GEOTHERM supports East Africa - regional boundary conditions for geothermal energy use

The volcanoes of the East African Rift

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The rift intersects major parts of the following countries (from north to south): Eritrea, Djibouti, Ethiopia, Kenya, Tanzania, Uganda, Rwanda, Burundi, Malawi, Zambia and Mozambique. Other countries like the D.R. Congo are crossed by the East African Rift to a minor degree. Nevertheless two neighbouring Virunga volcanoes in D.R. Congo, Nyamuragira and Nyiragongo, are responsible for nearly two-fifths of Africa's historical eruptions. These volcanoes have erupted very fluid lavas which were flowing down the flanks with a speed of up to 60 km per hour. This implies that also effusive eruptions can be dangerous for the local people as evidenced during the January eruptions of Nyiragongo in 1977 and 2002 (Figure 6b).

Figure 6b *Crater of Nyiragongo with lava lake (photographs by Jack Lockwood 1994)* ***a*** *Lava lake of Erta Ale (source of Erta Ale photographys: http://www.educeth.ch/stromboli/perm/erta/lake-en.html Copyright: J. Alean, R. Carniel, M. Fulle)*

The products of always violent explosive eruptions can sometimes be traced over more than 2000 km distance. An example is a 3.4 million year old volcanic ash at Lake Turkana in northern Kenya which can also be found in Hadar, Ethiopia and in the marine sediments of the Gulf of Aden. In historic times fortunately such mega-eruptions do not occur. The largest known historical eruption in Africa took place at Dubbi volcano, Eritrea in 1861. There 3.5 km3 of lava poured out of the crater as well as eruption clouds of pumice showering maritime traffic in the Red Sea and plunging coastal settlements into darkness (Figure 7).

In comparison to eruptions of other volcanoes active in historic times the East African volcanic activity is fortunately for the local people not very dangerous. Especially the volcanoes of the “ring of fire” around the Pacific Ocean can be orders of magnitude more hazardous.

The magmatic activity of the EAR has produced the continent's highest and lowest volcanoes, ranging from nearly 6000 m high (5895m) Kilimanjaro in Tanzania with an ice cap to vents in the Afar triangle that lie below sea level in the hottest region on earth (Danakil Depression). Spectacular lava lakes (Figure 6) at Erta Ale (Ethiopia) and Nyiragongo (D.R. Congo) as well as the unusual mineralogical composition of Oldoinyo Lengai (Tanzania) attract numerous volcanologists from all over the world to study these active volcanoes (Figure 8).

Figure 8 Crater of Ol Doinjo Lengai filled with carbonatitic lava

The magma ascends from the earth's mantle through the continental crust to the earth surface. If the pathways do not allow the original “primitive” melt a direct ascend to the surface, the accumulating melt sticks within the crust. Then a magma chamber forms in which cooling leads to the crystallisation of minerals. These early crystallising minerals are heavier than the melt and therefore settle down and accumulate at the base of the magma chamber. This process changes the composition of the remaining “evolved” melt. If the evolved melt finds then a way to the surface the growing volcano has not only a different composition but accordingly also a different shape and eruption style:
A) Primitive melts: flat shield volcano with low viscous lava flows => gas can escape easily which causes non-violent effusive eruptions (e.g. Erta Ale)
B) Evolved melts: high stratovolcano with steep flanks due to high viscous melt => gas cannot escape easily which causes sometimes violent explosive eruption cycles.

If the mass eruption rates are very high the magma chamber is partly emptied and the overlying rock mass is collapsing along circular fractures causing a special crater form called caldera.

Fragmentation of the lava is due to bursting of gas bubbles during pressure release of rising melt at a near surface level (bottle of champagne effect). The size of the fragments is ranging from big volcanic bombs falling down near the vent to fine-grained volcanic ash sometimes reaching some tens of kilometres height. The ash cloud is than drifting in the dominant wind direction over huge distances until the ash is deposited. The East African volcanic rocks do not contain quartz crystals and have a specific range of compositions which is characteristic for continental rifts.

Age of initial volcanic activity (as well as above mentioned initial rifting) decreases from North to South. The volcanic activity predates the rifting in the eastern branch of the EAR indicating an active rift mechanism (Figure 9) induced by the two uprising mantle plumes (Afar and Kenya plume).

