Chapter II.4

GYPSUM KARST OF FRANCE

Michel Chardon & Jean Nicod

Many small and scattered areas of gypsum karst are present in France. They occur in the plains and plateaux (Paris, Lorraine, Provence) as well as in the mountains, especially the Alps (Fig. 1). Typical gypsum karst landforms are well developed and widespread, but underground cavities are scarce, despite much exploration and the apparent existence of subsurface waterflow. The Alps and Provence contain the largest karstic areas.

Fig. 1. Gypsum karst in France (After Karstologia 25, 1995).

Fig. 3. Karst phenomena and landslides in gypsum karst of the Middle Var (Provence). 1 = late Cretaceous and Cenozoic basins, 2 = Jurassic limestone plateaux, 3 = Triassic, 4 = Permian depressions, 5 = main tectonic scarp, 6 = cuesta, 7 = funnel or "clape", 8 = collapse, 9 = landslide, 10 = doline, 11 = karst lake, 12 = uvala, 13 = filled polje, 14 = sulphate spring, 15 = other springs, 16 = travertines, 17 = old gypsum quarry.

At the centre of the Var district, a multi-bedded gypsum aquifer is fed by water leaking down from the overlying karstified Jurassic limestones; in the Issole valley various karstic ponds and lakes are related to this hydrological phenomenon. Many springs hereabouts have sulphate and chloride waters, such as La Foux de Roquebrussane in the Nartuby valley, which is the main spring feeding the ponds and lakes. It has the following characteristics: mean discharge $0.9\text{ m}^3/\text{s}$, mean ionic composition (in meq./L): $\text{Ca}^{2+} = 20.6$; $\text{Mg}^{2+} = 2.8$; $\text{SO}_4^{2-} = 15.1$; Cl^- and $\text{Na}^+ = 13$; the total solute load = $27,265\text{ m}^3/\text{year}$. This active chemical corrosion is responsible for the development of numerous superficial karstic landforms.

No important caves have been noted around here, but from time to time superficial collapse pits suddenly appear, due to breakdown of underground cavities. They include the "clapes" (funnels) in the Nartuby valley, just above Draguignan; of these "La Nouvelle Clape" formed in 1983 and "Le Trou de Bargemon" (about $40,000\text{ m}^3$ in volume) formed during August of 1992. Ponds or lakes (Grand Lucien, Besse) are located on the anticlinal structures of the Muschelkalk limestones, they are situated in collapse sinkholes formed by the dissolution of the underlying gypsum beds. Some of the flat-floored dolines have a thick colluvial cover along their slopes and small poljes such as Marais de Gavoty, with siliceous deposits, can be interpreted as having had a long evolution, possibly since the Late Miocene.

3. Other important areas of Triassic gypsum

Some large karst landforms are known in the Alpes Maritimes, North of Nice. These include the enormous sinkhole of Beuil-Valberg and the 200m-long cave of Source des Isles in Lantosque. The massive Roquebillière landslide, which occurred here in 1926, has also been attributed to gypsum dissolution after heavy rain.

In the Western Pyrénées, karst depressions are connected with Triassic gypsum that occurs in diapiric structures, the most conspicuous is Bassin de Sare in the Basque country.

In the eastern part of France, Lorraine and Franche-Comté, there are many landforms resulting from collapse, including funnels, pit holes and sinkholes or “mardelles”, which occur commonly in the forest areas. However, La “Font de Lure” in Haute Savoie is a sinkhole pond in the central part of the town.

Tertiary gypsum beds (Palaeocene and Ludien) are well-known in the central part of the Paris sedimentary basin; at Forêt de Montmorency they are up to 30m thick. Hereabouts many natural caves have been encountered in both ancient and modern mines. The old gypsum quarries of Vaulours and Béthemont-en-Forêt lead to a 350m-long cave network called Denis Parisis. The surface karst landscape above the gypsum is dotted by numerous collapse sinkholes, of which the best example is Chanteloup-les-Vignes.

4. Environmental and geotechnical problems

Numerous natural hazards and risks have been associated with gypsum karst processes and landforms. These processes can be accelerated by climatic variations and human impact, including amongst others, dam construction and water abstraction.

Many collapse phenomena have allowed the delineation of potentially dangerous areas in Provence. These include the centre of Draguignan, districts of Bargemon, Callian and Abbaye du Thoronet, plus Roquevaire, where the old gypsum quarries are now deserted. In the Paris district many events, reported as “fontis” or breakdowns, have occurred in Meudon, Aubervilliers, Montreuil, Chanteloup and Porte de la Chapelle. The same phenomena have been noticed in the Alps at Grand-Coeur and Aussois.

Landslides, torrential floods and mud flows are also more common where gypsum crops out, especially in the Alps: Tarentaise (Pralognan, Moutiers); Maurienne (Modane, Val Cenis); Alpes Maritimes, Beaufortin (Arèches).

These natural hazards are allowed for by geotechnical mapping and prediction. Z.E.R.M.O.S. maps and “Cartes et Plans de Prévision des Risques Naturels” (P.E.R.) have been compiled for many of the potentially dangerous zones. In the Paris Basin the collapse risk is increased by over pumping water from the underlying aquifers. In the Alps, where there is a lack of surface water flow, the contamination of drinking water supplied from springs is a serious problem for some important tourist centres and ski-resorts, such as La Plagne, Tignes and La Norma. Human activity has caused a severe increase in the rate of karstic denudation, slope gullyng, landslides and the sudden formation of subsidence pits. Many problems have been caused by civil engineering projects, including the construction of roads, artificial ski paths and artificial tunnels, which have

destroyed the natural morphological balance of the landscape in areas such as Val Fréjus, La Plagne, Tignes, Galibier and Modane.

References

- CHARDON, M. 1996. La mesure de l'érosion dans le gypse/anhydrite des Alpes Françaises du Nord, Méthodes et état des connaissances. *Rev. Géog. Alpine (Grenoble)*, 84, 2. 45-56.
- CHARDON, M. & ROVERA, G. 1996. Les karsts du gypse en Vanoise (cartographie et évolution géomorphologique). In: (Chambéry, ed.): *Parc National de la Vanoise. Bull. Travaux scientifiques du P.N.V. vol.XY*.
- NICOD, J. 1992. Recherches nouvelles sur les karsts des gypses et des évaporites associées; Première partie: processus et cavernement. *Karstologia* 20, 1-10.
- NICOD, J. 1993. Recherches nouvelles sur les karsts des gypses et des évaporites associées; Seconde partie: géomorphologie, hydrologie et impact anthropique. *Karstologia* 21, 15-30.
- ROVERA, G. 1990. *Géomorphologie dynamique et aménagements des versants en Moyenne Tarentaise*. Grenoble, Inst. Géog. Alpine, Thèse d'Université. 465 pp.