Video Observations Inside Channels of Erupting Geysers, Geyser Valley, Russia

A.Belousov[1], M.Belousova[1,2], A.Nechaev[3]

[1] - Earth Observatory of Singapore, 639798, Singapore, [2]-Institute of Volcanology & Seismology, Petropavlovsk, Russia, [3]- Logata Co Ltd, Moscow, Russia

Geysers are a variety of hot springs characterized by violent ejections of water and steam separated by periods of repose. While ordinary boiling springs are numerous and occur in many places on Earth, geysers are very rare. In total, less than 1000 geysers are known worldwide, and most of them are located in three large geyser fields: Yellowstone (USA), Geyser Valley (Russia), and El Tatio (Chile). Several physical models were suggested to explain periodic eruptions of geysers, but realistic understanding of processes was hampered by the scarcity of field data on the internal plumbing of geyser systems. Here we present data based on video observations of interior conduit systems for geysers in Geyser Valley in Kamchatka, Russia. To investigate geyser plumbing systems we lowered a video camera (with thermal and water insulation) into the conduits of four erupting geysers. These included Velikan and Bolshoy, the largest geysers in the field, ejecting about 20 and 15 m3 64 of water to heights of 25 and 15 m, respectively, with rather stable periods of approximately 5 h and 1 h. We also investigated Vanna and Kovarny, small geysers with irregular regimes, ejecting about ten liters of water to heights as much as 1.5 m, with periods of several minutes. The video footage reveals internal plumbing geometries and hydrodynamic processes that contradict the widely accepted "simple vertical conduit model", which regards geyser eruptions as caused by flashing of superheated water into steam. In contrast, our data fit the long-neglected "boiler model", in which steam accumulates in an underground cavity (boiler) and periodically erupts out through a water-filled, inverted siphon. We describe the physical rationale and conditions for the periodic discharge of steam from a boiler. Channels of the studied geysers are developed by ascending hot water in deposits of several voluminous prehistoric landslides (debris avalanches). The highly irregular contacts between adjacent debris avalanche blocks provided an environment that favored the formation of channel-conduit systems with the contorted configurations characteristic for the boiler model. The solitary geysers scattered all over the Earth can form by the occasional coincidence of several favorable factors and, perhaps, function according to the principles of any one of the existing geyser models. But why in some (very few) locations are multiple geysers grouped together in relatively small areas? We argue that in these areas, besides the necessary hydrothermal conditions, there are specific shallow geological structures or deposits that favor the formation of multiple complex systems of underground conduits, channels and chambers, including systems having the boiler model geometry. A required combination of geological conditions favoring generation of contorted channels, and hydrothermal discharge, explains the rarity of large geyser fields on Earth.