other tools developed especially for FAMOUS—the French-American Mid-Ocean Undersea Study.

Other rift areas have been photographed remotely from shipboard, but none so exhaustively as the dive site. Some 30,000 photos have been accumulated, many of them from last year's dives, both to show the divers where they are and to locate interesting targets.

The photos reveal that the hard rock floor of the valley seems to be somewhat different from lava flows on land, possibly because the new material that is being added from below is slowly forced through the rift like clothes through a ringer. James R. Heirtzler of Woods Hole, chief U.S. scientist on the project, says, for example, that the site shows strange flows resembling "toothpaste squeezed from a tube."

"We don't fully understand the processes and distribution of materials," Heirtzler says, but the limited observations so far do confirm that the sea floor does seem to be moving outward in both directions from the rift. In the one to three miles of the valley's width, rock samples have been found to range in age from too young to date, near the center, to as much as 100,000 years near the valley walls.

Seven French and six U.S. scientists, two at a time, will take part in the exhaustive schedule of as many as 60 dives, which are planned to run from June 20 to Sept. 2. Besides gathering samples, they will be looking for signs of geologic activity in the region, several of which have already been detected. The water close to the bottom is unusually warm over the rift, for example, a possible sign that heat from the interior of the planet is being brought up with the new material. The rift rocks are also more magnetic, again an indication of recent origin. Tiny earthquakes, as many as a dozen per hour in some parts of the site, signal the nearness of the living earth, although they are far too weak to imperil the submersibles.

Scarcely 20 miles from the project's four surface support ships, another remarkable vessel will be making its own contribution to riftlore. The Glomar Challenger, which has been drilling core samples from the floors of the world's oceans, will be working about 20 miles west of the dive sites. In their first attempt, Challenger scientists will try to drill their core tubes through 550 meters of bottom sediment and on into the hard rock beneath. If this works, they will use a cone-shaped guide developed by Challenger teams to reenter the hole a second time to bore even deeper. The goal is to penetrate up to 800 meters into the oceanic basement rock, far exceeding the 80-meter depth achieved so far. ☐

Uniting two forces: Ferment in physics

For some time particle physicists, and we, have been celebrating the discovery of the phenomenon called neutral weak currents and its meaning for the unity of particle physics (SN: 5/4/74, p. 284; 5/25/74, p. 340). Now there is further evidence in favor of the same trend, toward the unification of two kinds of natural force.

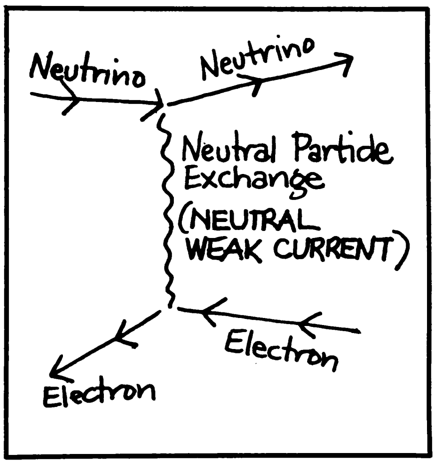
To give a brief recapitulation, there are now three experiments that have seen effects of neutral weak currents. They are at three of the foremost centers of modern physics, the CERN laboratory in Geneva, the Fermi National Accelerator Laboratory at Batavia, Ill., and the Argonne National Laboratory at Argonne, Ill.

In a recent publication the NAL people were a bit hedgy, pointing out that the particular phenomenon they had found might be attributed to other causes. But in a new report attributed to all of them and authored by David Cline, they seem to have dropped the hedge and are laying their result on the neutral weak current. It is gratifying to have such triple support for the phenomenon come so quickly. There have been some important steps in physics that have come in a much more frustrating manner.

The discovery, according to Cline (and we are indebted to him for the general ideas expressed here), is an incident in a phenomenological trend that is tending to show basic siimlarities between electromagnetism and the weak interaction and to which NAL now adds another piece of information. This is a similar trend to the series of experiments in the early 19th century that showed similarities between electricity and magnetism and led to James Clerk Maxwell's theory showing them to be reciprocal aspects of a single phenomenon, electromagnetism.

