intensive pumping tests on wells to establish that well recuperation is almost instantaneous. This facilitates the extraction of groundwater.

We have thus found that the floodplains are not only an incredible natural source of water, but also largely recharge naturally on their own. This makes them a perfect local source of water for cities on their banks and, further, a completely non-invasive solution to the water problem of cities. Having lost so much of our natural water repositories, it is vital that we have a non-invasive, 'preserve and use' solution to source water. This is unlike dams, which permanently damage river catchments and require long-distance transport of water from far-away water basins. Transport of water by canals involves major losses and causes groundwater salinity through waterlogging. Recycling sewage water is expensive and leaves its own waste. On the other hand, the scheme presented herein[2] is a perennial and very low cost solution for city water.

The recharge can be enhanced during the monsoon period when there is plenty of free flow in the river. As we have indicated, this can be accomplished by running shallow channels from an upstream barrage along the elevated embankments and let the water drain over the floodplains. Such inundation produces rapid recharge in the floodplains.

At present, the wells in Palla are run manually, without proper coordination and do not produce an optimum yield. To get an optimal yield would require that each well be fitted with monitoring equipment such as piezometers (or equivalent) to obtain real-time data of the local groundwater level and sensors to determine the discharge, salinity, and other chemical parameters of the water coming out from the delivery pipes of the tube wells. Wells would then have to be fitted with remote logic-based microprocessors (remote terminal units or RTUs) that would transmit real-time data on all parameters to regulate pumping from a central computer. For this, we can use an automated supervisory control and data acquisition (SCADA) system based on GSM technology that is employed in many groundwater applications (Such SCADA control systems are operational in many locations – e.g. in Holland and in Chandigarh (by the CGWB for the city groundwater supply), which has nearly 200 tube wells managed using a SCADA system.) This would give us a complete picture of the underground floodplain aquifer. All parameters would be monitored in tandem on a real-time basis for all wells. Controlled pumping will then ensure a maximum and sustainable yield without any invasion of the saline water that may reside at the bottom.

We have highlighted some remarkable features of floodplain aquifers that have natural storage and natural recharge, even in the absence of sufficient rainfall recharge. This makes it possible to have a systemic and ecological solution for water extraction. Such a solution is presently being implemented by us in collaboration with the Delhi Jal Board for the Yamuna floodplains. This will help in extending non-invasive, self-sustaining, local solutions for water-short cities located on rivers all over the world.

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# Petrographic evidence as an indicator of volcanic forest fire from the Triassic of Allan Hills, South Victoria Land, Antarctica

The Mesozoic ecosystems, as of today, were subjected to various natural disasters like volcanism, earthquakes, floods, droughts and forest fires[1–4]. Wildfire has important influences on the environment, climate and biota, but our ability to understand these linkages in geologic past has been hampered by difficulties in identifying evidence for palaeowildfires and their proximate cause. The Gondwana System of the Allan Hills, southern Victoria Land, Antarctica offers a unique window to understand past volcanic activity. Continental volcanism was considered to be one of the major causes of forest fire during the Late Triassic of Allan Hills. The nature and source of forest fire can be addressed through the studies of organic matter, geochemistry and fossil signatures[5,6]. Based on geochemical, palaeobiological and palaeowildfire evidences, many researchers have established volcanic activity in Antarctica during the Triassic[5,7–9]. Earlier palaeobotanical studies recorded well-preserved plant fossil assemblage (rich flora of *Dicroidium*) from A and C members of the Lashly Formation[10,11]. Further, past studies and the present study rule out marine influence and the palynological and palaeobotanical studies considered along with sedimentological aspects indicate a fluvial nature of the sediments[5,10,11].

The present study suggests continental volcanism as a source of forest fire, also supported by petrified gymnospermous woody material (phytoclast) preserved in the opaline silica. The samples collected are fine-grained. They got deposited in a low-energy hydrodynamic condition and settled in a suspension mode. The associated lithology comprises interbedded sandstone and carbonaceous siltstone of which the former was deposited by traction mode and the latter by suspension mode, as is evident from the texture of the fine grains. This implies that both horizontal and vertical means of deposition prevailed during the Triassic. Detailed petrographic studies carried out demonstrate the role of volcanism in destruction of vegetation of the Allan Hills during the Triassic.

