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Preface

Documentation of structures in different scales is the first step in many structural geological studies. This edited atlas gives an overview of diverse structures. Due to lack of space or inappropriateness, sometimes interesting structural snaps cannot be published in journals. This book fills that gap.
KEYWORDS
Columnar joints; Crater; Fissures; Fractures; Pull apart structure; Spheroidal weathering; Xenoliths.

This chapter presents various structures some of which are not worked intensely by structural geologists. Grain boundary migration in rocks observed under optical microscope can constrain the temperature the rock underwent (Stipp et al., 2002). Stability of buildings and fracturing during earthquakes has been a research topic to geoscientists (Krishnan et al., 2006). Study of faults and other structures has helped geoscientists to paleohydrology (Treiman, 2008) (Figures 6.1–6.60).

**FIGURE 6.1 Columnar joints, colonnade and entablature.** Thick solidifying lava flows develop contraction fractures that propagate from their cooling margins toward hotter interiors. These fractures, called columnar joints, divide a lava flow into columns, with polygonal (ideally hexagonal) shapes in plan. A subhorizontal basaltic lava flow of the Talisker Bay Group, Isle of Skye, Scotland is shown in the figure. The lower part of the flow shows well-developed vertical columns, suggesting nearly horizontal isotherms (contours of constant temperature within the lava flow). Such a columnar tier is called a colonnade. The upper part of this flow shows a highly chaotic and distorted internal structure, as would develop during rainfall or stream flow supplying water into the cooling flow interior and disturbing isotherms. This tier is known as an entablature. The colonnade and the entablature, though with greatly different field appearance, are part of a single lava flow. Here, the combined thickness of both is 120 m. (Hetu Sheth)
FIGURE 6.4  Southward panoramic view of the geothermal travertine area of Bridgeport, California. Photographed from the crest of the Hot Tub Ridge, which is an active and prominent fissure-ridge travertine deposit (Latitude N38°14′45″, Longitude W119°12′18″; Chesterman and Kleinhampl, 1991). The Hot Tub Ridge is 84 m long, 7 m wide, and 4 m high (De Filippis and Billi, 2012). The Long Ridge (a 360 m long fissure-ridge) and the Sierra Nevada mountains are also visible in the photograph. Fissure-ridge travertines are elongated mound-shaped deposits of travertine developed along open fissures usually in active geothermal-tectonic areas. The ridges can be straight, slightly curved or bifurcated in plan view, and are usually characterized by an axial extensional fissure extending along the crest of the ridge. The fissure-ridge in the photograph is unique for its singular tripartition of the fissure at the ridge tip. In active fissure-ridges, carbonate-rich hot waters ascending along the axial fissure cause carbonate precipitation both within the fissure-ridge and over the ridge flanks, thus generating banded and bedded travertine deposits, respectively (Hancock et al., 1999). Most fissure-ridges are located on the hanging wall of normal faults. Influence of active tectonics on the growth of fissure-ridge travertines may be moderate to important. Physicochemical attributes of fluids as well as their abundance (pore pressure) and climate oscillations (dry vs wet periods) also play an important role in the fissure-ridge nucleation and growth (Chesterman and Kleinhampl, 1991; Hancock et al., 1999; De Filippis and Billi, 2012). (Luigi De Filippis, Andrea Billi)

FIGURE 6.5  Southeastward panoramic view of the Kamara active fissure-ridge, in the Denizli extensional basin, southwest Turkey (Latitude N38°03′24″, Longitude E28°58′16″; De Filippis et al., 2012, 2013). An open axial fissure is well exposed along the ridge crest and is partly filled by banded travertine dated through U–Th methods (1.7±0.1 and 2.5±0.1 ka; De Filippis et al., 2012). The ridge crest is also characterized by a system of en-echelon open subvertical fractures with an average strike ~N120°. Fracture aperture varies between approximately a few millimeters and a maximum of c. 20 cm, and it is usually larger in the central section of the fissure-ridge than near its lateral closures. This fissure-ridge is 63 m long, 15 m wide, and 6 m high. Dimensions of known fissure-ridges on the Earth vary (e.g., Brogi and Capezzuoli, 2009) up to a maximum of ~2 km long, 400 m wide, and 20 m high (De Filippis et al., 2012). Both flanks of the Kamara fissure-ridge consist of bedded travertines dipping away from the axial fissure. This fissure-ridge is singular for the presence of a fossil waterfall along northeast flank and for the marked transverse asymmetry of the ridge. (Luigi De Filippis, Andrea Billi)
FIGURE 6.6 This photograph shows an exposure across the southeast flank of the Long Ridge (Latitude N38°14′43″, Longitude W119°12′19″), which is a fissure-ridge located in the geothermal area of Bridgeport (California). A subvertical banded travertine (dotted yellow lines) intruded within the axial sector of the fissure-ridge, whose flanks are mostly formed by steep travertine beds (dotted turquoise lines). The bedded travertine is a porous and stratified flowstone deposit forming the bulk (flanks) of fissure-ridges. The banded travertine, in contrast, is a nonporous, sparitic travertine filling the interior of fissure ridges with steep-to-vertical thick veins in the axial region and sill-like structures along the bedded travertine. The subvertical banded travertine usually cuts across the preexisting bedded travertine, which, in turn, may upward suture the banded travertine, thus providing evidence for the alternate growth of banded and bedded travertines. The ridge is unique because it exposes this reciprocal crosscutting and suturing relationships between banded and bedded travertines. From a paleoclimatic point of view, the bedded travertine growth is presumably connected with high stands of the water table during warm-humid periods (Faccenna et al., 2008), whereas the banded travertine growth is probably driven by coseismic exsolution events during low stands of the water table in cold-dry conditions (Uysal et al., 2009). Fissure-ridges can thus provide unique information on the relationship between paleoclimate, groundwater systems, and tectonics (Faccenna et al., 2008; Uysal et al., 2009; Crosse and Karlstrom, 2012). (Luigi De Filippis, Andrea Billi)

FIGURE 6.7 Microscopic view of a vein of banded travertine across the Akköy fissure-ridge (Denizli basin, Turkey, Latitude N 37°56′56″, Longitude E 29°05′28″). Main features are a series of long fibrous calcite (and subordinate aragonite) crystals with a typical competition pattern (featherlike structures). Multiple succeeding bands of crystals attest for the multiphase growth history of the veins (Uysal et al., 2007; Van Noten et al., 2013). The crystals are usually perpendicular to the vein walls and their growth typically occurred toward the center of the vein (symmetric syntaxial growth) or from one wall toward the other wall (asymmetric syntaxial growth), as also confirmed by radiometric dating (Uysal et al., 2007). The force of crystallization along the veins can induce the uplift of the rock above the veins, in the case of sill-like veins (Gratier et al., 2012), and the transverse opening of fissure-ridges, in the case of subvertical veins developed along the axial region of the ridges. (Luigi De Filippis, Andrea Billi)
REFERENCES