Of course a similarity and basic union between electromagnetism and the weak interaction are assumed in the theory of Steven Weinberg and others that the present excitement seems to support. But any comprehensive theory needs support at many points, not just one. There is a sense in which one could say that Newton's theory of universal gravitation was not fully proved until the first artificial satellite went into orbit.

The weak force was actually discovered as long ago as 1896 when Henri Becquerel came upon nuclear beta decay—or better, the phenomenon of beta rays because that's how he saw it. Becquerel was not aware that he was seeing the operation of a previously unknown force. At the time physicists believed in two kinds of force, gravity and electromagnetism. For decades physicists attributed atomic and subatomic happenings to electromagnetism. It was not until the 1930's with the discovery of the neutron and the postulation of the neutrino that it became clear that two new varieties of force were at work. They have been denominated quantitatively if not very distinctively the strong and the weak. The strong holds atomic nuclei together. The weak is at work in various varieties of radioactive decay.



The currents were the first similarity between electromagnetism and the weak interaction. They were a similarity that at first looked rather dissimilar and have now become very similar thanks to the latest experiments. The currents are analogous to electric currents in a wire, but are not the same thing.

Much of particle physics is based on what happens when two particles collide. There are several ways of viewing such a collision including the simple kind of picture one sees with balls on a billiard table. One of the views is that as the two particles approach each other they exchange an intermediary particle, in the case of electromagnetism a photon, in the case of the weak interaction a particle that has never yet been experimentally manifest, and this exchange somehow creates a force between the particles. The other most common view is the currents. The particles in the interaction are moving and can therefore be regarded as constituting currents. One current exerts a force on the other just as a current in a wire exerts a (magnetic) force on another current-carrying wire. The particle interaction can thus be seen as an interaction between currents.

The current picture proved fruitful in dealing with interactions under the control of electromagnetism. It became clear that in electromagnetism the proceeding was what is called a neutral current interaction, that is, it preserved the electric charges of the particles that went into it. Currents proved a good way of looking at the weak interaction too, but it became very clear that here one was dealing with a charged current interaction: In weak-interaction collisions the particles always exchanged a unit of charge, uncharged ones becoming charged and charged ones neutral. It seemed a fundamental dissimilarity between electromagnetism and the weak interaction.

But now neutral weak currents have been found. This provides an analogue and a similarity between the two kinds of interaction. Of course there was a theoretical development that anticipated the experiments and undoubtedly gave experimenters an idea of something to look for. But the phenomenon is there in nature and would have been found sooner or later, theory or not. Either theory or experiment is a significant achievement. The concatenation calls for imported rather than domestic champagne.

Now let's look for another similarity. The latest news is that the NAL group reports that it is finding a new similarity thanks to its ability to experiment at very high energies. NAL is the most energetic particle accelerator in the world, and it was designed with facilities for producing copious beams of high-energy neutrinos, a probe particle essential for studying the weak interaction. Cline compares studying the weak interaction with beta decay to the work of 18-century natural philosophers who studied static electricity. The connection between electricity and magnetism became apparent in the early 19th century when Hans Christian Oersted was able to experiment with currents in wires. Likewise, Cline expects, and he is not alone, the similarities between electromagnetism and the weak interaction should become more visible at NAL energies. Indeed they do. At least one more does. It has to do with the relative strengths of the two forces.

The four forces of physics do not all have the same intrinsic strength. From weakest to strongest they go: gravity, weak, electromagnetism, strong. Why the differences exist is one of the standing mysteries of physics, and philosophers of science make whole books out of the meanings of the numbers. The extreme-strength ratio, of strong force to gravity, is something like 10^{40}.

In low-energy processes like beta decay the strength of the weak force is about one ten-billionth that of electromagnetic forces in the same nuclei. If the forces are to be similar and eventually united, such a wide discrepancy seems a bad omen. Well, the good news from NAL is that as the energy of the proceedings goes up, so does the strength of the weak force. The NAL physicists expect that at higher energies than those now available at NAL, the weak force may even become stronger than the electromagnetic.

