HOW TO STOP VENICE FROM SINKING

The city of Venice is built on a group of low-lying islands in a lagoon that is cut off from the Adriatic Sea by a barrier beach (the Lido). In the Middle Ages, when the city was founded, the site was an ideal choice. It was easily defensible against the armies that periodically over ran the mainland, and it was admirably located to become the chief port of the Adriatic.

Today the seagoing trade goes largely to ports on the mainland. Venice has little industry (except the famous glass manufactures) and for the last hundred years or more has lived largely off the tourist trade. It is a unique place to see, and its Lido has been one of Central Europe's favorite resorts.

But the islands of Venice are gradually sinking: They have gone down by about 15 centimeters since 1930. This may not seem like much, but it is a great deal at Venice, where the islands have always been virtually flush with the water. If the subsidence continues much longer, the land will be below the normal level of the lagoon, and the city will be uninhabitable. The prospect dismays the Venetians and everyone else who loves the city.

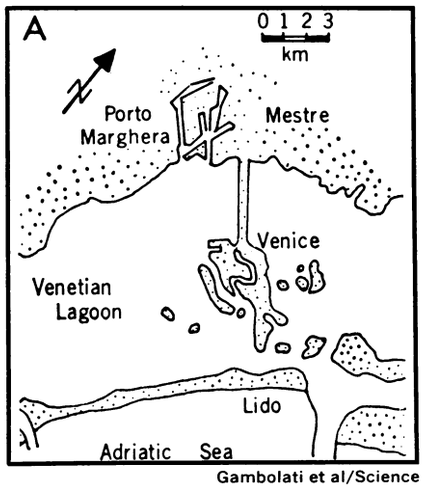
In the March 1 SCIENCE three earth scientists, Giuseppe Gambolati of the IBM Science Center at Venice, Paolo Gatto of the Italian National Research Council's Laboratory for the Study of the Dynamics of Large Masses also at Venice and R. Allan Freeze of the University of British Columbia, suggest an explanation for the subsidence and a prediction about its future.

Venice, the Lido and the adjacent mainland cities of Marghera and Mestre are all underlain by the same sediments, an extension of those found under the plain that comes down from the foothills of the Alps toward Venice. In the first 1,000 meters of depth these are unconsolidated sands, silts and clays of the Quaternary period. The strata form a system of aquifers and aquitards.

The cause of the subsidence, according to Gambolati, Gatto and Freeze, is withdrawal of ground water from these aquifers by means of wells in Marghera and Venice. Withdrawing water from the aquifers reduces the hydraulic head. (The hydraulic head can be measured at any point by tapping the aquifer with a pipe and seeing how high water rises spontaneously in the pipe.) The water can then no longer support as large a percentage of the load of overlying formations as before. This places more of the load on the grain-to-grain contacts of the geological material itself. Under this increase in stress the formations compact, and that results in subsidence of the surface.

It is industrial pumping rather than backyard wells that does the damage. Pumping wells on an extensive scale were first drilled at Porto Marghera in 1930. By 1969, 460 liters per second were being removed from the aquifers. There is one major well in Venice, drilled in 1953, that removes about 10 liters a second. Since 1969 no new wells have been drilled and the amount pumped has remained constant.

If the consumption in both Marghera and Venice is held constant at its 1973 value, Gambolati, Gatto and Freeze conclude, about three centimeters of further subsidence is to be expected, and then it will stop. A complete cessation of pumping in the Venice well alone would save about one centimeter of this. Stopping the Venice pumping and holding that at Marghera to about 75 percent of the present rate would arrest the subsidence at about its present state. A shutdown of all wells would halt the subsidence and provide a modest rebound of about two centimeters in the next 25 years. The three investigators say that they did not study any regimes under which pumping would be increased because that is obviously unacceptable if Venice is to be saved. An important point is that artificially recharging the aquifers would not repair the damage: Over 85 percent of the subsidence is unrecoverable.



Gambolati et al/Science

Ending the subsidence would solve only one of Venice's problems. Another major difficulty is the lagoon's response to tides and seiches in the Adriatic, which floods the city periodically. Then there is air pollution from industry on the mainland, which is corroding the city's architecture, and last but not least, the canals are dirty and they stink. (In Thomas Mann's *Death in Venice* there is a description of the odor of the canals during the Sirocco that almost makes the reader gag.) To preserve Venice as a livable and visitable city for the future requires solutions for all these problems that will not mar the city's beauty nor destroy its setting. Perhaps those with ideas will come forth. □

DO MAJOR PLANETS HAVE FAR-OUT ATMOSPHERES?

On Oct. 17, 1973 an occultation of the planet Saturn by the moon was visible from Canada. Observers from the Calgary Centre of the Royal Astronomical Society of Canada and the University of Calgary Physics Department set up equipment in different parts of the province of Alberta to observe the event. A visual observer at Ardrossan (near Edmonton) saw a curious glow that appeared at the dark edge of the moon a second or two before the first point of light from Saturn's rings appeared. In the Feb. 15 NATURE, G. Reed and F. J. Howell of the RASC and T. A. Clark of the University of Calgary present a proposed explanation of this glow.

Ruling out spurious effects of telescopes or the earth's atmosphere on technical grounds, they conclude the glow may represent a tenuous extension of the planet's atmosphere that goes to some 5,000 kilometers outside the rings. They point out that a similar glow around Jupiter was seen a few years ago by H. Brock when that planet was occulted by the mountains of the moon. B. J. Peek suggested that this represented a tenuous extension of Jupiter's atmosphere to 1,000 kilometers above the cloud tops.

Such atmospheric extensions would be made up of light elements. They would not scatter sunlight, but they could be made visible by mechanisms equivalent to aurora or airglow triggered by particles from the solar wind. They would be very faint and completely washed out when the brightness of the planet itself is in view, and thus only visible at occultations.

The Calgary astronomers end with this suggestion: "It is obvious that repeated measurements of this phenomenon . . . are necessary in order to verify the existence of the glows but these can be made only infrequently. Of much greater importance, bearing in mind the approach of the Pioneer spacecraft to Jupiter, is that extended glows should be searched for in data from these deep space probes." □