The Gondwana system exposed at Allan Hills, South Victoria Land comprises continental sediments ranging from Permian to Jurassic. This has two units – the lower Victoria Group consisting mainly of fluvial clastic sediments and the upper Ferrar Group which is of volcanic origin. The stratigraphy of Allan Hills has been discussed in detail by other workers[12–22] (H. I. Gabites, unpublished). The Triassic Lashly Formation (~ 500 m) in the Victoria Group gradationally overlies the Feather conglomerate and contains plant remains of the *Dicroidium* flora throughout the sequence. This Formation consists of four members (Figure 1 *c*): (i) Member A at the base is a cyclic sequence of fine-grained sandstone and green siltstone; (ii) Member B is predominately medium-grained sandstone; (iii) Member C is interbedded sandstone and carbonaceous siltstone and (iv) Member D consists of medium-grained sandstone. Member C has a lenticular bed of ~ 5 cm thick silicic tuff interlayered with *Dicroidium*-bearing shale indicating a proximate source of volcanism. This tuff layer shows fine bedding and contains abundant glassy material and fragments of other rocks and fossils.

Shale samples from the Member C of Lashly Formation (Triassic) of Allan Hills (lat. 76°43′S, long. 159°40′E,

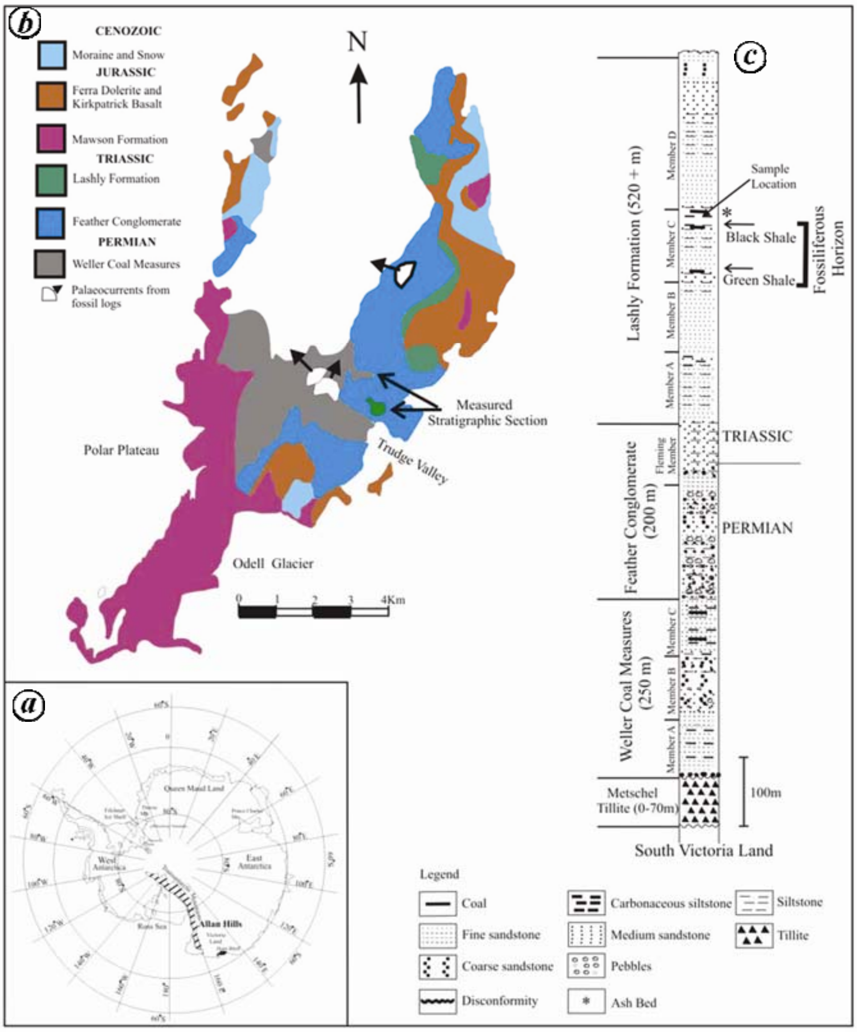


**Figure 1.** ***a***, (Inset) Location of Allan Hills (South Victoria Land). ***b***, Geological map of Allan Hills (modified after Balance[17]). ***c***, Composite litholog of Victoria Group (after Kyle[18]), the upper most Lashly Formation and sample location in member C.