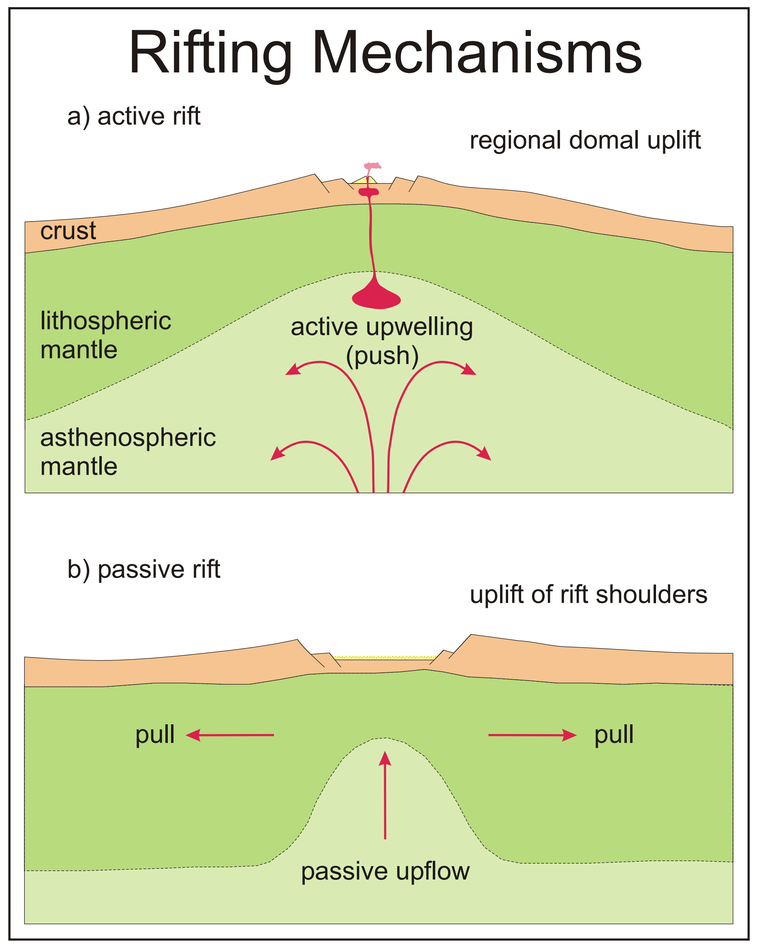

Figure 9 *Active versus passive rifting*

Minor volcanism of the western branch started around 12 million years ago and was contemporaneous with rifting or earlier. This implies that the western branch is not so easy to interpret and needs further research to clarify the rifting mechanism.

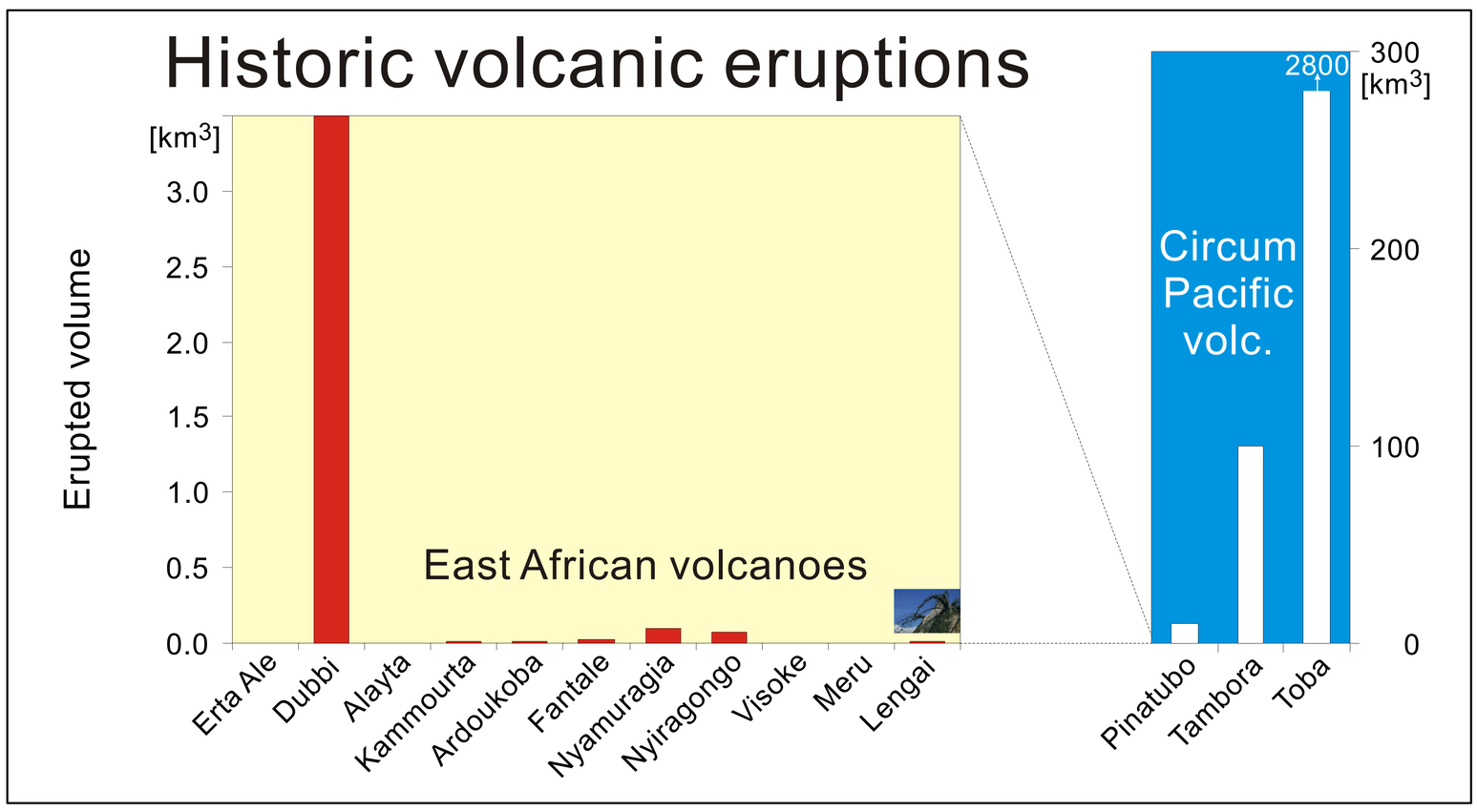

Figure 7 *Amount of erupted material during single historic volcanic eruptions in East Africa and the Circum Pacific region*

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