INTRODUCTION: The geologic origin of the Noachian-aged, phyllosilicate-rich bedrock at Oxia Planum, the landing site of the ExoMars 2022 rover, is unknown. The phyllosilicates are the main target of the mission, but it is unclear whether they are authigenic or detrital, or what processes formed the host bedrock. Oxia Planum itself comprises a shallow topographic basin, situated on the margin between Mars’s hemispheric dichotomy and Chryse Planitia. The phyllosilicate-rich bedrock basin fill-depth is unknown but is at least 100 m [1]. Sub-horizontal, meter-scale layering, exposed in the phyllosilicate-rich bedrock points to a sedimentary origin. Observations from HiRISE, CaSSIS, and CRISM divide the phyllosilicate-rich bedrock into at least two distinct sub-units, which may reflect compositional variations: an underlying, orange-toned unit and an overlying, blue-toned unit [2].

At the eastern margins of the landing ellipse is a 10 km long sediment fan. This has been interpreted as a delta [1], implying formation in a standing water body. The fan is sourced from an extensive highland catchment, including the extensive and long-lived Coogoon Vallis system [3, 4]. The fan illustrates how fluvial processes might have transported detrital phyllosilicates into Oxia Planum but is interpreted to postdate the formation of the phyllosilicate-rich bedrock. Two additional, geologically younger materials are found at Oxia: a dark, spectrally bland capping unit and a series of light-toned mounds. Both probably formed from what were once more extensive deposits, suggesting that the entire region was subject to widespread erosion [1, 5]. Having testable hypotheses ahead of the ExoMars Rover landing in 2023 is critical for its time-limited, in situ science investigations. Here, we use HiRISE [6] and CaSSIS [7] datasets to investigate fluvial sinuous ridges (FSRs; [8-10]) at Oxia Planum. We focus on the processes that they may record and their relationship to the phyllosilicate-rich bedrock at Oxia.

OBSERVATIONS: Morphology of FSR systems. FSR system 1, east of the landing site, is east-west trending and exposed to a length of ~20 km. The eastern end is ~200 m higher than the western, and here it grades into a subtle valley for ~5 km before merging into background where it is deformed by a wrinkle ridge. The ridge trend is perpendicular to contour lines, and inferred flow was east to west. The ridge is at most ~5 m high, as measured in HiRISE DEMs.

FSR system 2 (Lutetia Dorsum [10]), south of the landing site, is generally south-north trending with a semi-continuous exposure of ~40 km and secondary, fragmented ridge systems associated with the main ridge. The southern end is ~200 m higher than the

Figure 1: MOLA topographic map of Oxia Planum, showing the locations of the FSRs (yellow) and negative relief valleys and channels (blue). Modified from [3].
northern, so inferred flow was to the north. In the south, the ridges originate from shallow dendritic valley systems but overall the ridges only sometimes occur in valleys. At its northern end, the ridge is overlain by the eastern sediment fan.

FSR system 3, 80 km southwest of the landing site, is generally southwest-northeast trending and exposed to a length of 50 km, some of which is set within a shallow valley. The southwest end of the system is 100 m higher than the northeast, so inferred flow is to the northeast. Again, fragmented, secondary ridge systems are associated with FSR system 3.

**Relationship to surrounding terrain.** FSR systems 1 and 2 appear texturally similar to, and exhumed from, the phyllosilicate-rich bedrock. Specifically, the FSR systems generally occur in the upper, blue-toned unit [2]. Stairstep sub-horizontal layering is clearly present in the margins of FSR system 1, which grades into the underlying terrain. Periodic bedrock ridges (PBRs; parallel sets of ridges eroded into bedrock [11]) are seen both on the phyllosilicate-rich bedrock around FSR system 2 and superposed upon it. PBRs are not present on FSR systems 1 or 3, but neither are they present on the surrounding phyllosilicate-rich bedrock. Additionally, ridge pathways appear to have been altered in response to the changing landscape (i.e., diverted around new impacts).

Impact craters with (usually) bright-toned infill (typically < 500 m diameter) are particularly common around the margins of FSR systems 2 and 3 (visible only in HiRISE images). The infill comprises clearly layered deposits and some craters are infilled almost entirely. Much of FSR system 3 appears capped by a dark resistant unit, although this material does not appear to make up the entire vertical structure of the ridge, and examples elsewhere suggest that this material is of negligible thickness (~1 m). In addition, FSR system 3 is directly superposed by three light-toned mounds, providing a clear stratigraphic relationship between mound and fluvial ridge formation.

**Discussion:** We note that no FSRs are set within deep bedrock valleys; instead, they are found on plains (the phyllosilicate-rich bedrock) or set within shallow valleys. We suggest these FSRs represent the deposits of ancient, aggradational, alluvial river systems which traversed the plains at Oxia Planum, rather than erosive rivers incised into bedrock. Secondary ridges associated with the main systems could be either tributaries or earlier generations of rivers, or both. The stairstep layering and response to changing landscape dynamics argues against simple channel-fill composing the ridges. The concentric layered deposits adjacent to the FSRs may record overbank deposition and/or ponding in local accommodation (e.g., impact craters).

We suggest that these observations mean that at least some of the phyllosilicate-rich bedrock comprises alluvial deposits and this could be the case throughout the landing ellipse and the wider region. Infilled impact craters point to biotases in deposition of the bedrock that is now phyllosilicate-rich, so river systems may have been episodically active, although we expect other sources of sediment (e.g., volcanioclastic, impactogenic, aeolian) to have also played a role in building the terrain. If the deltaic interpretation of the sediment fan is correct, these alluvial plains may have formed before a large standing water body was present at Oxia. We note that our interpretation does not constrain the origin of the phyllosilicates themselves as detrital or authigenic. The low relief of the FSRs across the Oxia landscape may be due to a high mud fraction in the bedrock, which led to differential erosion producing more subdued topography than is typical of other landscapes containing FSRs. If widespread alluvial plains are present at Oxia Planum, diagnostic outcrops such as conglomerates and laminated mudstones should be present, so the presence of an alluvial landscape is a hypothesis testable by the ExoMars rover.

![Figure 2: FSR systems, south of the OP landing site.](image)