.34, 27.14)
TAC9	Slab	Volcanic-arc basalt	Alumina-rich (∼20%)	(1.34, 27.14)
TACA	Slab	Volcanic-arc basalt	Alumina-rich (∼20%)	(1.34, 27.14)
TAPS	Slab	Volcanic-arc basalt	Alumina-rich (∼20%)	(1.34, 27.14)
TO01	Slab	Deep-mantle plume, aqueously altered	Serpentine-rich (61%)	(1.34, 27.14)
WB04	Slab	Alkali-rich magma	Basanite	(1.34, 27.14)

Note—The 15 natural basaltic samples featured in First et al. (2025), in their directional-hemispherical reflectance form. Basalts are the most abundant volcanic rock on Earth, the Moon, and Mars and are expected to be the most abundant mantle rock in bulk silicate planets around FGMK stars (Putirka & Rarick 2019). This basaltic library, composed of altered and fresh basalts, can be used to test for specific mineralogical and bulk compositional signals in basalts. In particular, aqueously altered minerals (amphibole and serpentine) present in basalts have strong absorption signals that indicate the presence of past or present surface water, while bulk compositions (e.g., percentage of Al_2O_3) can probe magmatic processes. Bolded entries were featured in Figure 3 of First et al. (2025). Prefixes represent where samples were collected: CNE = Coastal New England, GOR = Gorgona, LC = Lunar Crater, SE = Santa Elena, TA = Talamanca, TO = Tortugal, WB = Wards Science. Plots of albedo vs. wavelength can be seen in 'Albedo Database' in `POSEIDON`'s online documentation.

Table A6. Lava-World Surface Library from Fortin et al. (2022)

Name (1)	Texture (2)	Parent Mantle Material (3)	Partial Melt Composition (4)	(Min, Max) µm (5)
Chond-30	Slab	Peridotite Mantle	30% Melt Fraction	(2.5, 28)
14684-30	Slab	Peridotite Mantle	30% Melt Fraction	(2.5, 28)
65639-30	Slab	Peridotite Mantle	30% Melt Fraction	(2.5, 28)
81262-30	Slab	Peridotite Mantle	30% Melt Fraction	(2.5, 28)
MM3-10	Slab	Peridotite Mantle	10% Melt Fraction	(2.5, 28)
6856-10	Slab	Peridotite Mantle	10% Melt Fraction	(2.5, 28)
6856-30	Slab	Peridotite Mantle	30% Melt Fraction	(2.5, 28)
6856-50	Slab	Peridotite Mantle	50% Melt Fraction	(2.5, 28)
59639-30	Slab	Pyroxenite Mantle	30% Melt Fraction	(2.5, 28)
22907-30	Slab	Pyroxenite Mantle	30% Melt Fraction	(2.5, 28)
MORB-10	Slab	Quartz-normative Pyroxenite Mantle	10% Melt Fraction	(2.5, 28)
MORB-30	Slab	Quartz-normative Pyroxenite Mantle	30% Melt Fraction	(2.5, 28)
MORB-50	Slab	Quartz-normative Pyroxenite Mantle	50% Melt Fraction	(2.5, 28)
MORB-100	Slab	Quartz-normative Pyroxenite Mantle	100% Melt Fraction	(2.5, 28)

Note—The 16 potential lava world surfaces featured in Fortin et al. (2022), which are directional-hemispherical reflectance measurements of rapidly quenched glasses. The glasses have compositions of partial melts of a parent material (i.e., for Chond-30 the glass that was measured is 100% composed of material made from the molten component of the parent material that is 30% melted). Entries are in order of decreasing SiO_2 content in the mantle composition they are made from (see Figure 1 of Fortin et al. (2022)). Includes reference Mid-Ocean Ridge Basalt (MORB), peridotite (Earth-like mantle material, MM3), and chondritic composition (Chond) measurements. Numbered lab samples are partial melts of bulk-silicate planet (BSP, bulk planet minus metallic core) compositions from the exoplanet mantle modeling of Putirka & Rarick (2019) (where primitive mantle compositions, before crustal formation, were modeled based off of stellar compositions). Peridotite compositions are olivine-rich while pyroxenite compositions are pyroxene-rich. The predicted percentage of exoplanets with each type of mantle depends on metalllic core-formation mechanisms (Mercury-like, Earth-like, and Mars-like): peridotite mantles (26.8%, 78%, 95.1%), pyroxenite mantles (59.8%, 20.6%, 4.2%), and quartz-normative pyroxenite mantles (13.3%, 1.2%, 0.2%). Not represented in this sample are magnesiowüstite-normative peridotite mantles, which represents $< 0.5\%$ of predicted exoplanet mantles. See Figure 1 of Fortin et al. (2022) for parent mantle material compositions, and resultant partial melt compositions of the samples. Users should also see Fortin et al. (2024), which explored in-situ temperature-dependent emissivity measurements. Plots of albedo vs. wavelength can be seen in 'Albedo Database' in `POSEIDON`'s online documentation.

Table A7. Surface Albedos - Reflection Alone for HWO Applications

Name (1)	Description (2)	Reflectance Type (3)	(Min, Max) µm (4)
Deciduous	Leaf Piles	Bidirectional reflectance + directional-hemispherical reflectance	(0.302, 14)
Coniferous	Needle Piles	Bidirectional reflectance + directional-hemispherical reflectance	(0.302, 14)
White Fig Tree†	Spring Leaves	Bidirectional reflectance	(0.35, 2.5)
Basalt	Fresh basalt	Absolute reflectance	(0.30, 2.69)
Grass	Grass Mixture	Absolute reflectance	(0.26, 2.98)
Snow	Melting Snow	Absolute reflectance	(0.35, 2.50)
Ocean	Ocean Seawater	Absolute reflectance	(0.21, 2.98)
Sand	Quartz Sand	Absolute reflectance	(0.24, 2.98)
Cyanobacteria (MarSipp)	Intertidal microbial mat	Polarized Reflectance	(0.35, 1.10)

Table A7 *continued*

Table A7 *(continued)*

Name (1)	Description (2)	Reflectance Type (3)	(Min, Max) µm (4)
Cyanobacteria (Drymat)	Dry mat	Polarized Reflectance	(0.35, 1.10)
Hypersaline biota (MarGuer)	Hypersaline intertidal microbial mat	Polarized Reflectance	(0.35, 1.10)
Purple plankton (Conpurp)	Purple plankton sulfur pool	Polarized Reflectance	(0.35, 1.10)

Note—Data originally collected in Goodis Gordon et al. (2025) (GG25). Data sourced from the `NASA JPL ECOSTRESS Spectral Library` (Baldridge et al. 2009; Meerdink et al. 2016; Meerdink et al. 2019) and `USGS Spectral Library Version 7` (Kokaly et al. 2017). Microbial mat samples are from Sparks et al. (2021) and are housed at NASA Ames Research Center. Unlike Table A4, albedos includes in this database are not standardized to directional-hemispherical reflectances. `ECOSTRESS` entries are bidirectional in short (0.3-2.5 µm) wavelengths and directional-hemispherical in longer ones. `USGS` datasets are taken with a myriad of spectrometers (detailed in Table 1 in Zenodo Supplementary Material (see §6.2)) that are generally calibrated to absolute reflectances. The Sparks et al. (2021) spectra are not explicitly defined, though reflectances are measured with a polarized instrument. †Dataset most similar to 'Forest' dataset highlighted in Goodis Gordon et al. (2025). For more examples of HWO-applicable datasets, see Zelakiewicz et al. (2026). Plots of albedo vs. wavelength can be seen in 'Albedo Database' in `POSEIDON`'s online documentation.

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