Figure 1), South Victoria Land, have been analysed for petrographic studies. The shale is grey to black in colour. Petrographic thin sections were made using diamond blade machine and polished with fine carborandum powder[23]. The thin sections were analysed in the Leitz petrological microscope. After critically analysing the thin sections, images were taken using plane polarized light (PPL) and cross-polarized light (XPL) 5X and 10X objectives (Figure 2).

The petrological studies on the selected material exhibit volcanic clasts, plagioclase grains, opaline silica grains and woody structures (Figure 2). After a close examination of the woody structure, it was found that cellular preservation is intact. Rectangular/polygonal tracheidal cells arranged serially resemble gymnospermous secondary wood. These tracheidal xylem cells occur along with black glassy matrix (obsidian). Poor sorting, presence of glassy material and gymnospermous phytoclasts are a clear indication of volcanic source in the close proximity of the depositional environment.

Earlier geochemical and palynological studies from the Prince Charles Mountain, East Antarctica suggest volcanism as a major cause of forest fire during the Early Triassic[6]. The lava and other pyroclastic flows are considered as the potential cause for ignition of wild fires[24,25]. The present study also supports such a view. It is found that volcanic glass (obsidian) contributed more than 90% of total minerals followed by plagioclase and some other silicified gymnosper-

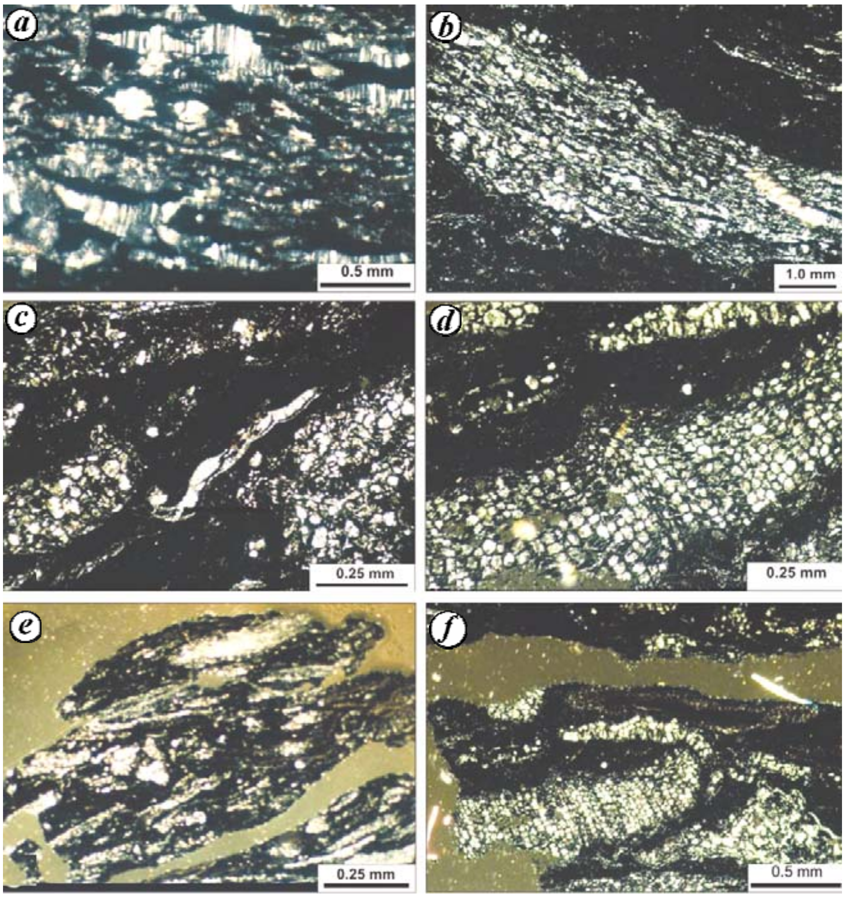


**Figure 2.** ***a***, Plagioclase crystals in glassy matrix. ***b*** and ***c***, Extinct glassy matrix (elongated black in colour) along with lithic fragments. ***d*** and ***f***, Woody phytoclast (gymnospermous) in glassy matrix. ***e***, Fiamme structures. All photographs are taken under cross-polarized light.

mous tissues in the Lashly Formation. The occurrence of thermally altered pollen grains and burnt charcoal material in addition to the ash beds from the Lashly Formation also supports volcanic activity as a cause of forest fire during the Triassic[5]. A local concentration of sulphide minerals (mainly pyrite and chalcopyrite) associated with wood fossils indicates a reducing environment[19], which also strengthens our findings.

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