"With these observations," says Cline, two important differences between weak and electromagnetic interactions are removed, and it appears more plausible that these interactions may somehow have a common origin." So we have here a lovely case in a matter of seminal importance for particle physics of theoretical and phenomenological courses that seem to be setting in the same direction. "It is possible," Cline goes on "that the study of weak and electromagnetic interactions is now entering the analogous phase of Oersted and Faraday [the other great 19th-century electromagnetic experimenter] in electromagnetism. Hopefully it will not take 42 years for a modern Maxwell to clarify the situation." □

Decoding the language of ancient Lycia

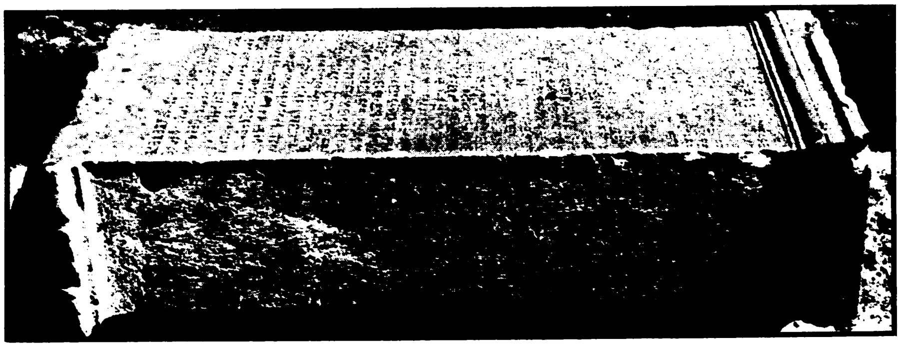
The Rosetta Stone, unearthed in 1799 near the Egyptian town of Rashid, or Rosetta, became perhaps the most famous archaeological discovery of all time when the two languages and three scripts of its inscriptions enabled Thomas Young and Jean Francois Champollion to crack the key to ancient Egyptian hieroglyphics. Now another multilingual slab is promising to open the door to another early written language: Lycian.

Lycia was a sea-faring kingdom occupying the rugged mountains and Mediterranean coastal region of what is now southern Turkey, several centuries before Christ. Most of the little that is known of the kingdom comes from excavations at the site of its capital city, Xanthos, but this is largely in the areas of art and architecture, with relatively few examples of writing. Some bilingual samples—in Lycian and ancient Greek—have been discovered, but most of these are simple tomb inscriptions with too few words and too little grammar to really "break the code."

At last, however, the key to the code may have been found. Last summer, a team of archaeologists headed by Henri Metzger of Lyon University in France discovered in southern Turkey a four-foot-high stone slab inscribed in not two languages, but three—Lycian, Aramaic and Greek. (Aramaic, besides being the language of Christ, was the official language of the Persian empire and the *lingua franca* of much of the ancient Near East.) The inscription on the stone, as deciphered from its better-known languages, is believed to concern the establishment of two new gods by a local governor named Pixodaros. Metzger dates the stone at 358 B.C., the beginning of the reign of Artaxerxes III over the Persian empire.

By comparing the Lycian account with the better-understood Greek and Aramaic versions, researchers hope to fill in the gaps in their knowledge of Lycian writing, part of whose alphabet is still not understood. The slab itself is in superb condition, Metzger says, and its inscriptions are deep and clear, but the task of decipherment is still not an easy one. One obstacle, warns Near East historian James Muhly of the University of Pennsylvania, could be that the inscriptions in the three languages are not identical. Often in multilingual tablets, he says, one language will carry the complete text while the others are only paraphrases. On the new slab, he adds, "I have heard that the Lycian text is much shorter."

This would not be completely unexpected, say Muhly, since by the date Metzger assigned to the slab Lycian was probably already an archaic language. Translators will have to try to make up for the lack of one-to-one correspondence by comparing the overall meanings in the different languages, even with their limited knowledge of Lycian. Difficult though the work will be, says Metzger, the slab "should allow us to make substantial headway in understanding more about the Lycian tongue." □



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This four-foot stone slab may unlock the ancient writing of the kingdom of Lycia.