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Growth of fissure ridge travertines from geothermal springs of Denizli basin, western Turkey

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The long-term evolution of endogenic travertines may provide important insights into paleoclimate, tectonic activity, geothermal resources, and, more in general, subsurface fluid circulation. Fissure ridge travertines grown from geothermal springs of Denizli basin, southwestern Turkey, are investigated through stratigraphic, structural, geochemical, and geochronological methods, with the aim of understanding the growth of these elongate mound-shaped structures. Two main types of travertine deposits are recognized: (1) bedded travertines, which form the bulk of fissure ridges, and (2) banded travertines, which grew as veins within the bedded travertine chiefly along its central feeding conduit. Stratigraphic and structural observations shed light on the bedded-banded travertine relationships, where the banded one grew through successive accretion phases, intruding the bedded travertine across its strata or along them forming sill-like structures. The bedded and banded travertines alternated their growth as demonstrated by complicated geometrical relationships and by the upward suture, in places, of banded travertine by bedded travertine that was, in turn, injected by younger banded travertine. The bedded travertine is often tilted away from the central axis of the fissure ridge, thus leaving more room for the central banded travertine to form. Travertine bed unconformities are, in places, the effect of bed tilting. U-series data confirm the bedded-banded travertine temporal relationships and show that the growth of the studied fissure ridges lasted several tens of thousands of years during Quaternary time. C and O stable isotope data together with previously published rare Earth element analyses indicate a shallow feeding circuit for the studied structures, where banded and bedded travertines are characterized by similar isotope signature and, therefore, by the same feeding fluid, but slightly different precipitation conditions. A crack-and-seal mechanism of fissure ridge growth is proposed, where the progressive tilting of bedded travertine limbs over a soft substratum creates the necessary space for the central veins to grow. This implies that active tectonics may have played a subordinate role in the growth of the studied fissure ridges. The role of paleoclimate and fluid pressure remains to be ascertained.

Keywords: travertine, fissure ridge, fluid flow, active tectonics, geothermal spring.